

**LEARNING BY DOING IN SOCIAL NETWORKS:
NORTH AMERICAN AUTOMOTIVE ENGINE PLANTS, 1995–2006**

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE
UNIVERSITY OF HAWAI'I AT MĀNOA IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

INTERNATIONAL MANAGEMENT

MAY 2012

By

Daegyung Yang

Dissertation Committee:

Mooweon Rhee, Chairperson

John Butler

Jennifer Chandler

Robert Doktor

Yeanju Lee

Copyright © 2012 by Daegyung Yang

All rights reserved.

To Shinyoung and Hyeonjae

ACKNOWLEDGMENTS

“Is it not pleasant to learn with a constant perseverance and application? Is it not delightful to have friends coming from distant quarters? Is he not a man of complete virtue, who feels no discomposure though men may take no note of him?”

(Confucius, from the beginning part of his *Analects*)

Whenever I read this part of the collection of the wisdom of Confucius, the Great Master in the ancient East Asia, I always realize that the pleasure of learning comes not only from one’s personal efforts to learn, but also from friendly relations in which something deep in one’s mind can be shared. It may not have been simply a coincidence that I also found my pleasure of learning during my doctoral courses just as Confucius did over two thousand years ago. While the paths I have been through during my course of doctoral program sometimes made me feel hard and lonely, I was able to complete it with the support and encouragement from the people to whom I am indebted a lot in many ways.

My deepest debt of gratitude belongs to Professor Mooweon Rhee for sharing his friendship and academic insights with me over the whole years of my doctoral course. The greatest luck that I have ever had in my life is that I had him as my academic advisor during the toughest time of my academic life. As a friend, he never overlooked when I was troubled, and as an academic mentor, he always guided me to the right directions. By Professor Rhee, I was invited to the Confucian-kind pleasure of learning that I mentioned above. I believe that he was an awesome example of academic mentors who have most humane virtues along with strict academic guidance.

The next person to which I am academically indebted a lot during my doctoral course is Tohyun Kim. Although we were together in Hawaii both as doctoral students only for a year, all the talks I shared with Tohyun at that time were the best encouragement for me. Tohyun was a man of few words, but those few words out of his mouth were always worth thinking over twice and helped me academically a lot. I will not forget the nights we both studied late at the lounge for doctoral students and the glasses we emptied at Choonchun chicken BBQ.

Studying and living abroad may be one of the most challenging experiences for any person, and I should admit that I was also one of those persons. Without the friends and colleagues around me, I could not have arrived at the final destination of doctoral course in this foreign island. Whi Chang helped me when I felt stressed out too much by works by reminding me of the fact that I was in a so-called “paradise on earth.” By that simple and short wisdom, I was able to regain composure by turning eyes to the beauty of the Hawaiian nature. Douglas Chun also helped me in similar ways by showing me his friendship with great Aloha. Douglas often invited me and my family to his place. I will not forget the scenery of the mountains I saw from Douglas’s farm in the Waimanalo side.

Having Jinsuk Park as a friend and colleague at the final stage of my doctoral course was such a pleasure for me to revive vital academic talks with other doctoral students. Jinsuk’s passion for research refreshed mine as well. He also helped me when I finalized my life in Hawaii. I would like to thank Kitae Park for the energies that he shared with me. I loved his enthusiasms about life and study. Kitae also helped me very much when I arranged my life in Hawaii.

My deepest gratitude regarding my life in Hawaii must go to Yangsook Park and Jongwon Park. They gave me and my family such a love that common church goers cannot or will not give other church members. They were almost like my aunt and uncle with such a care for me and my family, actually far better than the real aunts and uncles of mine. I will miss them very much. Of course, there are tons of people who deserve my gratitude in many different ways during my time of doctoral course, but I ask for the forgiveness of not mentioning their names due to the limitation of pages and memories.

Finally, my last and greatest gratitude belongs to all my family members. Without their faith in my decision to become an academic scholar, I could not have completed my doctoral course. My parents, Youngkwang Yang and Doya Lee, were always steadfast in their prayers for their son. If a life is all about debts one has, over ninety percentage of my debts of life are on my parents. My parents-in-law, Jaeman Noh and Gilok Kwon, provided the greatest supports during all my study, which others would not give even to their own sons. Shinyoung, my wife, is the last person that I have found to share the same soul with me on the earth. It is not an exaggeration to say that more than half of my study was done by her love and support. Hyeonjae, the most valuable gift that I would admit to have received from God in my entire life, has been the central source of all my energies. I loved seeing him raised as a Hawaiian kid full of Aloha minds. I wish him to take all those beautiful minds back to Korea. This dissertation is dedicated to my wife and my son.

I was really a lucky doctoral student in Hawaii because I learned from a good teacher about how to constantly learn and reflect and I was surrounded by many good friends who willingly share many things with me. That is, I can say that Confucius'

pleasure of academic life was exactly replicated in my life over the last five years in Hawaii. I will try to remember all good things in Hawaii for the rest of my life in that all those became a fertile soil on which my future academic outcomes will grow. Mahalo for every kind of Aloha I experienced!

ABSTRACT

This dissertation is an academic attempt to make answers to a couple of research questions: What are the potential factors to internally affect the effectiveness of organizations' learning by doing activities and how do the network characteristics of organizations influence the effects of those internal factors on the effectiveness of learning by doing? By using the automobile engine manufacturing plants in North America 1995-2006 as the research context, this study suggests three factors to influence the effectiveness of learning by doing: (1) the change of part-time worker ratio, (2) the in-house manufacturing ratio, and (3) the failure of quality control. To measure the effectiveness of learning by doing, this study uses the extent to which productivity is enhanced by following the convention of organizational learning perspectives.

In addition to the direct effects of the internal factors, this study pays attention to the interaction effects of the network properties of engine plants and each internal factor on the effectiveness of learning by doing in order to examine the influence of the networks in which engine plants are embedded. The network properties of engine plants used in this study are degree centrality and closeness centrality, which are obtained from the engine plants' production-based networks. The findings show that both the increase of the part-time worker ratio and the high in-house manufacturing ratio negatively affect the productivity enhancement and that those negative effects are mitigated when plants have high centralities in networks. Intriguingly, this study reports that plants with unsuccessful quality control tend to focus more on productivity enhancement, but such tendency is likely to be distracted by the high extent of centrality due to the contingency of knowledge irrelevance.

