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The impact of intellectual capital on innovation generation and adoption

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Abstract

Purpose – The purpose of this paper is to measure the separate and interrelated effects of three aspects of intellectual capital (human, social and organizational capital) on innovation generation and adoption.
Design/methodology/approach – Data were collected from 318 respondents' of chemical firms. This study used multiple regression analysis to analyze the influence of human, organizational and social capital on innovation generation and adoption.
Findings – Results suggest that organizational capital exerts significantly positive impact on innovation adoption. In the same vein, social capital exerts significantly positive impact on both innovation generation and adoption. Moreover, interaction of social capital further strengthens the influence of organizational capital on innovation adoption. Contrary to hypotheses, human capital does not exert significant influence on innovation generation. However, interaction of social capital further strengthens the impact of human capital on innovation generation.
Practical implications – Findings offer implications for modern managers to utilize the knowledge that resides in firm's different locations. It also enhances managerial ability to identify and apply these knowledge resources to expedite innovation generation and adoption.
Originality/value – Innovation generation and adoption plays a critical role in firm's acquiring success and competitive advantage, yet the influence of intellectual capital on innovation generation and adoption mostly remains as unexplained puzzle. This study contributes to knowledge-innovation literature by examining the missing link between different types of knowledge and innovation generation and adoption. It also helps to comprehend the enabling factors through which firms capitalize upon, and obtain, a sustainable competitive advantage.

Keywords Social capital, Innovation adoption, Intellectual capital, Human capital, Organizational capital, Innovation generation
Paper type Research paper

Introduction

Innovation is an important determinant of organizational success and a firm's ability to sustain a competitive advantage (Rhee *et al.*, 2010). In this context, knowledge is a more critical resource than other traditional resources, such as fixed or hard assets, when it comes to achieving a competitive advantage (Quinn *et al.*, 2005; Carmona-Lavado *et al.*, 2010). This is why research on innovation is shifting towards a focus on the roles that knowledge, or intellectual capital, can play as critical antecedents to innovation (Subramaniam and Youndt, 2005).

Intellectual capital describes the intangible-assets of an organization (Bueno *et al.*, 2004; Bontis *et al.*, 2005a; Petty and Guthrie, 2000), that helps organizations to achieve sustainable success (Youndt *et al.*, 2004; Subramaniam and Youndt, 2005), corporate performance (Firer and Mitchell Williams, 2003; Riahi-Belkaoui, 2003; Wei Kiong Ting and Hooi Lean, 2009; Clarke *et al.*, 2011). This research considers three aspects of intellectual capital – human capital; social capital; and organizational capital (Davenport and Prusak, 1998; Nahapiet and Ghoshal, 1998; Schultz, 1961; Subramaniam and Venkatraman, 2001). Each one has distinct characteristics. For example, human capital refers to individuals in a

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firm who apply their knowledge, skills and capabilities to act in new ways (Coleman, 1988). Social capital is an outcome of the interaction and collaboration among individuals who share their ideas (Wright *et al.*, 2001; Subramaniam and Youndt, 2005; Carmona-Lavado *et al.*, 2010). Organizational capital indicates the experience and tacit knowledge of an organization that exists in the form of manuals, structures and databases of an organization (Subramaniam and Youndt, 2005; Youndt *et al.*, 2004).

Although the construct of intellectual capital has been labeled as the driving factor of the firm's success and competitiveness, yet literature falls short to measure the impact of different aspects of intellectual capital (Bontis *et al.*, 2005b) on innovation. According to Subramaniam and Youndt (2005), the impact of intellectual capital on innovation is accepted in a broad manner, but still there is a need of an in-depth exploration of this impact. For instance, innovation management research concentrates on different degrees (incremental vs radical), types (product vs process) and sources (generation vs adoption). Each degree, type, or source has different antecedents (Murat Ar and Baki, 2011), and each leads to distinct outcomes (Subramaniam and Youndt, 2005; Atuahene-Gima and Murray, 2007). Consequently, studies on innovation have not produced consistent outcomes and our knowledge is limited regarding the antecedents of innovation and its consistent outcomes (Damanpour and Daniel Wischnevsky, 2006). In order to minimize this knowledge gap, recently Pérez-Luno *et al.* (2014), propose conducting of further research by measuring the separate impact of the aspects of intellectual capital on generation and adoption of innovation. Responding their call, this research investigates the separate and interrelated impact of the aspects of intellectual capital – human capital, social capital and organizational capital.

Organizations can generate and adopt innovation (Pérez-Luño *et al.*, 2011; Damanpour and Daniel Wischnevsky, 2006). Generation of innovation refers to changes made into the existing products, processes, services or technology which are new to the market and generating firm whereas adoption of innovation refers to the changes only new to the adopting organization (Dewar and Dutton, 1986; Pérez-Luño *et al.*, 2011). Each type of innovation has distinct outcomes for the organization. For example, the generation of innovation can lead to more market competitiveness by scanning new opportunities in the market or by taking advantage of existing market opportunities (Drucker, 1984). The adoption of innovation can help firms to overcome performance gaps and deficiencies, and it can also help the firm exploit new opportunities (Premkumar and Potter, 1995).

It is critical to understand the separate and interrelated impact of the aspects of intellectual capital – human capital, social capital and organizational capital – on generation and adoption of innovation for the following reasons: first, it is important to comprehend the differences between innovation and the generation and adoption of innovation in particular, and how different types of knowledge – human, social and organizational – affect the ways in which a firm decides to generate their own and/or adopt the innovations of the others. Second, the generation and adoption of innovation might be the reasons behind a firm's competitive advantage; therefore, a better understanding of the impact of different types of knowledge on generation and adoption of innovation will lead to a greater understanding of the enabling factors through which firms capitalize upon, and obtain, a sustainable competitive advantage.

