STRUCTURAL EMBEDDEDNESS OF ACCESSED NETWORKS AND INNOVATION AT WORK

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ABSTRACT

Purpose – *Structural embeddedness of social networks within and beyond work organizations has shown its association with the innovation at work for employees from literature. Structural embeddedness includes three dimensions: the diversity, density, and trust of accessed networks. This chapter attempts to compare how structural embeddedness mechanizes on innovation at work differently for employees in hi-tech and non-hi-tech sectors.*

Methodology/approach – *We analyzed 1,817 cases of currently employed respondents from the 2005 Taiwan national survey on social capital. All the indicators on structural embeddedness are operationalized from position-generated networks, and we performed regression models for total, hi-tech, and non-hi-tech samples.*

Findings – *Except the universal effects of diversity on innovation at work for employees in both hi-tech and non-hi-tech sectors, density and trust of accessed networks significantly affect innovation at work only for employees in non-hi-tech sectors. There is a slight interaction effect*

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between trust and density on innovation at workplaces. Those individuals with high-degree trust in accessed networks tend to have a lower degree of innovation while their network density is high. It implies that complementary networks seem to be more useful for applying new ideas at the workplace for non-hi-tech workers.

Originality/value of *chapter– This chapter contributes to the literature by presenting the importance of structural embeddedness of accessed social networks for innovation at work.*

Keywords: Position-generated networks; structural embeddedness; diversity; density; trust; innovation at work

INTRODUCTION

Hi-tech industries face fierce global competition and the challenge of upgrading industrial technologies. In order to deal with highly uncertain markets, firms perceive individuals' ability for innovation at work as an important intellectual asset. In Taiwan workers in both the hi-tech and non-hi-tech sectors have been asked to increase their innovative abilities. Many hi-tech firms have been promoting knowledge management ideology as a dominant belief in which knowledge sharing and product innovation in the work process are highly valued. In non-hi-tech small- and medium-sized firms, the shared beliefs of flexibility in the division of labor and learning by doing have also encouraged individuals to input new ideas for solving problems at work. Today the shared belief that workers with more innovative abilities can increase individuals' and organizations' intellectual assets is prevalent.

The intellectual assets of individuals and firms have been conceived as essential components of organizational innovation. The theory of intellectual capital asserts that innovation and learning abilities are corporate competitive advantages (Nahapiet & Ghoshal, 1998; Tsai & Ghoshal, 1998). To explain the formation of innovation, management scientists have proposed the theory of knowledge community and the mechanisms that affect knowledge sharing and knowledge creation within the firm, structural characteristics of cross-division networks, shared visions, and trust between divisions.

Are closed or open networks more advantageous for innovations? One contention is that the closure of individual networks reinforces the

reciprocity of interactions and the norm of trust (Coleman, 1988). In this structural context, network members are more likely to exchange tacit knowledge and develop innovative ideas to solve problems at work. The other argument is that individuals located in network positions with more structural holes are more likely to create better ideas (Burt, 2004). However, Burt (2001) also finds that combinations of trust and structural holes within or between the divisions of organizations have different effects on performance in the workplace.

The diversity of accessed social capital affects status attainment and work performance as well (Lin & Dumin, 1986; Lin, Fu, & Hsung, 2001), but its relation with innovative ability in the workplace has not been examined. We explore the effects of three dimensions of embedded social capital – extensity, trust, and density of position-generated networks – on innovative ideas and acts at work using 1,817 currently employed respondents from national survey data on social capital.

INNOVATION AT WORK

Innovation at work is the action of providing new ideas and acts to solve problems. Workers with the ability to apply new ideas and acts at work can more effectively and efficiently provide new ideas and actions to solve workplace problems. The more innovations at work they create, the more contributions they make to the organization. According to Subramaniam and Youndt (2005), innovational ability at work can be defined as identifying and using opportunities to create new products, services, or work practices. Individuals who apply new ideas and acts more frequently also cumulate more tacit knowledge for solving problems and therefore possess more individual intellectual assets; consequently, as we will see, they increase the collective assets of their organizations.

We often confuse the words "creativity" and "innovation." From a psychological perspective, creativity is a personal trait, while innovations are the social acts that are often constructed through exchanging or recombining different ideas in the work process to produce new ideas for solving problems. Schumpeter (1934) and Moran and Ghoshal (1996) point out that knowledge is created through two generic processes: recombination and exchange. Marshall (1965) agrees that knowledge diffusion and creation can be affected by organizational design, and he also indicates that knowledge is the most powerful engine of production. Tsai and Ghoshal (1998) examine the differential knowledge transfer and creation that cross different divisions

within organizations, and find that the linking capability and absorbability of knowledge are critical for knowledge creation. If the organizational design for knowledge transfer among different divisions is effective and efficient and different divisions can also efficiently absorb new knowledge, then the divisions and the individual are more likely to create new knowledge. That is, innovative acts at work are often learned in the work environment through cross-division networks. For this reason innovation at work is not an individual psychological creativity or trait, but a process of social construction.

Recombining ideas that cross different boundaries and times is an important mechanism of innovation. Uzzi and Spiro (2005) claim that there is no innovation that is completely new. In another words, ideas often have path-dependence effects, which is the repeated or cumulated knowledge from the past. Hargadon and Sutton (1997) point out that innovative ideas come from recombining cross-boundary ideas. For example, a product design firm's idea for a water bottle valve came from another designer who had worked on a previous shampoo bottle project. The requirement of innovational ability for engineers includes the engineer's ability to recombine cross-boundary knowledge for potential solutions through past and ongoing relations. For example, Thomas Edison is the most important inventor in history. He collaborated with his colleagues to recombine and transfer knowledge of different industries such as telegraph, lighting (Hughes, 1989; Millard, 1990).