This study makes at least two contributions to the extant literature of learning by doing: It first empirically examines the effects of three internal factors on the effectiveness of learning by doing based on in-depth literature review, while there are few empirical studies that did so. It also expands the research areas of learning by doing by investigating the effects of the network features of organizations on the effectiveness of learning by doing.

TABLE OF CONTENTS

ACKNOWLEDGMENTS	iv
ABSTRACT.....	viii
TABLE OF CONTENTS.....	x
LIST OF TABLES	xii
LIST OF FIGURES	xiii
CHAPTER 1 INTRODUCTION	1
CHAPTER 2 THEORY	7
2.1 Productivity and learning by doing	7
2.2 Network properties	11
2.3 Workforce composition.....	16
2.4 Process improvement activity	21
2.5 Multiple goals.....	24
CHAPTER 3 HYPOTHESES.....	28
3.1 Effects of network properties on productivity enhancement	36
3.2 Change of part-time worker ratio	38
3.3 In-house manufacturing ratio	43
3.4 Quality control.....	46
CHAPTER 4 METHODS	51
4.1 Data and sample	51
4.2 Dependent variable: Productivity	52
4.3 Independent variables.....	53
4.3.1 Part-time worker ratio change	53
4.3.2 In-house manufacturing ratio.....	54
4.3.3 Quality control.....	54
4.3.4 Network properties	56
4.4 Control variables	58
4.5 Model specification and estimation.....	59
CHAPTER 5 RESULTS	62
5.1 Network properties	65

5.2 The change of part-time worker ratio.....	67
5.3 In-house manufacturing ratio	72
5.4 Quality control.....	75
CHAPTER 6 CONCLUSION AND DISCUSSION	79
6.1 Summary	79
6.2 Contributions	82
6.3 Implications	84
6.4 Limitations and future study	86
BIBLIOGRAPHY	88

LIST OF TABLES

Table 1. Descriptive Statistics.....	63
Table 2. Pearson Correlation Coefficients	64
Table 3. GEE Estimates of Productivity, 1995–2006 (Network Properties)	66
Table 4. GEE Estimates of Productivity, 1995–2006 (Part-timer Ratio)	68
Table 5. GEE Estimates of Productivity, 1995–2006 (In-house Manufacturing Ratio)...	73
Table 6. GEE Estimates of Productivity, 1995–2006 (Quality Control)	76

LIST OF FIGURES

Figure 1. An example of a learning curve.....	9
Figure 2. Average HPE productivity per auto makers 1996–2005	31
Figure 3. Auto model application network, Ford 1999.....	35
Figure 4. The change of total number of workers of engine plants, 1995–2005	40
Figure 5. Average in-house manufacturing ratio, 1995–2006	44
Figure 6. Average CV of consumer ratings, 1995–2005	49
Figure 7. Interaction graphs of change of part-time ratio and degree centrality.....	70
Figure 8. Interaction graphs of change of part-time ratio and closeness centrality	71
Figure 9. Interaction graphs of in-house manufacturing ratio and closeness centrality ...	74
Figure 10. Interaction graphs of CV of consumers’ ratings and closeness centrality.....	77

CHAPTER 1

INTRODUCTION

Organizations have long been thought of as entities that proactively learn just as individuals do (Cyert & March, 1963; March & Simon, 1958). On this premise, a great number of scholars have participated in the academic endeavors to build a refined understanding of how and why organizations behave in certain ways to achieve their goals. Through this ongoing stream of collective academic effort, the organizational learning perspective has emerged as a solid foundation on which an extensive amount of academic research about organizations has been coherently conducted over five decades or so (Schulz, 2005).

From this perspective, various types of organizational learning that contribute to organizations' goal accomplishment have been theoretically suggested, and the effects of each type on the outcomes of organizations' behaviors have been empirically investigated. Among the suggested types, the notion of experiential learning, in which an organization learns from its own past experience, has been highlighted as a most compelling viewpoint. Obviously, experience is a primary route by which an organization learns and develops knowledge relevant to its activities (Argote, 1999; Huber, 1991; Schulz, 2005). Therefore, a number of previous empirical studies based on this notion have attempted to explore the hidden factors that affect experiential learning processes, positively or negatively. However, despite the extensive body of literature on learning by doing, a great many of the factors affecting experiential learning remain empirically unexplored.

Therefore, it is a crucial task of scholars with an organizational learning focus to find the hidden factors that are responsible for organizational learning from prior

experience. Given this task, many scholars attempt to identify the elements of experiential learning and suggest directions for future empirical studies. For instance, several scholars in learning curve studies have presented a set of the potential factors that are worth conducting research on: increased capabilities of individuals in organizations, motivations of workers, standardization of operational procedures, improvement of manufacturing processes, specialization and division of labor at both individual and organizational levels, and so forth (Adler & Clark, 1991; Argote, 1999; Epple, Argote, & Devadas, 1991).

However, it seems that the efforts to identify the factors affecting experiential learning are still limited in terms of the locus of learning sources. Most of the factors to which the learning curve scholars have paid attention tend to be something identified within organizational boundaries. In other words, the focus of learning curve studies, although they form a great part of the experiential learning research, still tends to maintain a closed-system viewpoint. At first glance, this seems quite natural because experience accumulated by learning by doing activities, by definition, is a kind that organizations endeavor to build by their own activities within their boundaries. However, organizations are also located in a broader environmental or social context in which they may also have chances to acquire knowledge relevant to their operational activities. Therefore, in order to respond to the challenges of the open-system view of organizations, other concepts of experiential learning have been suggested, such as vicarious learning (Huber, 1991). More specifically, learning curve scholars also admit that experience relevant to organizations' internal operations can be obtained from outside sources (Argote, 1999; Darr, Argote, & Epple, 1995; Epple et al., 1991). However, how

organizations learn from others, especially in regard to operational activities, has not yet been properly investigated in terms of social processes.