Literature review

Human capital

Among the elements of intellectual capital, human capital is the most fundamental (Bontis *et al.*, 2005a). It refers to the economic value of the skills, experience and

knowledge that an individual brings to a firm (Snell and Dean, 1992). Human capital is defined as the knowledge, skills and abilities residing within, and utilized by, individuals (Schultz, 1961; Subramaniam and Youndt, 2005). It includes the characteristics of managerial and entrepreneurial experience and knowledge, academic records, vocational training, an individual's age, and aggregate household income (Pennings *et al.*, 1998; Hinz and Jungbauer-Gans, 1999) positively correlated with firm performance (Kilkenny *et al.*, 1999).

Literature broadly categorizes human capital as firm-specific and industry-specific human capital (Sandberg, 1986; Siegel *et al.*, 1993; Pennings *et al.*, 1998; Hinz and Jungbauer-Gans, 1999; Kenney and Von Burg, 1999; Florin and Schultze, 2000; Bianchi, 2001; Mayer *et al.*, 2012). Firm-specific human capital refers to the type of human capital, that is enriched with the knowledge and skills only valuable to a specific firm. For example, research shows the positive association between the human capital of the founders of high-growth start-up firms and their firm-related know-how and firm's success rate (Sandberg, 1986). The firm-specific human capital is the outcome of knowledge built over the years (Mahoney and Kor, 2015). The efficient utilization of such capital turns out to the source of competitive advantage (Lawler *et al.*, 1995; Mahoney and Kor, 2015). Industry-specific human capital, on the other hand, refers to the knowledge derived from knowledge and experiences related to an industry (Siegel *et al.*, 1993). Researchers identify the association between industry-specific human capital and firm growth and economic performance (Siegel *et al.*, 1993; Kenney and Von Burg, 1999). They also suggest that such capital becomes more important for industrial innovation when the main players in that industry are inclined to exchange knowledge (Bianchi, 2001). Industry-specific knowledge is often tacit in nature, therefore, it is easy for industry specialists to decode (David, 1975). This research focuses on firm-specific human capital. Firm-specific human capital concentrates on the knowledge, skills, and abilities of the individuals within a specific firm, and it is applicable to the broad range of firms and industries (Pennings *et al.*, 1998; Raffiee and Coff, 2015). According to Snell and Dean (1992), the hallmarks of a firm's human capital are the creativity, intelligence and skills of its employees (including their expertise in their roles and functions), who constitute the predominant source of new ideas and knowledge in their organization. This research argues that the firm-specific human capital facilitates to the generation of innovation, it is because such capital is a repository of the diverse skills of individual employees (Hayek, 1945; Mahoney and Kor, 2015) that allows them to be flexible enough to acquire requisite new skills (March, 1991), and becomes a source of sustained competitive advantage (Raffiee and Coff, 2015; Mayer *et al.*, 2012). In this research, the authors operationalize firm-specific human capital as individuals with firm-specific knowledge, skills and abilities that become the sources of new ideas and innovation.

Social capital

The literature on social capital suggests that originally this concept was applied to explain relational sources linked in cross-cutting individual ties that are considered useful for the improving individuals in community and social organizations (Loury, 1977). Research has considered social capital as an important resource based on its supporting actions that range from an individual's occupational attainment (Marsden and Hurlbert, 1988), a firm's business operations (Baker, 1990; Burt, 2009; Coleman, 1988), value creation (Tsai and Ghoshal, 1998), new knowledge creation (McFadyen and Cannella, 2004), to innovative capabilities (Subramaniam and Youndt, 2005). Later research has applied the social capital concept to the broader range of social

phenomena, including relations within and outside the family (Coleman, 1988), relations inside and outside the firm boundaries (Burt, 2009), the organization-market interface (Baker, 1990), and public life in contemporary societies (Putnam, 1995). However, others have conceptualized social capital as a set of social resources embedded in relationships (Baker, 1990; Loury, 1977), and associated values and norms with such relationships (Coleman, 1988; Putnam, 1995). The common notion of social capital among all these levels is the networking of relationships that lead to individual or collective benefits in an organization (Dakhli and De Clercq, 2004). In this study, the authors adapt the definition of social capital as the knowledge, that is embedded in an organization and utilized by interaction among the individuals and their relationship networks (Nahapiet and Ghoshal, 1998). This definition of social capital deals with at individual and firm levels (Inkpen and Tsang, 2005) business relationships establish and develop social capital of employees and firms.

The literature identifies three sub-dimensions of social capital (Nahapiet and Ghoshal, 1998). Each dimension carries distinct characteristics. First, the structural dimension describes the position of a person in a social structure and his/her level of interaction with others that leads to certain benefits. People can use this type of social capital to get job information or to access resources. It includes social interactions (Tsai and Ghoshal, 1998). Second, the relational dimension of social capital explains the nature of the relationships that people build with each other during the period of interaction (Carmona-Lavado *et al.*, 2010). In other words, it refers to the development of trust, respect and friendship that develop among individuals, which influence their behavior (Nahapiet and Ghoshal, 1998). Third, the cognitive dimension is the collection of characteristics and shared codes or shared paradigms that are the foundation of the collective goals and appropriate behavior of a social system (Tsai and Ghoshal, 1998).

Each dimension of social capital has specific implications for innovation. For instance, the structural aspect refers to network ties (to identify who is making and maintaining contacts with whom). The relational aspect emphasizes the features of these relationships (Moran, 2005). The cognitive aspect focuses on the principles and procedures required to act collectively to achieve common goals in the social system (Tsai and Ghoshal, 1998).