Knowledge management recently became the dominant ideology of management science. The major goal of knowledge management is to build a social environment that is beneficial for knowledge sharing and knowledge creation. Knowledge management scientists believe that the capability of knowledge creation will be the most important competence that is not the zero-sum game. The more diversified exchange of ideas that employees have, the larger the total sum of knowledge creation or intellectual capital. The major strategy for facilitating the knowledge creation capability of a firm is to build up the knowledge community, which requires an advantageous network structure. From the perspective of knowledge management, the firm is conceived as "a social community specializing in the speed and efficiency in the creation and transfer of knowledge" (Kogut & Zander, 1996, p. 503). How efficiently knowledge is created or transmitted largely relies on patterns of social networking among different divisions within a firm.

Taiwan has been involved in the international trade and global market, and industrial organization is incorporated into the global value-added chain. Firms compete for upgrading their position and value addition in the

global commodity chain. Taiwan business was incorporated into this commodity chain during the 1980s for non-hi-tech firms. The high-tech firms were founded in the 1980s and grew rapidly during the 1990s. Different firms had different strategies for locating their companies in different positions on these chains. Generally, the path of industrial upgrading or division of labor in these chains moves from original equipment manufacturer (OEM) to original design manufacturer (ODM) to own branding and manufacturing (OBM). In Taiwan most industrial firms are either OEM or ODM firms. Most hi-tech firms generally have the capability of doing research and development, so they are often ODM firms. Most non-hi-tech firms have manufacturing capability with quality control certification and less capability for research and development, so they are often OEM firms. OEM firms originally manufacture the product, and the products (or components) are purchased by another company or retailed under other company's brand name. An ODM company designs and manufactures a product with another's firm's brand.

Most non-hi-tech firms are OEM firms that take orders from global buyers and producers. The main requirement of OEM firms and workers is to replicate or learn the manufacturing process from global buyers or producers. In contrast, most hi-tech firms try to catch up to the ODM position on the global commodity chains. Global producers expect hi-tech firms in Taiwan with innovational capability to design a manufacturing process once they have obtained a contract from global producers. ODM firms catch up and surpass their global producers in the design of the manufacturing process. In these firms workers are expected to have better innovational ability, and firms put more emphasis on job training and knowledge sharing and creation.

Recently scholars observed that the form of Taiwan's "global factory" model constrained innovation. Although OEM/ODM arrangements have helped Taiwanese firms import advanced technology from foreign customers or more advanced competitors. Through learning and improving the technology from the first-move country, late-developing Taiwanese firms saved the cost of radical innovations. Radical innovation used to be a breakthrough innovation in the early stage of a first-move company, and is characterized by a high level of uncertainty. Most firms in Taiwan prefer to utilize existing interfirm connections of the global economy to learn and improve on transferred knowledge. Taiwanese firms thus typically concentrate on incremental innovations within existing product architectures that are defined by global brand leaders; this incremental innovation is associated with dense networks and trust relations.

STRUCTURAL EMBEDDEDNESS OF SOCIAL CAPITAL AND INNOVATION

Granovetter (1985) first proposed the idea of structural embeddedness in economic action. Structural embeddedness is defined as the extent to which a "dyad's mutual contacts are connected to one another" (Granovetter, 1992, p. 35). This definition focuses on the actors' immediate network of contacts. The structural embeddedness of social capital and innovation includes three dimensions: diversity, density, and trust. The literature reviews on these three dimensions and their association with innovation at work are presented in the following sections.

Diversity of Accessed Social Capital and Innovation

Social capital has been conceptualized as the diversity of accessed contacts and social resources for individuals (Lin & Dumin, 1986; Lin et al., 2001). The definition of social capital focuses on the relation between individual assets of accessed networks and its return (e.g., status attainment and mobility); diversity of social capital is defined as a series of resources that are accessible through contacts that people are aware of (Erickson, 1996, 2001, 2004; Lin & Dumin, 1986). Variety of social capital is often measured by the extensiveness of networks, highest prestige of accessible positions, and range between the highest and lowest occupational position (Flap & Boxman, 2001; Lin et al., 2001). The effect of variety of social capital on the return of instrumental actions has been widely tested in different industries (Erickson, 2001; Hsung & Breiger, 2009) and different countries. Managers in the security industry require more social capital, and diversity of social capital especially benefits these managers (Erickson, 2001). Managers in the fields of sales and service require more social capital than those in the field of production (Burt, 1997). Hsung and Breiger (2009) found that the variety of social capital is associated with better income returns for human resource managers. However, all the literature on the variety of social capital and its returns seems to ignore the function of diversity of accessed networks in innovation at work.

Diversity of social capital through accessing different people, organizations, and industries is beneficial for idea creation or product innovation. New ideas are often recombined from different groups of ideas through diversified networks. The association between innovational ability and social capital seems to be dynamically interdependent. Fu and Hsung (2013)

found that applying new ideas in problem solving at work facilitated the creation of diversified social capital. Innovation at work requires workers to share ideas with coworkers, clients, and others in order to recombine ideas from different groups of people. This process of recombining ideas from different groups reproduces more diversified social capital as well.

We propose the following hypothesis according to the above-mentioned literature and empirical findings.

H1. Individuals embedded in accessed networks with greater diversity are more likely to create new ideas at work.

Density of Networks and Innovation

There are two approaches to network density and innovation. One approach stresses that closed networks (high density of social networks) can facilitate and monitor the learning performance of children at school (Coleman, 1988). In Coleman's view, these high-density or closed networks create the obligation to learn at school and social control of network members' misbehavior. Once a positive learning culture has become the obligation norm of mutual reciprocity for exchanging knowledge, constructed nonwritten collective binding contracts control the learning behavior of network members. Consequently, members in such closed networks tend to learn and create more knowledge.