This dissertation is an attempt to both theoretically and empirically respond to these challenges to full understandings of organizations' learning by doing activities. Despite the somewhat narrow focus of the extant learning curve studies, they have provided some noteworthy insights on learning by doing that are relevant to this study. First, they emphasize the importance of examining how and why organizations show conspicuous variation of the effectiveness of learning activities, despite the general phenomenon that an organization improves its performance as it continues to obtain operation-related experience, although the rate of improvement in performance tends to decrease over time. Next, they provide a solid theoretical and empirical foundation for the idea that a notable outcome of learning by doing is increased productivity, which allows the effectiveness of learning by doing to be empirically examined. Based on these insights, the first task of this study is to suggest a set of potential factors that affect the effectiveness of learning by doing, which can be captured by productivity enhancement and is to empirically investigate how those factors influence productivity enhancement.

As pointed out, it is also academically necessary to expand the idea of learning by doing by taking into consideration the fact that organizations also are exposed to opportunities to acquire knowledge about their experiential learning activities from outside their own boundaries. In order to explore this, I choose to build my theoretical framework on the social network perspective. Briefly, the social network perspective views the social structure of organizations as a relational structure in which organizations are linked to one another by a certain type of relation. Organizations, by taking certain

positions in a given relational structure, would be given opportunities to enhance performance as well as obligatory roles derived from their relations.

More specifically, certain relational positions give organizations not only chances to obtain relevant knowledge flowing from their relations to their learning activities, but also roles in which they can coordinate the control of knowledge with others linked to them in the relational structure. In this study, I argue that the extent to which organizations enhance their learning by doing effectiveness, particularly by internal factors within their boundaries, also would be affected by certain network properties that organizations can have because of the specific characteristics of their network positions.

I also contend that the present study is comparatively advanced because it examines not only the bright side of network properties, but the potentially dark side as well. Most previous studies that investigate the effects of network characteristics of organizations are inclined to simply assume that the beneficial effect of network properties is more compelling, based on theories such as those of social capital, structural holes, or the strength of weak ties (e.g., Adler & Kwon, 2002; Burt, 1992, 2005; Granovetter, 1973, 1983). However, as Burt (1997) points out, the benefit of network properties has very contingent aspects, so it is not naturally guaranteed under certain conditions. With careful attention to this argument, this study also examines whether network properties of organizations benefit or damage the organizations' learning by doing.

As for the internal factors that affect the outcomes of learning by doing activities, this study suggests three such factors: (1) the change of workforce composition captured as the part-time worker ratio, which is considered the repository of knowledge acquired by ongoing experiential learning; (2) the change of manufacturing processes as the in-

house production ratio, considered as knowledge from experience which is technologically embodied in improved production systems; and (3) the extent to which other goals than productivity are well achieved, considered as the effectiveness of quality control, a potential factor affecting the productivity-related learning curve. Each factor is first examined for its direct effect on the extent to which productivity is enhanced in terms of experiential learning, relying on relevant organizational learning theories. Next, how the effect of each factor would be affected by a set of network properties that an organization is given by the relational structure in which the organization is linked to others is investigated based upon the social network perspective. In this study, the network properties of organizations are presented as a set of network centralities known to crucially influence the organizations' activities in the network structure in terms of learning processes: degree centrality and closeness centrality. While degree centrality focuses on local network contexts, closeness centrality sees broader global network contexts.

This study makes at least two contributions to the study of organizational experiential learning. First, it suggests potential factors that affect the effectiveness of experiential learning based upon an intensive literature review and empirically examines those factors through a well-designed analysis. Second, it expands the learning by doing literature from the intra-organizational level to the inter-organizational level by including a social network perspective. This makes it possible to see how certain features of network positions will influence the extent to which organizations make internal efforts to enhance the productivity of the learning curve. Given that there are few studies that

conduct research with this focus, it provides a previously lacking in-depth understanding of the social influence on learning by doing activities.

The research context of this study is automotive engine manufacturing plants operated in the North American region from 1995 to 2006. The automotive industry has often been used as the research setting of organizational learning research that focuses on internal aspects of experiential learning. In this vein, the research setting of the current study is not only appropriate for the examination of the specific research questions, but is also somewhat advanced in that the data on the variables of theoretical interest was directly collected at the plant level.

CHAPTER 2

THEORY

2.1 Productivity and learning by doing

Although there are various definitions of productivity across industries, increased productivity is one of the most important goals that complex organizations make efforts to accomplish (Banker, Chang, & Natarajan, 2005; Brush & Karnani, 1996; Lapré & Van Wassenhove, 2001; Lieberman & Demeester, 1999; Lieberman, Lau, & Williams, 1990). In particular, the organizational learning perspective sees productivity not only as a goal that an organization tries to achieve but also as an indicator of how effectively it learns through its operational activities. From an organizational learning perspective, organizations are entities that learn from various sources and utilize what they previously learned so as to reach the goals that they purposively set. As Cyert and March (1963) point out, not every behavior of an organization can be captured as a learning activity due to the complex characteristics of the behaviors of organizations. Therefore, a certain kind of lens is required to see how well an organization performs in its learning activities, and productivity is suggested as an indirect, yet powerful way to examine the effectiveness of learning (Argote, 1999).

Among the sources of organizational learning, previous experience is a primary one by which an organization can enhance its productivity (Huber, 1991; Levitt & March, 1988; Schulz, 2005). The close association of experience and productivity has been examined particularly in the learning curve literature. Since Wright (1936) first discovered the relationships between experience and productivity and presented his empirical findings as the learning curve, a great number of scholars in this area have

empirically confirmed the generalizable features of the learning curve phenomenon and theoretically elaborated it within the academic tradition of organizational learning (Argote, 1999; Lapré & Nembhard, 2010). In sum, the association of experience and productivity is graphically illustrated in the well-known learning curve. As Figure 1 shows, productivity is a positive function of experience accumulated by an organization. Based on this solid and consistent research finding, I assume that productivity is a very appropriate lens through which the effectiveness of experiential learning can be examined, despite its retrospective nature.