Organizational capital

Winter and Nelson (1982), define the nature of organizational capital as codified, and stressed that its creation, preservation and enhancement occur through structured, repetitive activities. It has also been referred as an organizational memory, that is preserved in databases, manuals and patents, that is accessed by individuals to garner and retain the organization's knowledge (Carmona-Lavado *et al.*, 2010). Organizational memory includes archival information about the firm's history that may need to be accessed to ensure prudent decision making (Walsh and Ungson, 1991).

Organizational capital exists in the structures and processes of an organization that are concerned with storing, utilizing and retrieving the organizational knowledge (Subramaniam and Youndt, 2005). Organizations need a specialized knowledge and skills that indicate their organizational capital and then formally integrate them for innovation to occur. Zahra *et al.* (2000), describe this process as knowledge integration that requires the necessary information and expertise to become an embedded part of organizational processes. By combining all of its collective knowledge, it is then clear what has already been learned, to avoid repetition, and managers are better able to decide how this knowledge can be applied. When organizational capital is understood

as organizational memory, it is easier to appreciate how it is used as a tool to interpret knowledge sharing at the firm level: it is there even after the people who contributed it have left the organization.

Innovation generation and adoption

All firms need to generate and/or adopt innovation (Damanpour and Daniel Wischnevsky, 2006; Pérez-Luño *et al.*, 2011). Innovation generation refers to generating a product, process or technology, that is new for the market whereas innovation adoption refers to adapting existing knowledge from outside the organization (Dewar and Dutton, 1986). In other words, generated innovations are new to a firm and its market and adopted innovations are only new to the firm that adopts them. This distinction is similar to distinctions that have been made between innovation and imitation (Brozen, 1951; Schumpeter, 1934; Dell'Era and Verganti, 2007) or between exploration and exploitation (March, 1991).

There is some confusion about how to address the scope of innovation (generation vs adoption) in the literature. Some discuss the degree of newness, such as when Subramaniam and Youndt (2005) distinguish between radical and incremental newness. In another example, Zheng Zhou (2006) speaks of "creative followers" that produce incremental innovation by making any radical innovation as a base. Studies by Damanpour and Daniel Wischnevsky (2006) and Pérez-Luño *et al.* (2011) have addressed the prevailing confusion about the scope of innovation (generation vs adoption) by focusing instead on the scale of innovation. The authors adopt their terminology for this research, and believe that the generation of innovation requires new knowledge derived from exploration, experimentation, observation and discovery (March, 1991). The adoption of innovation, on the other hand, occurs when a firm applies a new approach by incorporating replications into the prevailing organizational knowledge (March, 1991; Dewar and Dutton, 1986).

Both types of innovations are the outcomes of the combination of new and adaption to the existing knowledge. For example, generation of innovation requires the creation and application of new knowledge (Alguezaui and Filieri, 2010) and acquisition of new knowledge is the direct outcome of social capital (Nahapiet and Ghoshal, 1998; Kogut and Zander, 1992) and human capital, whereas adoption of innovation relies in the replication in the already existing knowledge (Damanpour and Daniel Wischnevsky, 2006). But such modification needs to pursue a much more planned process, relying more on the selection, refinement and execution characteristics of exploitation (March, 1991). In this context, innovation-generating firms may rely on new knowledge, whereas, creation of new knowledge is exploratory process characterized by variation, search, experimentation, uncertainty and discovery (March, 1991).

Generation and adoption of innovation offer firms distinct opportunities to gain market newness (Damanpour and Daniel Wischnevsky, 2006; Pérez-Luño *et al.*, 2011; Pérez-Luno *et al.*, 2014). For instance, the generation of innovation contributes to organizational competitiveness by creating new opportunities or by taking advantage of existing ones (Drucker, 1984). And the adoption of innovation helps organizations to either overcome performance gaps and deficiencies or to exploit new opportunities (Premkumar and Potter, 1995).

Hypothesis

This study examines the separate direct and interrelated impact of three aspects of intellectual capital on generation and adoption of innovation (Figure 1).

Organizational capital, social capital and adoption of innovation

Adoption of innovation implies to any change in the products, services or processes which is only new to the adopting firm. This procedure is similar to the exploitation of innovation, which depends on prevailing knowledge of a firm and pursues a planned process that selects, refines and executes specific characteristics (March, 1991). Firm's knowledge plays an important role for innovation. Knowledge resides in different locations in firms, for instance, existing knowledge of a firm is available in manuals, databases, patents and licenses (Hansen *et al.*, 1999). Considering the location and existence of knowledge, it is also known as preserved knowledge or organizational capital of a firm.

The authors argue that preserved knowledge of a firm facilitates the innovation adoption for the following reasons. First, reinforcing of preserved knowledge is easy as it reminds firms to remember what has already been learned and know how to use it (Carmona-Lavado *et al.*, 2010; Subramaniam and Youndt, 2005). Second, preserved knowledge is the compilation of routine activities of firm's employees, therefore such routines encourage the regular application of preserved knowledge (Hansen *et al.*, 1999). Third, preserved knowledge broadens the technological skills of employees and facilitates the integration of new and diverse knowledge into the firm's existing knowledge (Zahra *et al.*, 2000). Lastly, knowledge which is captured, coded and flexible enough has ability to be used for the new contexts (Sørensen and Lundh-Snis, 2001). In different words, knowledge available in systems, files, databases, patents or licenses is important for adoption of innovation because such knowledge is the outcome of routine activities of employees, reminds usage process, flexible to be used for new contexts and more importantly it develops technological skills of employees. Therefore, it can be hypothesized that:

H1. Organizational capital positively impacts on innovation adoption.