The other perspective is that individuals located in network positions with more disconnected network members or less density among their network members are more likely to create good ideas (Burt, 2004). Information diffusion among divisions is more efficient through weak ties or in networks with more structural holes (Burt, 1992, 1997, 1998; Nonaka & Takeuchi, 1995). Knowledge can generally be classified into explicit and tacit knowledge (Polanyi, 1958). Tacit knowledge is exchanged mainly through strong ties and dense networks; however, explicit knowledge or information can be easily diffused through weak ties and networks with more structural holes.

In a rapidly changing competitive environment, economic actors or workers with brokerage position in loosely connected networks tend to solve problems more efficiently and effectively (Burt, 1992, 2005). These individuals with more nonredundant social circles are more likely to produce new ideas through the selection and synthesis of more diversified knowledge. There are many empirical studies that support the arguments on the individual position of structural holes in whole networks and

innovations in the workplace. Ancona and Caldwell (1992) provide empirical evidence using 409 individuals from forty-five new-product teams in five high-technology companies. They evaluate a team composed of people with diverse functions as the best team for innovation because they had more new alternatives and faster access to more diverse information than a team composed of people with a single function. Reagans and Zuckerman (2001) studied performance in 223 corporate R&D units within twenty-nine major American firms in eight industries. They found that teams of scientists from different cohorts produced more output.

The brokerage role connecting loose but diversified networks is often associated with a high level of innovation and learning capability at workplaces. A broker can break prescribed routines and search for better strategies to solve problems at work (Marsden & Gorman, 1999); they are therefore more likely to fill uncertain jobs that involve complex work and require creative thinking. Flap and Boxman (2001) showed that employers prefer to recruit college graduates with more diversified social capital for their first full-time job, and are able to easily train them to learn a variety of social skills and coordination ability. Hansen, Podolny, and Pfeffer (2001) found that new product teams in a leading electronics firm that were composed of people with more nonredundant contacts beyond the team completed their assigned task more quickly. Burt (2004) also found that managers' networks that crossed diversified or nonredundant social circles were more competitive because this helped create good ideas about solving problems at work (Burt, 2004).

Burt (2004) theorized that individuals located in positions with more structural holes in their networks are more likely to have better ideas. Those with more holes in their networks are more likely to play brokerage roles. As the broker between two disconnected groups, the individual often looks for differences between themselves and others to justify their assertions. Brokerage facilitates the synthesis of different ideas. People familiar with the activities in two groups are more likely to see new beliefs or behaviors that combine elements from both groups, and are therefore more likely to create new ideas at work.

In fact, the structural holes theory on innovation did not find consistent empirical evidence in Chinese societies. Xiao and Tsui (2007) studied the effect of structural holes in four high-tech companies in China. The Chinese culture values high commitment and mutual reciprocity in the organization. In such Chinese organizations, structural holes are detrimental to employees' career achievements. Similarly, Guan, Hsung, and Lin (2012) also found that structural holes had negative effects on the impact of

inventors' patents in the Taiwanese semiconductor industry. With more focus on the function of network density in the historical and culture contexts of Taiwan, we propose the following hypothesis on the association of network density and innovation.

H2. Individuals embedded in accessed networks with higher density are more likely to create new ideas at work.

Trust and Innovation

The trust relation is embedded in social interactions and varies with the characteristics of social networks. Coleman defines the trust norm as constructed by a system of continuous exchange behavior of all two-party pairs in a network (1990). Once the trust norm is constructed it becomes a collective asset for network members. As a consequence, the members of an individual's network whose members know each other tend to be more likely to trust one another.

The literature on innovation in a knowledge community conceives trust relations that cross different people, divisions, and firms as a collective asset of a community. Granovetter (1985) was a pioneer in defining trust relations, and presented a theoretical elaboration on the embeddedness of economic actions. Trust relations embedded in repeated and reciprocal long-term relations are commonly found in economic transactions because trust relations can avoid cheating. The cost becomes low once the trust relation has been built up.

There are two dominant lines of thought in the literature on trust relation and innovation. One states that the trust relationship among different firms in an industry facilitates performance of a firm (Uzzi, 1996, 1999). Trust relations – repeated transactions – between customers and manufacturers or banks and firms in the past easily trigger commitment. These reciprocal long-term exchanges strengthen the trust relations that cross organizations. In empirical findings the effects of trust relations and economic actions are nonlinear; the optimum degree of trust relations in a firm is the best strategy for survival in the market (Uzzi, 1996, 1999). Uzzi (1999) also proposed the concept of complementary networks that mix embedded ties and arm-length ties. Firms often build up multidimensional networks, and the mix of different characteristics in different dimensional networks can complement the limitations of embedded networks. Firms that have interorganizational networks composed of a complementary mix of ties optimize the benefits

of embeddedness. There has been no research to date that examines the function of complementary networks on individuals' accessed networks at the workplace.

The other line of thought is the association between trust relationships among different persons or divisions within a firm and innovation. These repeated exchange relations often occur in workplaces and become social capital for knowledge sharing and knowledge creation. Krackhardt (1992) stressed the outcome of philo or strong-ties relations in the workplace. Strong-tie relations connect people who interact and create collective sentiments. These collective sentiments with the obligation to commit to collective goals can cause ego and related alters to commit to a relationship before they know how the other person will behave in the workplace, especially committing to inputting new ideas for problem solving.

Trust norms among different divisions within a firm produce an efficient social community that specializes in speed and efficiency in the creation and transfer of knowledge (Ghoshal & Moran, 1996; Tsai & Ghoshal, 1998). Empirical findings on the relation between trust and knowledge creation have been supported by studies of firms in Taiwan (Tsai, 2000, 2001). The strategic position of interdivision networks within the firm determines the effectiveness and efficiency of knowledge exchanges and knowledge creation (Tsai, 2000, 2001). Tsai (2001) found the core position has a better linking capability in intraorganizational networks. The linking capability is the ability of an actor (or organizational division) to utilize its strategic linkages to access and transfer strategic resources from other actors. The most central position in intraorgnizational networks is a more strategic position that is more accessible to all other divisions and has better linking ability. The core position in intraorganizational networks also plays the role of brokerage. The primary brokerage position is the center and bridge of knowledge exchange and sharing; this position is thus the most innovative position in intraorganizational networks.