Given this assumption, my next question is what experience enhances productivity and how this varies over organizations in terms of processes. An organization is a complex set of various routines as a learning entity (Cyert & March, 1963; March & Simon, 1958). However, extant empirical research that explores experiential learning based on the learning curve perspective does not seem to directly address the internal processes that consist of learning activities in detail. In fact, the previous studies of learning curves mostly use accumulated production as a proxy variable that can capture the overall effect of experiential learning by assuming that experience is absorbed in the products as a whole (e.g., Argote, Beckman, & Epple, 1990a; Argote & Epple, 1990; Darr et al., 1995; Epple, Argote, & Murphy, 1996; Lapré & Tsikriktsis, 2006; Levin, 2000). Therefore, despite the extensive amount of research, the details of experience that contribute to productivity enhancement are not yet unveiled.

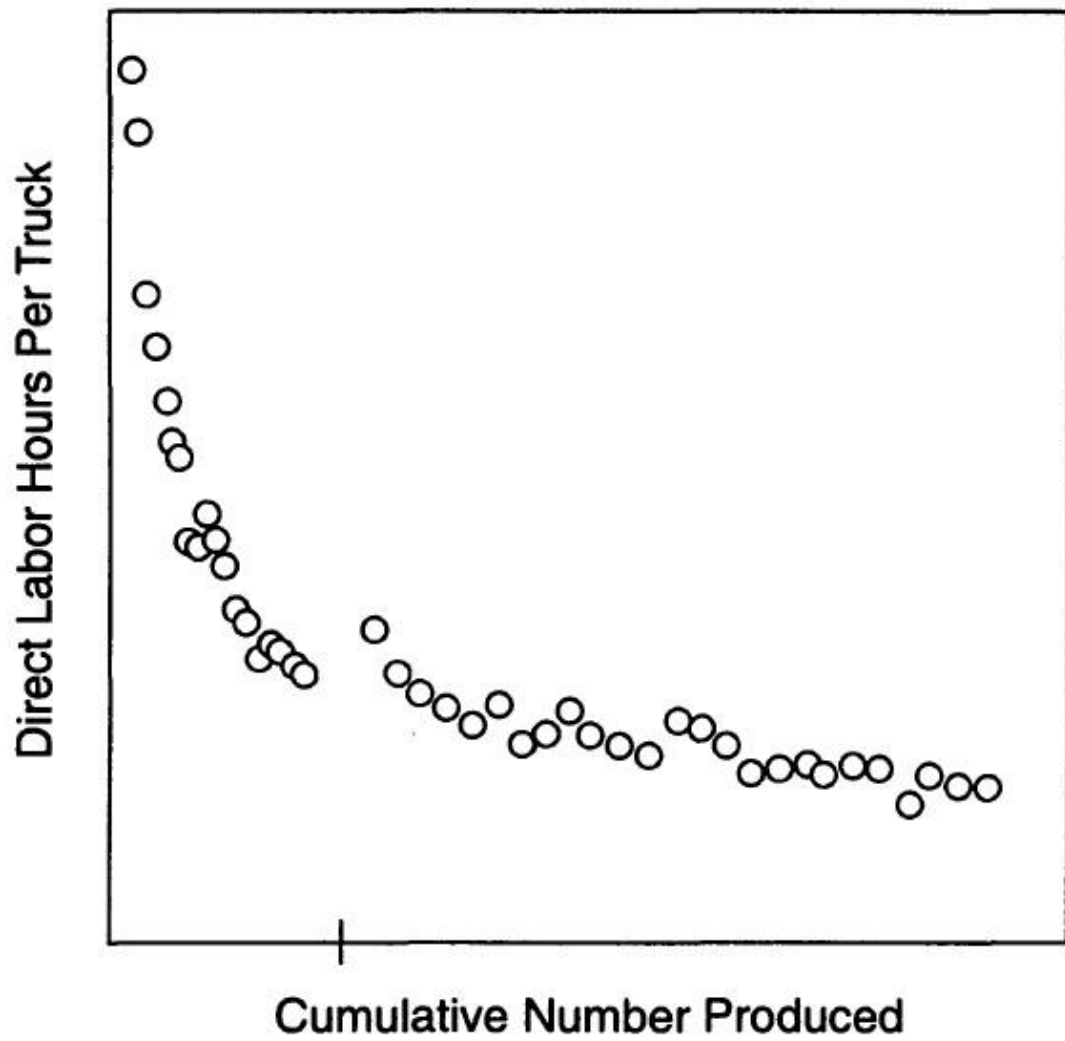


Figure 1. An example of a learning curve

Source: Epple, D., L. Argote, & R. Devadas, 1991, "Organizational learning curve: A method for investigating intra-plant transfer of knowledge acquired through learning by doing," *Organization Science*, 2, 58-70.

As Lapré and Nembhard (2010) point out, an organization deliberately employs as many activities that may enhance its learning by doing beyond those involved in its basic operation as possible. In a broad sense, these deliberate activities are also considered to be composed of experience from which an organization learns overall.

It does not seem to me, after an intensive literature review, that a satisfactory synthesis has yet been introduced that comprehensively covers the factors that may affect learning by doing. However, several scholars have suggested lists of plausible factors affecting learning by doing. For example, Epple et al. (1991) suggest a brief list of factors based on their literature review, and Adler and Clark (1991) also provide a short list of factors. More recently, Lapré and Nembhard (2010) attempt to construct a theoretical framework by which the inside of learning by doing can be explored. Reading these papers led me to develop a set of factors that are both conceptually independent and empirically testable.

I propose that the effectiveness of learning by doing can be captured by the productivity outcome. Therefore, the effects of the factors of learning by doing on the productivity enhancement outcome will be examined in the following section. As for the factors, I first pay attention to relatively internal activities that operate within the organizational boundaries. I then propose that under certain social conditions, the direct effects of these factors would be moderated or enhanced. This attempt to develop a theoretical frame is, obviously, based on the open-system view in which organizations not only learn from their inside activities, but also are conditioned by their social characteristics. Because I argue that the outcome of each internal activity is influenced by social conditions, I begin to develop my theoretical frame by focusing on social factors

by which organizations may be influenced in their learning by doing activities in the following section.