This research argues that the social capital will have a positive impact on the innovation adoption. According to Damanpour and Daniel Wischnevsky (2006) adoption is a problem-solving process in which an existing idea is adapted to address the recognized needs and identified problems within an organization. It requires a mechanism of communication and coordination among the actors to alter the prevailing knowledge through knowledge sharing, learning and knowledge transfers between the firm's departments. It also emphasizes the integration of the external innovation into the organization (Damanpour and Daniel Wischnevsky, 2006; Tornatzky *et al.*, 1990).

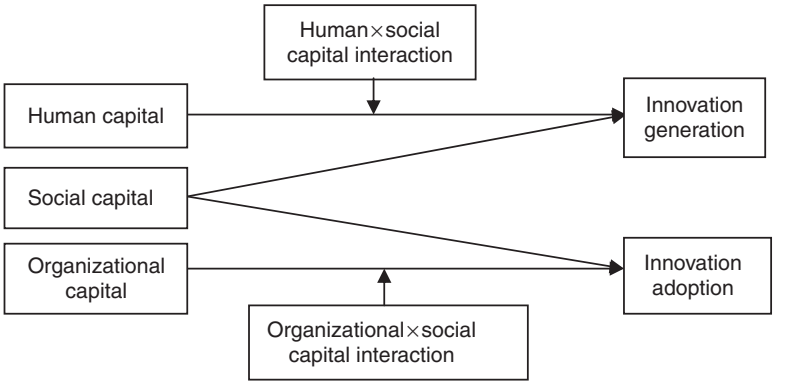

Figure 1.
Conceptual model of three aspects of intellectual capital and innovation generation and adoption

Information and knowledge are acquired when two parties interact. According to Frambach (1993), effective communication with both "technology supplier" and third party known as adopters of innovation, advisors brings useful information. Knowledge acquired from outside the firm's boundaries becomes useful when the goal is to adopt innovation. This is because adopted products and processes already exist in the market, so the adopting firm just needs to acquire that knowledge from the suppliers and/or customers and share it among individuals in the firm. Information-learning theories describe processes through which firms learn by drawing inferences from the behavior of others (Lieberman and Asaba, 2006). In this study, learning is defined as the process through which firms modify acquired information and utilize it for adoption purposes. Throughout this process, the role of social capital functions as a tool in which individuals remain in relationship networks (Bourdieu and Wacquant, 1992). Several studies stress that the knowledge shared through social relationships has useful innovation outcomes (Kogut and Zander, 1992; Nahapiet and Ghoshal, 1998). Because social relationships facilitate the quality of interactions among individuals and strengthens the information exchange among teams and groups (Subramaniam and Youndt, 2005). Thus, this study suggests that social capital, with its characteristics of knowledge sharing, networking and interaction, facilitates knowledge acquisition from within and outside a firm's boundaries and has a positive impact on the adoption of innovation:

H2. Social capital positively impacts on innovation adoption.

Social capital, human capital and generation of innovation

Innovation generation is a creative process in which new and existing ideas are combined in a novel way to produce an invention or a configuration that was previously unknown (Duncan, 1976). According to Damanpour and Daniel Wischnevsky (2006) innovation-generating process evokes new problems, and creates knowledge and information. This research argues that social capital of a firm displays a positive influence on the generation of innovation. Social capital represents the resources, including knowledge and information, implanted inside, accessible through and resulting from the network of relationships (Adler and Kwon, 2002; Inkpen and Tsang, 2005; Mura *et al.*, 2014). When a firm's employees are skilled at interacting, collaborating, sharing knowledge and information, with each other and with business partners, such as suppliers, customers and alliance partners, the firm will most likely generate innovation.

Research distinguishes generation of innovation from its adoption based on the degree of newness (Damanpour and Daniel Wischnevsky, 2006). Generated innovation is "new" to the firm itself and market where it operates, therefore, it requires the creation and application of new knowledge. New knowledge is the combination of sharing and integrating existing information through network ties. Social capital facilitates the creation of new knowledge. Knowledge-innovation theory researchers suggest that the creation of new knowledge occurs when new information is shared (Calantone *et al.*, 2002; Hult, 2002; Hult *et al.*, 2004; Song and Thieme, 2006; Aragón-Correa *et al.*, 2007) networked, combined and exchanged (Chiu *et al.*, 2006; McFadyen *et al.*, 2009).

Nahapiet and Ghoshal (1998), argue that "the fundamental proposition of Social Capital Theory is that network ties provide access to resources." Furthermore, Moran (2005) illustrated the added value of social capital for innovation by noting that "this is the difference between a short and possible guarded hallway conversation about a new idea and active and open brainstorming and tweaking of a new initiative." Knowledge

is embedded in individuals and people are inclined to accumulate knowledge and share it with those whom they recognize as group-mates or close allies. In other words, social capital through network ties encourages knowledge sharing among the actors, which in return enables the creation of new knowledge that will generate innovation:

H3. Social capital positively impacts on innovation generation.

Generation of innovation may require specialized knowledge, skills and abilities which embed with individuals and their human capital. The knowledge, skills and abilities of these individuals can question the prevailing norms (Subramaniam and Youndt, 2005). Firm-specific human capital acquires explicit knowledge through interaction among other employees, managers, members, technological, physical and other resources of a firm (Mahoney and Kor, 2015). These individuals remain and grow within firm boundaries through interacting and learning experiences by performing job assignments, socializing with different people and resources.

There is consensus among the knowledge-innovation researchers on transformation of knowledge. Transformation of knowledge must be preceded by changes in current norms and should offer new solutions to prevailing problems (Tushman and Anderson, 1986). Those knowledge, skills and abilities and expertise are the components of human capital that constitute the predominant source of new ideas, knowledge, and vital for innovation outcomes (Snell and Dean, 1992; Subramaniam and Youndt, 2005; Marvel and Lumpkin, 2007). This study argues that the same holds true for the generation of innovation, as it requires organizations to cater to individuals with a specific type of knowledge. Thus, it can be hypothesized that individuals with specialized knowledge of routine resources, firm's capabilities, habits, abilities and limitations will facilitate an environment of collaboration which in return will assist in the generation of innovation. Therefore, it can be hypothesized that:

H4. Human capital positively impacts on innovation generation.