Trust is good for innovation, especially for tacit knowledge exchange. As data from a large multinational electronics company in Taiwan show, mutual trust and social interactions among different divisions are highly related to the extent of interunit resource exchanges, which in turn significantly affect product innovation (Tsai, 2001; Tsai & Ghoshal, 1998). Trust relations between or within firms appear to be important for collaborations and innovations. We thus propose the following hypothesis:

H3. Individuals embedded in accessed networks with a high degree of trust in their network members are more likely to create ideas at work.

Are complementary networks of individual-accessed networks still appropriate for explaining individuals' economic behavior, such as innovation at work? Individuals' networks that integrate repeated ties and trustable relations, and less-dense networks may benefit innovation at work. Trustable relations with network members facilitate tacit knowledge sharing, and combining with less-dense networks brings more benefits than combining with highly dense networks. Less-dense networks promote information exchange and diffusion more efficiently.

When Western theory meets Taiwanese society, the networking strategies of operating social capital are influenced by their own culture. In Taiwan, a collectivist society, sharing and creating knowledge requires trust norms with embedded long-term reciprocal relations. Small- and medium-sized businesses depend on these flexible collaborations with implicit rules of trust. The person who can contribute new ideas at work shows that he/she not only has the ability to think innovatively but can also implement his or her ideas at work. In order to think of and practice applying new ideas and actions appropriately in more flexible networks within and outside small- and medium-sized firms, the optimum networking combinations should include both trustable relations for mutual commitment to contributing new ideas and actions and less-dense networks with some structural holes to effectively gain and diffuse information for knowledge creation. We thus add a complementary hypothesis as follows:

H3-1. Individuals embedded in complementary networks with a high degree of trust in their network members in less-dense networks are more likely to create new ideas at work.

The trust relationship is essential for building an effective knowledge community. In Taiwan the efficiency of knowledge transfer and knowledge creation in a large firm is mainly determined by trust relations among divisions (Tsai & Ghoshal, 1998). Similarly, small- and medium-sized firms in Taiwan depend on a variety of contracts from global companies and must effectively and efficiently coordinate supply chains. The pseudofamily or closed networks in these large local supply-chain networks among firms and within the firm facilitate innovational capability or problem-solving ability in the workplace (Chen, 1994). After considering the literature on social networks and economic action in Taiwan, we advocate that the above-mentioned hypotheses will be supported more for employees in non-hi-tech sectors.

DATA AND MEASURES

Data in this study were drawn from the research project "Social Capital: Its Origins and Consequences" sponsored by Academia Sinica in Taiwan. This chapter used the first wave survey data from 2004–2005. These data are national representative samples of respondents aged 21–64. This study includes only 2,407 respondents who were employed during the survey period. After filtering missing data in the variables, we used 1,817 cases for statistical analyses.[1] A detailed description of dependent variables, independent variables, and controlling variables is presented in Table 1.

Table 1 presents the descriptive statistics of the variables by technology sector. The classification of technology sector is based on the following question: "[Does/did] the company (organization) you work[ed] for belong to a hi-tech sector?" "Yes" was coded as 1 and "No" was coded as 0. Table 1 also presents the means, standard deviations, and significance of differences on variables of innovation at work, social capital, social environment at work, individual characteristics, organizational characteristics, and work characteristics in both the hi-tech and non-hi-tech sectors.

Innovation at Work

In this study we used one item to indicate innovation at work. The question on the survey regarding innovation at work was: "How often [do/did] you apply new ideas or actions at work?" The values of the frequency were (4) frequently, (3) occasionally, (2) seldom and (1) almost never or never. Respondents in the hi-tech sector tended to apply new ideas at work more frequently (3.19) than those in the non-hi-tech sector (2.83).

Social Capital

All variables on structural embeddedness of social capital were measured by the items on position-generated networks. The key position-generator question was: "I am going to ask some general questions about jobs some people you know may *now* have. These people include your relatives, friends, and acquaintances (acquaintances are people who know each other by face and name). If there are several people you know who have that kind of job, please tell me the one that occurs to you first." Twenty-two occupations in Taiwan were selected to represent different levels of

Table 1. Description of Variables of Individual Characteristics, Organizational Characteristics, Social Capital, Social Environment at Work, and Work Nature for those Employed in Hi-tech and Non-Hi-tech Sectors ($N = 1{,}817$).

	Hi-Tech Sector (304)	Non-Hi-Tech Sector (1513)	Sig.
New ideas at work	3.19 (.87)	2.83 (1.02)	***
Social capital			
Variety of accessed positions	10.65 (4.79)	9.96 (5.00)	*
% of accessed positions through kin	17.80 (18.40)	20.03 (20.30)	
% of accessed positions through colleagues	22.95 (23.10)	12.95 (19.08)	***
Density			
Low density	10.86	20.09	***
Middle density	70.39	63.38	
High density	18.75	16.52	
Trust	(100%)	(100%)	
Low trust	34.87	34.63	
Middle trust	51.32	49.37	
High trust	13.82	15.99	
Individual characteristics			
Gender (male) %	71.05	56.58	***
Marital status (married) %	58.55	66.49	**
Years of education	14.07 (2.96)	12.91 (3.34)	***
Age	36.05 (9.64)	38.30 (10.11)	***
Organizational characteristics			
Size (≥ 100) %	67.43	33.84	***
Size	306.73 (201.47)	156.98 (187.87)	***
Primary industries %	0.66	2.78	***
Secondary industries %	66.45	32.67	
Commerce %	21.71	36.77	
Service %	11.18	27.78	
Work characteristics			
Frequency of contacts demanded by job	2.99 (1.18)	2.77 (1.24)	**
Information more from inside the firm %	57.89	46.73	***
Information from inside and outside equally	27.96	27.17	
Information more from outside	11.84	17.60	
No need/no source of information	2.30	8.50	