2.2 Network properties

Organizations do not exist alone, but are located in a broader context in which many of them are somehow interlinked. Organization studies are mostly based on the open-system perspective, as it is an intuitive fact that organizations, autonomously or not, are social entities by their nature. Therefore, in order to understand any kind of organizational activity it is necessary to consider the social characteristics of organizations. The social network perspective provides a solid theoretical foundation by which the social nature of organizations can be explored. According to the social network perspective, a social structure is an interlinked relationship structure in which social actors take certain positions to encourage or discourage their actions (Wasserman & Faust, 1995). A great amount of attention has been paid to this relational view of social structure because it not only enables scholars to theoretically explore the social processes among actors quite closely, but provides them with a useful lens with which to investigate in depth how the actors in a relational structure interact with one another in terms of their value-seeking activities. By using the social network perspective, scholars are able to examine not only the behaviors of individuals, but also those of collective actors such as organizations.

Over the past three decades or so, the social network perspective has been widely used, particularly by scholars with a strong interest in organizational studies (Borgatti & Halgin, 2011). This tendency within academia is primarily due to the notion of the social network perspective that some organizations may benefit from positional features derived

from where they are located in a relational structure (Burt, 1992). For instance, previous research has investigated the possibly beneficial effects of organizations' network characteristics in a variety of organizational activities: innovation (Powell, Koput, & Smith-Doerr, 1996), alliance formation (Gulati, 1999; Stuart, 1998), attention in markets (Hansen & Haas, 2001), and so on.

Briefly, the logic behind network benefits is that a network structure functions as a conduit of knowledge that is relevant to purposive organizational activities (Owen-Smith & Powell, 2004; Podolny, 2001). This logic becomes more compelling when the benefit of knowledge flowing in an organization's relations is understood particularly from the organizational perspective. As Argote (1999) argues, the outcomes of organizational learning from experience can be embodied conceptually as various types of knowledge, which can be not only elaborated better within organizational boundaries, but also potentially transferrable even beyond these boundaries. Thus, a relational structure captured as a network configuration may provide opportunities by which an organization enhances the effectiveness of its internal activities of learning by doing.

Given this, it is obviously worth exploring how social network structure affects experiential learning, which can be captured as the enhancement of productivity. There have been several theoretical attempts to describe how organizations specifically benefit from their network characteristics. By focusing on the value of the objects that may flow through the linkages between organizations, scholars with a resource-based view emphasize the value of the knowledge itself. However, such an approach does not seem to pay attention to the importance of social structures, because it sees the impact of what is transferred through a network rather than the role of the network configuration. Thus,

this approach suffers from a shortcoming in that it cannot see how valuable knowledge can be reached by organizations in need.

The social network perspective, therefore, introduces more structure-based theories that focus on relational features such as the strength of weak ties (Granovetter, 1973, 1983), the structural holes argument (Burt, 1992), or the competitive importance of relational status (Podolny, 1993). In particular, these ideas of the social network pay attention to how well a social actor is connected to others in a relational structure, and emphasize that certain ways of building connections with others may generate network benefits for social actors. Based on the beneficial characteristics of social networks, scholars in the social network perspective have developed a metaphorical concept of “social capital,” (Adler & Kwon, 2002; Burt, 2005) and, recently, a growing number of empirical studies about inter-organizational dynamics have been emerging that are based on this concept.

Organizational learning is also an area that extensively incorporates the social network approach to understand how an organization can learn from others (Ingram, 2005). For instance, a growing number of empirical studies focusing on vicarious learning have been conducted based on social network theory (Denrell, 2003; Kim & Miner, 2007; Srinivasan, Haunschild, & Grewal, 2007). As Podolny (2001) suggests, networks function as a set of interlinked pipes through which can flow the knowledge that organizations seek. Likewise, Burt (1992) also points out that one of the largest advantages of taking certain positions in a network is the informational benefit. From an organizational learning perspective, therefore, network properties that organizations obtain by taking certain positions in a network possibly contribute to organizations in

their learning by doing activities. Given this, more refined knowledge is created and is possibly transferred to others over network linkages. In this sense, network properties emerge as a crucial type of social capital by which an organization learns more effectively. Previous empirical studies using this logic of social network benefits support this argument. In particular, the positive effect of network properties on productivity enhancement is supported (Darr et al., 1995). Therefore, I present my first proposition as follows:

Proposition 1. Owing to the knowledge benefits provided by network properties, an organization with good network connections may enhance the effectiveness of its learning by doing and increase its productivity more effectively.

However, taking a network position with more benefits does not in itself and autonomously give an organization such benefits. It is very important to pay careful attention to the fact that network properties are by nature given as structural conditions. This means that what certain network positions provide in terms of connectivity is not knowledge, but opportunities to more effectively access knowledge (Burt, 2005). Unless an organization makes appropriate efforts to utilize the beneficial functions of network properties, it is unlikely to enjoy the benefits. Even worse, despite such efforts, it is also possible that an organization cannot actually make use of its network properties in favorable ways. As Adler and Kwon (2002) carefully point out in their critical review on social capital, social capital actually has two faces: benefits and risks. Social capital does not always function as capital, literally. Even the same network property functions differently under certain conditions. Although it is still in an early stage, a stream of network research that looks into the dark side of network properties is being presented in

both conceptual and empirical studies. The studies focusing on the potential damages of network characteristics suggest a counter-concept of “social liability” opposed to social capital (Adler & Kwon, 2002; Hansen, Podolny, & Pfeffer, 2001; Johanson, 2001; Labianca & Brass, 2006; Nooteboom, 2001).

Based on these two distinctive approaches to the effects of network properties, I also carefully approach how network properties function in their effects on organizations’ learning by doing activities. The argument that even the same kind of network properties could work on organizations in opposite ways leads me to suggest that there might be contingent aspects of network properties. In other words, the effects of network properties are likely to be conditioned by contingencies, such as whether organizations have other contingent factors that are intermingled with the social factors derived from network characteristics. Although still burgeoning, there are few academic attempts to theoretically approach this matter (Hansen et al., 2001; Nooteboom, 2001). As previously mentioned, Adler and Kwon (2002) developed such an approach to social capital in a conceptual manner. It is also intriguing that Burt, one of the most prominent of the figures who emphasize the benefits of network properties, has often pointed out the contingent features of network properties and has even conducted empirical studies on this with his colleagues and on his own (Burt, 1997; Burt, Jannotta, & Mahoney, 1998).