The moderating role of social capital

Prior research has already identified the importance of organizational preserved knowledge and its usage for formative and recurrent activities (Hansen *et al.*, 1999). The influence of preserved knowledge is expected to strengthen when it is networked through collaborations and relationships among the groups of individuals who operate with this preserved knowledge. For example, groups and teams have been found to deploy knowledge in organizations (Nonaka, 1991; Gerard, 1995) and their performance can be enhanced through networking, information exchange and knowledge sharing. An organization's social capital also enhances the quality of group work and the richness of information exchange among team members (Subramaniam and Youndt, 2005). Social capital helps to improve the quality of interactions and exchange of ideas. This study, in turn, expected to find that knowledge sharing and the networking of social capital would strengthen the influence that preserved knowledge would have on innovation adoption:

H5. The higher the social capital, the stronger the impact of organizational capital on innovation adoption.

Despite the fact that a firm's human capital can challenge ongoing norms and introduce new ways of thinking, when individuals network new ideas with one another, this can generate innovation. Social networks assist in encouraging individuals at a firm or industry level to introduce novel ideas (Subramaniam and Youndt, 2005). For example, research on product champions emphasizes how networking and lobbying dynamics

within organizations facilitate the approval and execution of radical innovations (Schon, 1963). In their study on dominant designs Tushman and Murmann (2002) found that evolving networks and relationships across organizations were critical to industry-wide acceptance of new standards arising from revolutionary ideas. Network theorists have found that ties and networks are key attributes of social capital that encourage knowledge sharing among a wide range of individuals (Subramaniam and Youndt, 2005) and that this enhances the role that human capital plays in knowledge transformation. In other words, a firm's human capital brings diverse ideas and thoughts to the organization and its social capital acts as a bridge to connect them for useful combinations that can result in the generation of innovation:

H6. The higher the social capital, the stronger the impact of human capital on innovation generation.

Methodology

Population, sample frame and sample

To test the research hypothesis, this study collected the data sample from the firms involved in chemical production. The motivation behind choosing the chemical industry was its dynamism, perpetually growing and owing to tough competition is pressuring these firms to innovate is high. Chemical producing firms tend to produce new formulas and patent them to gain sustainable competitive advantage. These new formulas are sometimes entirely new for the industry and/or market or at times adopted from the existing knowledge in the industry.

Empirical evaluation of the construct relationship is conducted by incorporating the data from 318 respondents. The sample was consists of the companies that actively involved in innovation, and have at least one innovation either generated and/or adopted. This method is consistent in the prior studies (Pérez-Luño *et al.*, 2011; Pérez-Luno *et al.*, 2014). Chief executive officers, production managers, R&D personnel, chemical engineers, design engineers and marketing managers were selected as sample for data collection. Questionnaire was sent in-person, through post and e-mail. Study applied a key informant technique for data collection which is very much consistent in the prior literature (Kumar *et al.*, 1993). These informants were those who controlled overall innovation activities and well informed about their organizational strategies. Study's units of analysis were middle- and senior-level managers who were directly involved in innovation activities. It was also mentioned that if there was no concerned manager available, instead asked CEOs to respond.

Measurement

Intellectual capital – human, social and organizational capital

The independent variable of intellectual capital is composed of three aspects – human capital, social capital and organizational capital. This study adapted all three aspects of intellectual capital from a study by Subramaniam and Youndt (2005). Human capital was measured through a scale used by Schultz (1961) as well as by Snell and Dean (1992). The items of human capital reflected to the overall skill, expertise and knowledge levels of individuals of an organization. Social capital was measured by a scale used by Burt (2009). The items of social capital measured the overall ability of an organization to share, leverage knowledge among and between networks of employees, customers, suppliers and alliance partners. Organizational capital was measured by using four-items scale developed by Davenport and Prusak (1998). The items of

organizational capital assessed the overall ability of an organization to store knowledge appropriately in physical repositories such as databases, manuals and patents.

Innovation generation and adoption

The dependent variables of innovation generation and innovation adoption were adapted from Pérez-Luno *et al.* (2014). Originally these items appeared in the definitions of studies conducted by Lieberman and Montgomery (1998), and Zheng Zhou (2006). These items measured a firm's tendencies towards innovation generation and/or innovation adoption. The three innovation generation items investigated the following: first, whether or not ideas for new products/services were generated internally. Second, whether or not the firm imitated others or was instead, always first to generate its own products/services. And lastly, whether or not the firm's generated products/service innovations were new to the reference market. The three items of innovation adoption investigated the following: first, whether or not the firm acquired ideas from others and then used them to develop its own products/services; second, whether or not the firm applied imitation as a common practice; and lastly, whether or not the firm responded to product/service innovations from others, by copying them.

Firm age and size

The two control variables considered the possible influence that firm size and age could have. Firm size was assessed based on the total number of full-time employees, and firm age was measured based on the number of years since the firm was established (Gulati and Higgins, 2003).

Results

Characteristics of sample companies

The questionnaire survey was sent to 900 respondents in 129 organizations in the chemical industry. Out of 900 questionnaires, the authors received 358 responses (response rate – 39.8 percent). Overall, only 318 responses were valid for use for further analysis. In total, 88 percent of the companies were in the businesses of manufacturing industrial chemicals, pesticides and consumer products. In all, 34 percent of the companies were in operation for less than 15 years and 79 percent were in operation for less than 25 years. In total, 53 percent of the companies had less than 85 employees.