Table 1. (*Continued*)

	Hi-Tech Sector (304)	Non-Hi-Tech Sector (1513)	Sig.
Discussions more inside the firm %	75.66	70.86	**
Discussions inside and outside equally	17.11	18.17	
Discussions more outside the firm	6.25	5.59	
No need/no source of discussion	.99	5.38	
Training	25.49 (31.88)	20.46 (28.03)	**
Job tenure	7.21 (8.41)	8.03 (8.42)	
Occupational prestige	48.41 (10.40)	41.88 (12.74)	***

Note: ( ) indicates standard deviation.
$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$.

occupational prestige; this study follows the Standard International Occupational Prestige Scale (SIOPS) constructed by Ganzeboom and Treiman (1996). The sampled occupations were divided into three hierarchical groups: upper class (e.g., professor (78), lawyer (73), CEO of a large company (70), and congressmen (64)); middle class (e.g., middle school teacher (60), personnel manager (60), production manager (60), writer (58), nurse (54), administrative assistant in a large company (53), computer programmer (51), bookkeeper (45), and policeman (40)); and lower class (e.g., receptionist (38), operator in a factory (36), hairdresser (32), taxi driver (31), security guard (25), janitor (22), and hotel bellboy (20)).

There are five variables on social capital in Table 1. The diversity of social capital was measured by summing 22 positions that respondents accessed (yes = 1, no = 0). The total number of accessed positions indicates the diversity of access to social capital. Compared to those in the non-hi-tech sector who accessed 9.96 positions, the respondents in the hi-tech sector accessed 10.65 positions on average. There was only a small difference in the percentage of position-generated network members accessed through kin ($p = .077$) by respondents between the hi-tech and non-hi-tech sectors. Non-hi-tech respondents had more accessed positions through kin. In contrast, respondents from hi-tech industries had a significantly higher percentage of accessed positions through their colleagues than those who were in the non-hi-tech sector.

The degree of acquaintance density among network members was also divided into three categories: low, middle, and high. The density of position-generated networks was measured by the question: "Among the people you mentioned above, how many know each other?" The response

categories were (5) they all know each other, (4) most of them know each other, (3) about half of them know each other, (2) only a few of them know each other, and (1) none of them know each other. We recoded (5) and (4) into high, (3) and (2) into medium, and (1) into low degree of density. The differences among these three groups of density in the hi-tech and non-hi-tech sectors were very significant. The percentage of low density in the hi-tech sector was much lower than those in the non-hi-tech sector. The percentages in the groups of medium and high density for respondents in the hi-tech sector were higher than those in the non-hi-tech sector. The possibility that members in social networks of the respondents know each other was higher in the hi-tech sector than in the non-hi-tech sector.

We determined that the association between trust and innovation at work was not linear; using a categorical variable can better illustrate this fact. We used trust and density to identify the structural embeddedness of social capital. Three levels of trust (low, middle, and high) were classified by the perception of degree of trustworthiness among network members. The degree of trustworthiness of members of position-generated networks was measured by the following question: "Among the people you mentioned above, how many can be trusted? (5) All of them can be trusted, (4) Most of them can be trusted, (3) Some of them can be trusted, (2) Most of them cannot be trusted, (1) None of them can be trusted." We recoded (5) as high, (4) as middle, and (3), (2), and (1) as low degree of trust. There was no difference among the three levels of degree of trustworthiness for employees in either the hi-tech sector or the non-hi-tech sector. Evidently, trust is an essential networking principle in Taiwanese society, regardless of the type of sector.

Individual and Organizational Characteristics

The survey respondents from the hi-tech sector had a greater proportion of males, a lower proportion of being married, greater number of years of education, and were younger in age. The size of the work organization was measured by the following question: "About how many people work[ed] for this company (organization)?" The response categories were (1) 1–9, (2) 10–24, (3) 25–99, (4) 100–499, and (5) 500 and above. The response categories of firm size only showed the range of each category, so we transformed each ordinal category by the mid-point of that range. We also recoded firm size categories into two types in order to distinguish small- and medium-sized firms and large firms: (1) firm size is equal to or greater than

100 and (2) firm size is less than 100. The majority of respondents from the hi-tech sector worked in firms with more than 100 employees (67.43 percent) and in the secondary industry (66.45 percent). The size of hi-tech firms was significantly larger than those in the non-hi-tech sector.

The original industries were regrouped into four categories: primary, secondary, commerce, and service industry. The primary industry included agricultural and mining industries. The secondary industry included manufacturing and construction industries. The commerce industry included commerce, transportation, communication, and financial and insurance industries. The service industry included public, social, and personal service industries.

Work Characteristics

The work environment[2] and work characteristics of employees vary in the hi-tech sector and the non-hi-tech sector. Some jobs require employees to make contact with other people; we thus queried how frequently respondents needed to contact other people at work. The answer was coded as (4) frequently, (3) occasionally, (2) seldom, and (1) almost never. Respondents needed to contact other people for business reasons more frequently in the hi-tech sector (2.99) than in the non-hi-tech sector (2.77). In this survey jobs in the hi-tech sector appear to require workers to contact people more frequently.