In this vein, I also argue that the way that network properties function is dependent on the contingent features of the modes of learning by doing activities (Burt, 1997; Emirbayer & Mische, 1998; Harrington, 2001). Although the findings of previous empirical research on the effects of social networks on organizational learning are fairly consistent in reporting the beneficial effects, the effects of the same kind of network

properties that an organization obtains from its network positions and connectivity may differ, depending upon the contingent factors interacting with the network properties. More specifically, the beneficial aspects of network properties can be thought of as burden-loading ones, given that a network position that previous studies have proposed to include opportunities to utilize knowledge benefits could also suffer from either overflow of irrelevant knowledge or knowledge-controlling obligations among network partners. This potential drawback in the functionings of network properties could emerge under certain contingent conditions such as peculiar aspects of internal learning by doing processes. Therefore, I propose my second proposition as follows:

Proposition 2. Under certain contingent conditions, the network properties known to be beneficial in learning by doing activities may function in unexpected ways to hamper the effectiveness of learning by doing activities.

In the following sections, I develop propositions about several intra-organizational factors that may directly affect the effectiveness of organizational experiential learning in terms of productivity outcome. Based on the two propositions regarding the effects of network properties developed in this section, I go further with the theoretical elaboration of how the internal factors of learning by doing activities are affected by the network characteristics of organizations.

2.3 Workforce composition

As Cyert and March (1963) point out, an organization is a collective entity that is composed of people. If the notion that an organization can learn on its own is valid, it is also valid to say that the primary learners within the boundaries of an organization are people who work for the organization (Nonaka, 1994). Therefore, I pay attention to how,

collectively, the workforce of an organization may function as a primary factor that affects the organization's learning by doing. Argote (1999) argues that experiential learning is a behavioral process by which useful knowledge for operational improvement can be created and retained within the organization. In experiential learning processes, the first level agents that apply established knowledge to the operation, capture any potential opportunity to create knowledge for the organization, store the knowledge in a stable form, and appropriately retrieve the knowledge when required are the people who participate in the operation. Therefore, how an organization deals with its workforce must be examined in depth to see the underlying factors that affect the effectiveness of learning by doing (Argote, 1993). From a knowledge-based viewpoint, people-embodied knowledge is the foundation of an organization's core capabilities of learning by doing and is fundamental to the improvement of productivity, while organizational knowledge may be embodied in various forms, such as tools, tasks, technologies, and people (Argote & Ingram, 2000).

In addition, the importance of people in organizational learning processes can be found in the typology of organizational knowledge. In its on-going operational activities, an organization is also given chances to document the obtained knowledge and embody it into technology-based routines through standardization. Despite organizational capability of transforming knowledge from operations, it is often pointed out that certain knowledge is very difficult to standardize and transform from its existence in human minds to machinery knowledge bases. Therefore, organizational efforts to build technology-based knowledge out of people-embodied knowledge through refined codifying systems cannot

be completely successful. People tend to maintain tacit knowledge not only in their minds, but also in the interrelated collaborative work procedures among them.

Given the importance of the workforce, human resource management studies have investigated how an organization effectively utilizes its workforce in terms of knowledge management and organizational learning within the boundaries of the organization. For example, it is established common knowledge in the traditions of human resource management that highly motivated workers with job satisfaction and organizational commitment contribute to the overall performance of organizations, which also generates the assumption that workers encouraged to have good attitudes toward organizations are a crucial factor for an organization to increase the effectiveness of its learning by doing processes (Porth, McCall, & Bausch, 1999). In general, a stable work environment in terms of job security or trust among workers built by workers' good job attitudes is essential for effective organizational learning.

However, in circumstances either in which individual workers voluntarily leave the organization or in which organizations have to lay off their workers or change the workforce's composition with labor externalization due to competition and fluctuating economies, the learning by doing ability of a stabilized workforce can inevitably be damaged. Thus, change of workforce composition, which may occur as high turnover or frequent membership change among workers, becomes an important factor of organizational learning. For example, in his well-designed simulation in which various factors of organizational learning can be examined, March (1991) also included the turnover factor by reconstructing the simulation model as an open system where people come and go. Briefly, the result shows that while the extent of socialization among

workers and that of turnover are intermingled, high turnover and low socialization result in low exploitation, which can be interpreted as a way of internal learning within the organizational boundaries. This report provides a useful insight by which the effect of the change of workforce composition on organizational learning is anticipated. Additionally, Argote (1993) conducted an in-depth literature review about the effect of turnover on learning curves, and concluded that in general, turnover has a significant negative effect on the effectiveness of organizational learning. For example, as Argote, Epple, Devadas, and Murphy (1990b) report, turnover of highly skilled workers has a significant negative effect on productivity.

Research that focuses more on human resource management (HRM) practices also supports the negative association between insecure job environment due to rapid changes in workforce composition and the effectiveness of organizational learning (Harvey & Denton, 1999; Sterman, Nelson, & Kofman, 1997). For example, Pucik (1988) points out the importance of HRM practices for organizations' capability of learning, especially in the strategic alliance context. Invisible assets such as tacit knowledge accumulated in people resources are articulated by appropriate HRM practices. Obstacles to organizational learning may result from a complex set of HRM practices, which, for instance, focus on short-term outcomes such as decreasing costs. By replacing comparatively expensive workforces that are employed full time with cheap and flexible part-time workers, firms may make themselves look good in financial reports. However, in the long term, this may do damage to the most valuable human assets containing hard-to-codify knowledge regarding the production processes. This goes beyond simple issues of cost-focused priorities. Based on this argument, I propose:

Proposition 3. The frequent and intensive change of workforce composition has detrimental effects on the effectiveness of learning by doing, because it may cause the demoralization of a workforce in its activities of experiential learning.