Reliability and validity

Reliability of the constructs was assessed using Cronbach α scores. The scores are given in Table I. It can be seen all constructs satisfied the threshold level of 0.70 (Nunnally, 1978). Validity (discriminant and convergent) of the constructs was assessed based on confirmatory factor analysis (McFadyen *et al.*, 2009) and using the criteria recommended by Hair *et al.* The criteria are: the factor loading of item on the construct must be more than 0.50; composite reliability (CR) of the constructs must be more than 0.70; average variance extracted (AVE) of each construct must be more than 0.5; and AVE of each construct must be more than the squared correlation of that construct with other constructs. The factor loadings, CR, AVE and correlations are given in Table I. From the table, it can be seen that the constructs satisfy all the threshold values.

Descriptive analysis

Table II provides the means, standard deviations and correlations for the variables in the study. As expected, human capital and organizational capital correlated significantly

Constructs	Standardized loadings	R^2	Composite reliability	AVE	Cronbach's α
Social capital			0.954	0.805	0.77
SC2	0.955	0.912			
SC3	0.937	0.878			
SC1	0.884	0.781			
SC4	0.869	0.755			
SC5	0.835	0.697			
Organizational capital			0.787	0.491	0.82
OC1	0.849	0.722			
OC3	0.851	0.724			
OC4	0.821	0.674			
OC2	0.806	0.650			
Human capital			0.962	0.886	0.87
HC3	0.956	0.971			
HC4	0.932	0.952			
HC2	0.945	0.912			
HC5	0.912	0.932			
Innovation generation			0.916	0.785	0.85
IG2	0.961	0.928			
IG1	0.933	0.851			
IG3	0.921	0.877			
Innovation adoption			0.912	0.785	0.86
IA2	0.764	0.584			
IA3	0.932	0.669			
IA1	0.818	0.868			

Notes: Goodness-of-fit statistics: $\chi^2(169) = 498.57$; $\chi^2/df = 2.95$; CFI = 0.96; GFI = 0.93; RMSEA = 0.078

Table I.
Confirmatory factor analysis and Cronbach's α

	Variables	Mean	SD	1	2	3	4	5	6	7
1	Size	138.4	13.63	1						
2	Age	5.79	2.84	0.16*	1					
3	Human capital	4.88	0.76	0.04	0.21*	1				
4	Social capital	4.97	0.69	0.19*	0.03	0.42**	1			
5	Organizational capital	5.27	0.43	0.11*	0.26*	0.25	0.52**	1		
6	Innovation generation	5.56	0.89	0.06	0.11*	0.37*	0.46**	0.57**	1	
7	Innovation adoption	5.37	0.41	0.09	0.13*	0.42**	0.28**	0.55*	0.22*	1

Notes: $n = 318$. *,**Correlations are significant at the 0.05 and 0.01 level (two-tailed), respectively

Table II.
Descriptive statistics and Pearson's correlations

with innovation generation ($r = 0.37$, $p < 0.05$; $r = 0.57$, $p < 0.01$, respectively). Human capital and organizational capital were also found to correlate significantly with innovation adoption ($r = 0.42$, $p < 0.01$; $r = 0.55$, $p < 0.05$, respectively).

Operational model was used to examine the hypothesized relationships by using the structural equation modeling. The results presented in Table I indicate that model fit the data well ($\chi^2(169) = 498.57$, $\chi^2/df = 2.95$, CFI = 0.96, GFI = 0.93 and RMSEA = 0.078). Table III provides the regression results of direct and interactive effects of intellectual capital and innovation generation and adoption. The effect of

Table III.
Results of the regression analysis for intellectual capital and innovation generation and adoption[a]

Variables	Innovation adoption			Innovation generation		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Control						
Firm age	0.08 (0.04)	0.07 (0.02)	0.05 (0.02)	0.19 (0.04)*	0.19 (0.03)*	0.18 (0.02)*
Firm size	0.12 (0.02)	0.11 (0.03)	0.10 (0.03)	0.13 (0.04)	0.12 (0.05)	0.11 (0.05)
Intellectual capital						
Human capital		0.06 (0.02)	0.07 (0.02)		0.14 (0.06)	0.15 (0.05)
Social capital		0.63 (0.03)**	0.63 (0.03)**		0.46 (0.04)**	0.48 (0.05)**
Organizational capital		0.42 (0.03)**	0.43 (0.03)**		0.09 (0.03)	0.09 (0.03)
Intellectual capital interactions						
Social capital × Organizational capital			0.32 (0.03)**			
Social capital × Human capital						0.27 (0.06)**
R^2	0.41	0.55	0.56	0.17	0.34	0.42
F-value	39.93**	46.31**	41.79**	10.40***	11.52***	14.27***
ΔR^2		0.14	0.01		0.17	0.08

Notes: [a]Innovation generation and adoption are the dependable variables. Values are unstandardized regression coefficients. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (all two-tailed tests)

organizational capital on innovation adoption was positive and significant ($\beta = 0.43$, $p < 0.01$), supporting *H1*. The effects of social capital on innovation adoption ($\beta = 0.63$, $p < 0.01$) was positive and significant, supporting *H2*. The effects of social capital on innovation generation were significant ($\beta = 0.37$, $p < 0.01$), supporting *H3*. And the effects of human capital on innovation generation was positive but not significant ($\beta = 0.15$, $p = < 0.05$), which did not support *H4*.

The authors further conducted a simple slopes test. Results of this study confirmed that human capital has a stronger positive effect on innovation generation when social capital is high ($\beta = 0.48$, $t = 9.23$, $p < 0.01$) than when social capital is low ($\beta = 0.29$, $t = 6.09$, $p < 0.01$), supporting *H6*.