The literature on innovation at work also suggests that information exchange and discussion inside and outside organizations became an important issue in organizational innovation. The design of the following two questions is quite similar. One question asked: "How much work-related knowledge or skills, when needed, can you get from within the company (organization)? How much from outside the company (organization)?" The second question asked: "Among the people with whom you discuss work-related issues, how many of them are from within the company (organization)? How many are from outside the company (organization)?" The answers for these two questions were the same: (1) almost all of them are from within the company (organization), (2) most of them are from within the company (organization), (3) half of them are from within the company (organization) and half of them from outside the company (organization), (4) most of them are from outside the company (organization), (5) almost all of them are from outside the company (organization), (6) I do not need work-related knowledge or skills (or do not need to discuss work-related

issues with people), and (7) I need work-related knowledge or skills but cannot find it. These seven categories were recoded into four types in Table 1: information (discussion) more inside the organization, information (discussion) from inside and outside the organization equally, and information (discussion) more from outside the organization, no need/source of information (discussion). Then, we define type of information (discussion) more inside the organization as 1 of the dummy variable and the other types as 0 in the statistical models in Table 2. The respondents in the hi-tech sector tended to exchange information and have more discussions inside than outside the firm compared to those in the non-hi-tech sector.

Number of years of specialized job training was measured by the following question: "Besides the education obtained from school, how much specialized training do you think is required to be qualified for your job?" The answers were (0) I do not need special training, (1) less than 1 week, (2) less than 1 month, (3) less than 1 year, (4) 1–3 years, (5) 3–10 years, and (6) more than 10 years. We transformed each category into an interval scale by using the mean as the years of job training. The respondents in the hi-tech sector had significantly longer job training (25.49 months) than those in the non-hi-tech sector (20.46 months). Job tenure was lower but not significant for hi-tech employees (7.21 years) compared to non-hi-tech employees (8.03 years). As for occupational prestige, respondents in the hi-tech sector had a significantly higher score (48.81) than those in the non-hi-tech sector (41.88), as expected.

Effects of Social Capital on Innovation at Work

Table 2 presents six models for examining the effects of three-dimensional characteristics of social capital on innovative ideas and acts at work. The total samples of Model 1 and Model 2 both are 1,817 cases. Model 1 includes the variety of accessed positions, trust, density, and the percentage of accessed positions through kin and through work. We also found a slightly negative interaction between high density and high trust (Fig. 1). The variety of social capital positively affects the frequency of innovative ideas and acts. Compared to the medium level of density of individuals' networks, networks with high or low density have no effect on innovation at work without controlling any other variables. Individuals with a low degree of trust in network members are more likely to apply new ideas and actions at work in contrast to those with a medium degree in network members. There is no significant difference of innovation at work between individuals

Table 2. Regression Models of Innovative Ideas at Work (OLS Models).

			High-Tech		Non-High-Tech	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Social capital						
Variety of accessed positions	.059***	.033***	.047***	.029*	.059***	.035***
	(.005)	(.005)	(.011)	(.012)	(.006)	(.006)
% of positions accessed through kin	−.003**	−.001	−.003	.001	−.003*	−.001
	(.001)	(.001)	(.003)	(.003)	(.001)	(.001)
% of positions accessed through work	.002	.000	−.001	−.000	.001	.001
	(.001)	(.001)	(.002)	(.002)	(.001)	(.001)
Low density	−.091	−.019	−.149	−.127	−.071	−.002
	(.063)	(.058)	(.166)	(.160)	(.068)	(.063)
High density	.077	.153*	.081	−.010	.087	.208**
	(.071)	(.065)	(.145)	(.143)	(.080)	(.074)
Low trust	−.212***	−.114*	−.237*	−.160	−.204***	−.109*
	(.050)	(.046)	(.106)	(.104)	(.056)	(.051)
High trust	.057	.105	−.026	−.002	.077	.129
	(.075)	(.069)	(.176)	(.177)	(.083)	(.076)
High density * high trust	−.236	−.181	.339	.291	−.366*	−.278
	(.145)	(.133)	(.309)	(.298)	(.162)	(.149)
Controlling variables						
Individual characteristics						
Gender		.137**		.178		.138**
		(.044)		(.107)		(.048)
Marital status		.027		−.005		.030
		(.055)		(.122)		(.062)
Years of education		.022*		.051*		.018
		(.009)		(.021)		(.010)
Age		.019		.062		.013
		(.017)		(.042)		(.018)
Age2		−.000*		−.001		−.000
		(.000)		(.001)		(.000)

Organizational characteristics						
Hi-tech sector (=1)		.227***				
		(.060)				
Scale of organization (log)		−.023		−.017		−.028
		(.014)		(.038)		(.015)
Primary industries (con=commerce)		−.086		−.351		−.042
		(.141)		(.635)		(.147)
Secondary industries		−.013		.021		−.026
		(.053)		(.125)		(.059)
Service industries		.194***		−.024		.209***
		(.057)		(.174)		(.061)
Work characteristics						
Frequency of contacts demanded by job		.142***		.074		.153***
		(.019)		(.050)		(.021)
Information more inside the firm		−.150***		−.080		−.157**
		(.046)		(.115)		(.051)
Discussions more inside the firm		−.011		−.218		.014
		(.050)		(.132)		(.055)
Months of training		.005***		.004*		.005***
		(.001)		(.002)		(.001)
Job tenure		.009**		.007		.009**
		(.003)		(.008)		(.003)
Occupational orestige		.009***		−.003		.011***
		(.002)		(.005)		(.002)
Constant	2.411***	1.263***	2.841***	1.117	2.358***	1.307***
	(.079)	(.331)	(.181)	(.837)	(.087)	(.365)
N	1817	1817	304	304	1513	1513
Degree of freedom	8	24	8	23	8	23
Adjusted R^2	.106	.261	.085	.185	.104	.258

*$p<.05$, **$p<.01$, ***$p<.001$.