As argued in Chapter 1, organizations do not exist alone, but are located in social environments in which they have certain relationships with others. This relational structure provides the organization with opportunities to benefit from its network properties, which may be captured in how it is connected to others. The relations can also function as a conduit of knowledge relevant to the organization's learning by doing activities. Given this, I argue that the proposed detrimental effects of the change of workforce composition can be understood to be influenced by relational conditions. In this study, the workforce is conceptualized as a main part of organizations that is capable of creating and retaining knowledge. From this knowledge-based understanding of the workforce, it is also likely that the potential loss of knowledge due to the change of workforce composition can be compensated for by a network resource captured as a good connection to other organizations. The internal processes of dealing with knowledge created and retained by the workforce may be damaged if the individual workers having knowledge do not remain in the organization or if a good job environment in which the workers build a trustful working community within the organization's boundaries is corrupted by an intensive change of workforce resulting from managerial practices intended to reduce costs. However, such an internal process may be, to a certain extent, overcome if organizations have chances to fill in the loss of knowledge by obtaining knowledge from their direct and indirect network partners. However, to obtain such benefits, it is necessary that the organization have a good network position, such as a position with efficient and effective connectivity to others who have the knowledge the

focal organization seeks to compensate for the loss of the knowledge that used to be contained in its workforce (Owen-Smith & Powell, 2004; Powell et al., 1996). In addition, my argument is supported by previous empirical studies that examine the moderating effects of network properties on the detrimental association of malfunctioning internal activities and the outcome of organizational learning (Dekker & Van den Abbeele, 2010; Hansen, 1999; Mizruchi, Stearns, & Fleischer, 2011). Thus, I present my fourth proposition as follows:

Proposition 4. The detrimental effects of a change of workforce composition can be mitigated by network properties with good connections, because the network properties may provide opportunities to compensate for the internal loss of knowledge with knowledge from outside.

2.4 Process improvement activity

As repeatedly emphasized, an organization learns from its own experiences and enhances its productivity as a result of learning activities. Along with the workforce that is capable of extracting and storing more refined knowledge about its operation, an organization also attempts to build tangible types of knowledge bases in order to spur its experiential learning. In other words, organizations do not simply rely on the workforce, but articulate the knowledge obtained from the experience of the workers into a codified version of that knowledge. Through this transformational process, organizations are able to improve their operational procedures. Regarding this process of converting knowledge, Nonaka (1994) argues that tacit knowledge residing in the minds of the workforce is transformed into externalizable explicit knowledge and that this can be done with the help of artificial intervention such as organizational development programs. According to

Dutton and Thomas (1984), who extended Levy's (1965) concept of induced learning, an organization's efforts to capture the knowledge of the workforce in an explicit form for the purpose of improving the production processes is an important part of learning by doing. The embodied version of explicit knowledge obtained through such knowledge conversion can be found in organizational settings as improved standardization of operational procedures, improvement of product design, improvement of product-based technology, and so forth. Thus, I pay attention to the improvement of operational processes as a crucial factor that potentially contributes to organizations' learning by doing activities.

Considering the current trends of production practices, in which whole processes of production are not done by a single organization from start to finish, the extent to which an organization has achieved noticeable improvement of operational processes can be captured by how much an organization externalizes its production processes by building trustful production networks with partners under its effective control (Sturgeon, 2002). This kind of practice can be possible when the production processes reach certain levels of standardization and modularization of the product components, and thus the organizations that are able to utilize the practice of externalizing their operational processes are considered to have accumulated knowledge to that extent. Furthermore, the extent to which an organization utilizes the externalization of production shows the organization's capabilities of effectively enhancing its productivity. For example, the externalization of production enabled by modularized product procedures may encourage the organization to pursue more specialized types of learning by doing (Mikkola, 2003). This is very plausible, because an organization is able to reserve its resources by

externalizing the sufficiently exploited parts of its operation as transferrable embodiment of knowledge and concentrate the reserved resources on the yet unexploited parts of its operation. Thus, the improvement of productivity can be more effectively achieved by the organizations that can focus more on where new knowledge can be made (Espino-Rodríguez & Padrón-Robaina, 2006; Lei & Hitt, 1995; Prahalad & Hamel, 1990). In addition, by making use of external production processes, an organization may also invite external knowledge (Jiang, Belohlav, & Young, 2007). Therefore, I propose:

Proposition 5. The improved form of operational processes such as the externalization of production processes contributes to organizations' learning by doing, because it gives an organization more opportunities to focus on yet unexploited areas of learning.

If an organization outsources parts of its production processes, while it sustains the core knowledge of production and designs good control of outsourced components with the help of good relations with the other parties in outsourcing contracts, the extent to which the production is outsourced may be considered as a gauge to see how much it achieves organizational learning in terms of production routines. Conversely, if the extent to which an organization utilizes its opportunities to externalize its operation as explicit types of operational knowledge is lower, it is likely to suffer from a relatively low degree of learning by doing. Assuming that the network types of production currently prevail over various industries, the organizations that still maintain all procedures of operation within their boundaries are likely to lose competitive advantages to their opponents in the same industry. Therefore, it is necessary for those that lack the capabilities of utilizing

external production processes to compensate for the disadvantages derived from their underdeveloped operational processes.

As argued above, the beneficial aspects of production externalization come from its contribution to more opportunities to internally develop experiential learning processes. Organizational resources reserved from the practice of externalizing operations can be more concentrated in exploitative learning activities, so the organizations without good use of this practice cannot take advantage of more opportunities to develop operational knowledge. Therefore, from the learning by doing viewpoint, the difference between the organization using the practice and the one not using it can be found in the potential variation of knowledge development. In Section 2.2, I argue that network properties may contribute to learning by doing by external knowledge acquirement through network connections. Focusing on the fact that externalization of processes also plays a crucial role in knowledge acquisition, I suggest that network properties may compensate for the lack of the opportunities to enhance experiential learning that may be given by process externalization. Therefore, I present my sixth proposition as follows:

Proposition 6. The disadvantage of the underuse of improved forms of operational processes such as production externalization may be compensated for by network properties because of the knowledge benefits provided by network properties.