Similarly, a simple slope test was conducted to identify the interactive effects of social capital for organizational capital (see Figure 2). Results confirmed that organizational capital has a stronger positive effect on innovation adoption when social

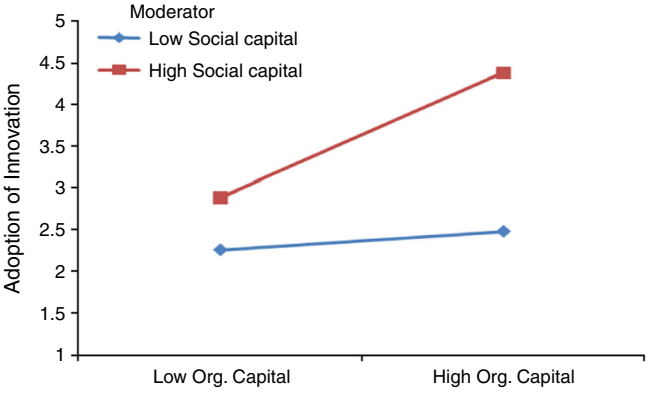

Figure 2.
Hypothesized interaction plot of social capital and organizational capital

capital is high ($\beta = 0.48$, $t = 5.64$, $p < 0.01$) than when social capital is low ($\beta = 0.22$, $t = 3.87$, $p < 0.05$), supporting *H5*.

Discussion

In this research, the authors developed and tested a conceptual model by investigating three aspects of intellectual capital on the generation and adoption of innovation. Few studies in the knowledge-based literature have investigated how different aspects of intellectual capital can affect whether or not a firm generates innovations or adopts innovations (Pérez-Luno *et al.*, 2014). Each aspect represents a distinct type of knowledge and each innovation outcome is affected by different kinds of knowledge. The study's findings suggest that chemical manufacturing firms acquire knowledge from different sources to generate and adopt innovations in their products and services.

The findings on innovation adoption are presented in Table III, which found that both social capital and organizational capital displayed significantly positive influences on innovation adoption. This suggests that knowledge preserved in physical repositories, in the form of databases, manuals and databases (Davenport and Prusak, 1998) has implications for the adoption of innovation. These outcomes are consistent with the prior research of Dewar and Dutton (1986), which found that the adoption of innovation is the outcome of modifications applied to available knowledge. The study shows that social capital, through individuals and their interrelationships, collaborative networks and partnerships, all have an impact on the adoption of innovation. Similarly, the effect of two-way interactions between social capital and organizational capital displays a positive correlation in Figure 2. This means that preserved knowledge becomes a more reliable and effective resource for innovation adoption when individuals discuss and interpret that knowledge with their networks and partners.

Contrary to this research's hypotheses, human capital did not reveal significant impact on the innovation generation. One possible explanation might be that individuals' skills, expertise and associated human capital are not favorable to innovation generation. However, the effect of two-way interactions between social capital and human capital had significantly positive results. This implies that when some individual experts work independently, they might not share their valuable ideas with colleagues, and this could be counterproductive for the organizations. This is consistent with results from prior research (Subramaniam and Youndt, 2005). Figure 3 shows more explicitly the two-way interactions between social capital and human

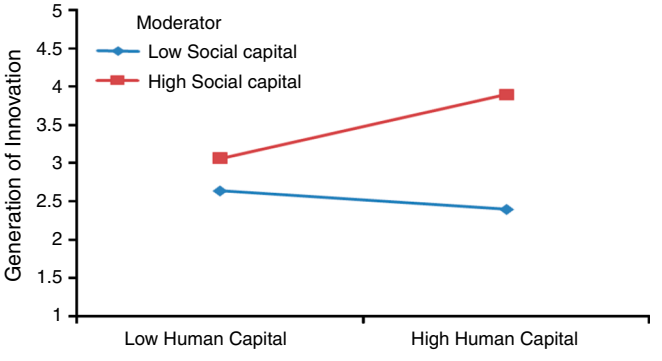

Figure 3.
Hypothesized interaction plot of social capital and human capital

capital, which implies that organizations generate innovations when their individual experts communicate, network and share knowledge with each other.

Social capital showed a significantly positive impact on both innovation generation and innovation adoption. These results validate findings from a study by O Reilly and Tushman (2004) and Subramaniam and Youndt (2005). The former took an in-depth look at the efforts of two companies to become "ambidextrous," which refers to the ability to apply both exploration and exploitation techniques at the same time. They identified proper efforts to build reliable social networks. The latter study found that social capital had a significant influence on incremental and radical innovative capabilities. Although the authors did not develop hypotheses for the control variables, but yet firm age displayed a significantly positive impact on the generation of innovation. It suggests that an organization's age would help innovation because: first, "new ideas are more efficiently assimilated if a solid base of knowledge has been established"; and second, "organizations with a larger knowledge base are more likely to pursue innovative opportunities that would further contribute to the accumulation of knowledge" (Cohen and Levinthal, 1990; Sørensen and Stuart, 2000). This research responded to a call from Subramaniam and Youndt (2005) to investigate how the structural, relational and cognitive dimensions of social capital could explain the "ambidextrous" impact of social capital that they discovered. This research also measured the impact of three different types of knowledge on innovation generation and adoption as proposed by Pérez-Luno *et al.* (2014).

Conclusions

This research measures the separate and interrelated influence of three aspects of intellectual capital – human, social and organizational capital on generation and adoption of innovation. The study provides empirical evidence that chemical producing firms generate and adopt innovations through applying different types of knowledge. Innovation-generating firms depend on the combination of new and existing knowledge, whereas, firms adopt the others innovation highly rely on the existing knowledge.