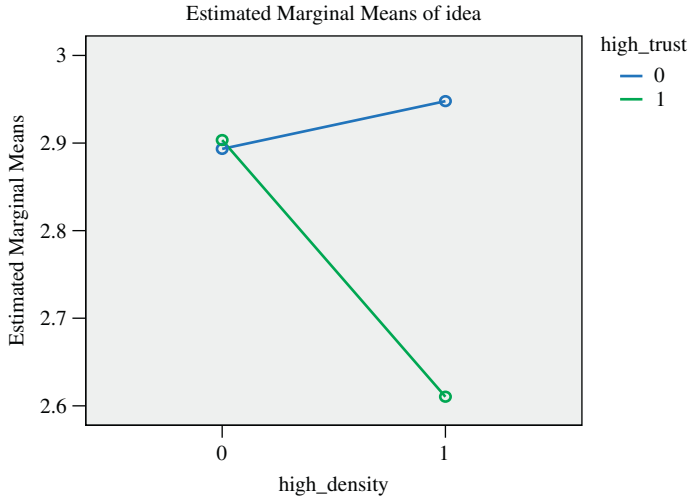

Fig. 1. Estimates of Interaction of High Density and High Trust in Accessed Networks.

with high and medium degrees of trust. The effect of the percentage of accessed positions through kin is negative on innovation at work; the effect of the percentage of accessed positions through colleagues is not significant on innovation at work.

Model 2 includes social capital and individual and work characteristic variables; adjusted R^2 increased from .106 to .261. Apparently an individual with characteristics of higher frequency of making contact with other people at work, acquiring information more from outside the firm, being male, having a higher education, working in a hi-tech or service sector, having a job that requires longer training, longer tenure, and higher occupational prestige tends to apply ideas and actions at work more frequently. After incorporating the control variables of individual, organizational, and work characteristics, the effect of high density becomes significant.[3] The effect of degree of trust in network members on innovation at work is still nonlinear after controlling individual, organizational, and work characteristics.

We now present Model 3 and Model 4 for employees in hi-tech sectors (304 cases), and Model 5 and Model 6 for employees in non-hi-tech sectors (1513 cases). Model 3 presents the stable effects from the variety of accessed positions (+) and low trust (−). But the effect of percentage of accessed positions through kin is no longer significant. In Model 4, after controlling all other variables, only education and duration of training have significant

net effects on innovation at work. Evidently human capital is the most important for innovation at work, and social capital is not the factor to determine variation in applying new ideas and acts at work.

In fact, the non-hi-tech respondents made the most contributions in the models of the entire sample. The patterns look alike for the total sample and the non-hi-tech sample. The significance of the interaction item in Model 5 indicates that individuals with accessed networks of high density and high trust tend to have a lower degree of innovation at work compared to those with high trust and lower density. Trust does matter for innovation. An optimum degree of trust seems to be more beneficial to innovation. Model 6 shows that a variety of accessed positions, high density, and high trust have a positive effect on innovation at work. The interaction of high density and high trust has a slight negative effect on innovation at work. Frequency of contact demanded by the job has a positive effect on innovation at work, and information exchange occurring more inside the firm has a negative effect on innovation at work. This means that innovation at work is associated with more information exchange outside the firm. Diversified information and resources from heterogeneous social circles outside the work field are beneficial for employees in non-hi-tech sectors. Individuals who are male, are in service industries, serve more years in a specialized job, have longer job tenure, and have higher occupational prestige still have strong positive effects on innovation at work.

In sum, Table 2 points out that variety of accessed positions is a very stable and robust social capital for innovation at work. In contrast to a middle degree of trust, low trust is disadvantageous to innovation at work. Therefore we can see that trust appears to be the foundation of innovation in Taiwanese society. Although the interaction between density among members of accessed networks and degree of trust in network members is only slightly significant ($P = .06$) for non-hi-tech sector employees, the result deserves to be further elaborated. Individuals with a high degree of trust in their accessed network members in highly dense networks tend to have a lower degree of innovation at work compared to those in less-dense networks in both Model 1 and Model 6. This result implies that mixing optimum network combinations appears to be an important strategy for creating ideas at work.

CONCLUSIONS AND DISCUSSION

Along with the globalization of manufacturing and rapid development of technology, knowledge creation or the ability to create new ideas at work

and better ability to solve problems have become a management ideology in Taiwan since 2000. This study brings the approach of structural embeddedness to the study of innovation at work. Social capital does matter for such innovation, and different dimensions of individuals' accessed networks have different effects on it. This study examines the effects of diversity, density, and trust in individuals' position-generated networks on innovation at work.

Workers in hi-tech firms tend to produce more new ideas and actions at work than those in non-hi-tech firms. Investment in individuals' accessed networks is important for innovation ability in daily life, including applying new ideas and actions at work. Innovation ability is often related to the requirements of work environments; however, once we controlled these work requirements we find innovation was still affected by the social capital invested in daily life. Generally, workers in hi-tech sectors in Taiwan are required to have the capability to create more new ideas at work more than those working in non-hi-tech-sectors. Most workers in hi-tech firms worked in large firms with more organized environments related to knowledge management. These environments included setting up an intranet system within firms and encouraging workers to exchange more information and have discussions with other workers within firms. Once the management ideology of innovation became institutionalized, the variance for hi-tech workers of innovative ideas and actions at work became smaller, and the institutionalized social environments for encouraging innovative acts were more similar.

In contrast, more than 80 percent of our sample worked in non-hi-tech sectors. Their working environments and behavior are characterized by the work nature of small- and medium-sized firms in Taiwan. Innovational capacity and capability are not expected as much from workers in non-hi-tech firms compared to those in hi-tech firms. Fewer workers worked in firms with an intranet system and the organizational culture of knowledge management. Most non-hi-tech small- and medium-sized firms produce products and services and depend more on interpersonal relationships from the stock of accessed networks in their daily lives.

Different types of interpersonal relations are invested in social capital stock for hi-tech workers and non-hi-tech workers. The literature on technology and work in Taiwan promotes a popular myth that hi-tech firms make business deals mainly through previous classmates or colleagues, and firms in traditional sectors tend to conduct business through kin relations or pseudo-kin ties. This study also found that workers in the hi-tech sector include a greater percentage of previous and current colleagues, while

in the non-hi-tech sector a greater percentage of workers' accessed contacts are kin.

When we did not control individual, organizational, and work characteristics, the percentage of kin ties in accessed contacts had a significant negative effect on innovation at work for both the total sample and non-hi-tech workers. After controlling all other variables, the effects of percentage of kin ties on accessed social capital were not significant. The percentage of accessed contacts through colleagues had a slight effect ($p<.10$) on innovation at work; however, this effect disappeared after controlling all other variables. In fact, the structural embeddedness of accessed social capital in daily life matters for explaining innovation at work, especially for those in non-hi-tech sectors.

Diversity of social capital was the most important factor in explaining the frequency of applying new ideas and acts at work for both the hi-tech and non-hi-tech sectors. This result supports our first hypothesis. This chapter used the measure of extensity of accessed positions to indicate diversity of social capital and demonstrate its effects on innovation at work. Diversified stock of an individual's social capital provides the opportunity structure to access diversified information and synthesize new ideas and acts. In terms of network strategies for increasing employees' ability of innovation at work, recruiting people with more diversified accessed networks is a good policy for employees of both hi-tech and non-hi-tech sectors.

Density of and trust in embedded accessed networks are only important for individuals in non-hi-tech sectors. The individual and work characteristics for these workers are different from those in the hi-tech sector. Number of years of education is the most important variable in the creation of new ideas at workplaces in the hi-tech sector. However, number of years of education is not important for employees in non-hi-tech sectors for applying new ideas and actions at work. Instead, social capital variables, jobs requiring contacts, and jobs in which information is often exchanged with people outside the firm are important for applying new ideas and acts at work. After controlling individual, organizational, and work characteristics, density and trust are still significant in explaining innovation at work for non-hi-tech workers.

High density of an individual's accessed network facilitates his/her innovation at work or applying new ideas and acts at work, especially for workers in the non-hi-tech sector. Individuals' accessed networks in which almost all network members know each other facilitate knowledge exchange and knowledge sharing for network members and ego. Investment in dense

social networks provides ego with knowledge and information in daily life, and also helps ego create ideas and deal with problems in the workplace. This result supports H2. No previous studies have used a national survey to measure the density of individuals' accessed networks, so it is difficult to understand the function of density in these networks. In addition, there are still some limitations to the conclusions on the effect of density on innovation at work. The density measure in this study is used with only one item of perception, "the degree of knowing each other among network members of accessed contacts." Therefore the function of density in individuals' accessed networks needs to be studied further using actual perceived network ties.

The degree of trust in members of individuals' accessed networks is associated with the density of these networks. According to Coleman's (1988) study of closure of community and school networks, high-density networks facilitate the building of the trust norm. Individuals embedded in a network in which ego trusts most of his/her own network members tend to create more new ideas at work. In our study the relation between the degree of trust in members of individuals' accessed networks seems to be nonlinear. Individuals' innovation at work increases along with the increase of degree of trust in their network members until some moderate level, then the level of innovation does not change with further increase of the degree of trust. Previous findings on trust and economic action (Uzzi, 1996, 1999) had already found optimum trust to be the most efficient networking strategy in manufacturing transactions and financial loaning actions for firms. This study also found the optimum degree of trusting network members is efficient for creating new ideas at work after controlling all the variables that are significantly associated with innovations in the workplace, such as jobs that require social contact, information exchanges and discussions on the job, job training, and occupational status.

Although the interaction between density among members of accessed networks and degree of trust toward network members is only slightly significant for non-hi-tech sector employees, there are still some implications for this result. For those individuals who have a high degree of trust in their network members of accessed networks, density has a negative effect on creating ideas at work. However, for those individuals with a lower degree of trust, high density did not significantly affect innovation at work. Both trust and density are important for employees working in non-hi-tech sectors; however, a strong degree of trust in their network members with strong closed networks is not beneficial for network expansion or information exchanges and gaining good ideas. These results imply that

mixed and complementary networks benefit innovation at work for employees in the non-hi-tech sector, and also support our H3 and H3-1.

The findings in this chapter cannot fully account for the causal relations between social capital and innovation at work because there are some limitations to the measurements and analyses. Although our findings show that diversity, density, and degree of trust are still significantly associated with innovation at work after controlling all variables on an individual's job that requires more social contact, we would rather keep more reservation for the plausible causal effects of social capital and innovation at work. The major limitation in this study is that the concept of innovation at work was measured by only one item. In order to confirm the causality between social capital and innovation at work, we need to design a series of items to increase the validity and reliability of the concept of innovational behavior at work. In addition, it is important to discuss the likelihood of reverse causality – people who work in jobs that require innovation may be structurally located in firm positions that put them in greater contact with a broader range of occupational connections. This chapter used cross-sectional data that are unable to effectively establish the temporal priority of independent variables. In order to distinguish the priority of temporal causality between social capital and innovation at work in the future, we should use the second-wave panel data of the social capital survey to examine the causal relationship more specifically.

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NOTES

1. In order to examine whether there is a sample bias in the filtering sample, we performed Heckman regression analyses for the regression models and found that the missing data of the variables in the analyses are random. There is no sample bias problem in the filtering sample.

2. The work infrastructure and environment vary in hi-tech and non-hi-tech sectors. A question was asked regarding "an intranet within the company." A higher proportion of respondents in the hi-tech sector (92.93 percent) worked in organizations with intranet systems than in the non-hi-tech sector (58.90 percent). It is obvious that hi-tech firms provide employees with better intranet systems, which facilitates knowledge sharing and creation.

3. The major reason the effect of density on innovation at work becomes significant from Model 1 to Model 2 is the correlation between number of years of education and density. Number of years of education has a negative correlation with high density (−.112) and low density (−.093). This implies highly educated employees tend to establish medium network density to facilitate their innovation at work.

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