Paper's findings reveal that organizational capital and social capital has a significantly positive impact on innovation adoption. Social capital also exert positive impact on innovation generation. In contrast to study hypothesis, human capital exerts positive but insignificant impact on innovation generation. The moderating role of social capital positively and significantly strengthens the impact of organizational capital on innovation adoption. Similarly, moderation of social capital positively and significantly strengthens the impact of human capital on innovation generation. Overall, it can be said that all of the hypothesis are proved true except *H4*.

Limitations

Although this study's findings are useful and encouraging, there are some limitations and suggestions for future research. First, this research mainly focused on a single industry, which might affect the generalizability of the findings. Second, the present study tried to fill a knowledge gap that Pérez-Luno *et al.* (2014) alluded to, by investigating the impact of separate aspects of intellectual capital on innovation generation and adoption. Third, the present study did not offer a hypothesis for the impact of organizational age on the generation of innovation but results showed a significant impact.

Implications for practitioners and researchers

The findings of this research offer several important implications that not only contribute to the theories of knowledge-innovation and knowledge-management but could also be applied as useful guidelines for managerial practices. The theoretical contributions of this research are threefold: first, the findings of this research argue literature on innovation in general and generation and adoption of innovation in particular. The current literature is replete on innovation, but limited on the generation and adoption (Pérez-Luno *et al.*, 2014). This research has tried to fill this gap by examining the separate and interrelated impact of three aspects of intellectual on generation and adoption of innovation.

Second, besides its direct impact, social capital also played the moderating role between organizational capital and innovation adoption, human capital and innovation generation. This explains that preserved knowledge of a firm can best be utilized by interpreting, sharing and explaining it and applying it for adopting others innovation. On the other hand, social capital strengthened the impact, human capital had on generation of innovation. This explains that mere human capital of a firm might not be productive for generating innovations until they interact, network, share and discuss their knowledge with other colleagues within and outside the firm.

Third, this study's main contribution to the knowledge-based theory of the firm is by showing how organizational capital, human capital and social capital can be aligned to complement and supplement each other to facilitate the generation and adoption of innovation. This established stream of research consists of two studies in particular that are worth mentioning, the work of Subramaniam and Youndt (2005) and Pérez-Luño *et al.* (2011). In both studies, innovation is the outcome. The first one measures the influence of intellectual capital on different types of innovative capabilities, while the latter discusses the impact of entrepreneurial orientation on innovation generation and adoption. This research study further expands upon these two studies by measuring the impact of three aspects of intellectual capital on innovation generation and adoption.

The managerial of implications of this research are multifold: first, the findings assist in explaining how the value of organizational capital is linked to adoption of innovation, and how it is tied to the social capital of a firm. This explains that firms which tend to adopt the innovations of others need to invest in the systematic arrangements of their preserved knowledge and social capital in terms of giving space to members to network, interact, share knowledge and interpret knowledge preserved in the various locations of a firm. It can help managers to assess the knowledge at their disposal to use for adopting the innovations of the others.

Second, the social capital of a firm has emerged as an important antecedent of generation and adoption of innovation. This implies that firm's overall ability to share, leverage knowledge among and between networks of employees, customers, suppliers and alliance with partners' communication, networking, interactions and knowledge sharing facilitates the generation and adoption of innovation. The findings are consistent with the arguments of prior research on the "ambidextrous" effects of social capital (Tushman and O'Reilly, 1997; Subramaniam and Youndt, 2005). Besides its ambidextrous effects on generation and adoption of innovation, social capital also facilitates in shaping the firm's ability to build dynamic capabilities. Dynamic capabilities make firms to think beyond their competitive lens and offers firms new competitive advantage opportunities (Subramaniam and Youndt, 2005; Teece *et al.*, 1997; Coff and Blyler, 2003).

Third, in fact firm-specific human capital of a firm has displayed positive insignificant impact on the generation of innovation. The moderation of social capital strengthened the impact the firm-specific human capital had on innovation generation. This suggests that individuals and their associated firm-specific human capital are tied to the quality of communication, networking and knowledge sharing to accelerate innovation generation. Managers who intend to make their firms innovative and eager to gain competitively aggressiveness in the industry, then they need to utilize their employees who possess specific, routine and specialized knowledge, skills and abilities. These managers also require to provide/arrange adequate working conditions so that these individuals can interact, communicate, network and share knowledge within and outside firm boundaries. This as a result helps firms to create new knowledge by combining the existing and new knowledge. The study firmly believes that the promotion of the effective social capital environment within the firm can help firms to enhance the impact of human capital for innovation generation. Another important motivational factor which could help managers to engage their core knowledge employees in the knowledge sharing, networking and effective communication is offering them incentives. This can encourage them to share their ideas. Consistent with Subramaniam and Youndt (2005) that change occurs when individuals with knowledge, skills and abilities to work together and deliver pragmatic solutions to the challenging problems.

Fourth, the findings of this research, identify how direct and interrelated impact of three dimensions of intellectual capital affect innovation generation and adoption, and how such knowledge is derived from organization's intangible resources. Research emphasis on the interrelated effects of intellectual capital (St-Pierre and Audet, 2011). This has implications for modern managers to manage the knowledge that resides in different locations in the organization. It also helps in managerial ability to identify and utilize these intangible resources to enhance both innovation generation and innovation adoption.

Directions for future research

Future researchers could explore how different aspects of intellectual capital affect innovation generation and adoption in other industries and compare and contrast the findings. Moreover, in order to fully understand how such innovation is applied, future research could look into the impact of innovation generation and adoption on a firm's performance. It will be also worthy to investigate the interrelationships among firm age, size and innovation generation and adoption.

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