2.5 Multiple goals

Organizations are entities that pursue certain goals they priorly set, and the goals are usually more than one (Cyert & March, 1963; Simon, 1964). In the current study, I focus on productivity enhancement as the main goal of organizations' learning by doing

activities. While in previous sections I discussed a couple of factors that are rather directly related to the goal of productivity enhancement, I here pay attention to the existence of other goal achievement activities and their effect on learning by doing activities in terms of productivity goals, based on the fact that organizations tend to pursue multiple goals at the same time. According to the behavioral theory of the firm, an organization has to allocate its attention resources to a set of goals due to bounded rationality (Cyert & March, 1963). Multiple goals of an organization, therefore, have to compete for managerial attention resources in terms of priority (Ocasio, 2010). To allocate its limited resources of attention to the right places, an organization examines the importance of each goal it pursues (Price, 1972). In this goal priority assessment, the organization relies on how well each goal was previously achieved and whether it will be effectively improved in the future compared to the others (Kernan & Lord, 1990). A goal that wins according to these two criteria will obtain more organizational attention than other goals, and therefore it can be focused on more in terms of learning by doing activities.

Assuming that productivity enhancement is highly ranked among organizational goals, an organization would decide to pay more attention to productivity enhancement if another goal that has a similar priority rank was not comparatively well achieved and is not likely to be more improved than productivity in an expected time. I argue that organizations also tend to compensate for the loss that may derive from failed goals by focusing on goals with high rank in priority. Therefore, I propose:

Proposition 7. In the case that an organization experiences unsuccessful outcomes of other goals, it will make more effort in the goal of enhancing productivity to make up for the losses of those other goals.

As argued in Section 2.2, the effect of a social network is not always beneficial. Whether the effect is beneficial or harmful depends on the contingent characteristics of how an organization intends to utilize the network properties. The contingent aspects of social networks have often been mentioned in previous studies, but there are few studies that have specifically touched upon the negative effect of network properties considered as social capital. In my review of the literature, Hansen et al. (2001) study looks like the only empirical study to date. Intriguingly, they found that the same network properties function in completely opposite ways depending on the characteristics of tasks that social actors are engaged in. The findings of their study present a useful insight, which is that distinction of goals can also function contingently on the effect of network properties.

It is likely that organizations' motivation to pay more attention to productivity enhancement activities by responding to the failure of other goals to meet expectations is hindered by network properties because overflow of knowledge regarding productivity would make the organization neglect the motivational signal from other goals' failure. Therefore, compared with those having network properties with less benefits, organizations with good network properties may disregard the attention-related signals from other goal activities. Unlike the two factors that I argue would be benefited by network properties because they are both presumably productivity-oriented activities, the extent to which other goals are achieved is by definition distant from productivity enhancement. I argue that this goal-based difference may contingently function on the effect of network properties, so it leads organizations to show different outcomes of interaction of network properties. Based on this, I propose:

Proposition 8. Due to the distinctive contingencies of goals other than productivity, an organization with good network properties in a production-related network is unlikely to allocate its attention from failed goal activities to productivity enhancing activities.

CHAPTER 3

HYPOTHESES

As mentioned in Chapter 1, this study develops hypotheses to test based on the research context of automotive engine manufacturing plants in the North American region from 1995 to 2006. The automotive industry has been one of the most advanced manufacturing industries since the modern industrial revolution began. From the managerial viewpoint, it has not only adopted the most state-of-the-art technologies introduced so far, but also developed the most advanced versions of operational processes. For example, one of the earliest applications of Taylor's managerial ideas of time and motion study was industrially realized in Ford's conveyor belt assembly lines, an application widely accepted as having revolutionized cost productivity in industrial history. In sum, the automotive industry is the very spot where virtually every kind of new managerial idea is experimentally invited in to be applied in a variety of areas, and therefore it has had tremendous use as a research setting in which scholars interested in organizational studies examine their ideas (e.g., Cachon & Olivares, 2010; Chung, Mitchell, & Yeung, 2003; Dobrev, Kim, & Carroll, 2002; Dobrev, Kim, & Hannan, 2001; English & Marchione, 1983; Goyal, Netessine, & Randall, 2006; Haunschild & Rhee, 2004; Lieberman & Demeester, 1999; Lieberman et al., 1990; MacDuffie, Sethuraman, & Fisher, 1996; Rhee & Haunschild, 2006; Rhee, Kim, & Han, 2006). More specifically, a great number of studies about experiential learning have been conducted by using this industry (e.g., Haunschild & Rhee, 2004; Lieberman & Demeester, 1999; MacDuffie et al., 1996; Rhee & Haunschild, 2006).

In addition, the automotive industry is known to actively utilize network forms of governance in its production, such as supply chain networks based on trustful relations. Not only that, but most automakers also have actively been utilizing multiple manufacturing plants in many locations due to the expansion of the industry over many decades. Therefore, beyond the supply chain networks of the industry that have become an established cliché of both business practitioners and academic scholars, network types of division of labor among the plants manufacturing the same end-products are widely witnessed in this industry. For example, General Motors, a U.S. automaker, operated ten engine manufacturing plants in the North American region in 2005. This means that a car user who drives a *Malibu*, a family-purpose sedan of General Motors, may not know or may not need to know whether the engine of his or her car was produced by the Ramos Arizpe plant, the Spring Hill plant, or the Tonawanda plant. Nonetheless, to a scholar interested in this varying production of the same products on the market, this plant level network emerges as a spot in which his academic ideas about network forms of production can be investigated.

Cost productivity is one of the biggest concerns in the automotive industry. It is found in Henry Ford's story of how he achieved revolutionary advances in cost reduction by applying conveyor belt assembly lines to car production and put his company solidly at the top of the car market in his time (Watts, 2006). It is undeniable that this legendary figure changed the landscape of production systems across various manufacturing industries by introducing a striking method of cost reduction. More recently, the introduction of so-called "lean production" to the car manufacturing industry by Japanese automakers created enthusiasm about the industry's efforts to achieve as high cost

productivity as possible (Womack, Jones, & Roos, 1990). From these two noteworthy cases of cost productivity, it can be seen that the largest concern of the automotive industry regarding production processes is to reduce the production cost, therefore achieving the highest productivity that it can.

As I have already mentioned, I attempt to understand the efforts of cost reduction by using the lens of organizations' learning by doing activities. From the view of learning curves, the automotive industry has long been endeavoring to achieve the lowest cost in its operational processes. The internal efforts of the industry can be seen as a history-long process of learning by doing. The revolutionary changes described above are also part of continuous efforts to enhance their learning from their experience, because the workplaces of the industry have been encouraged to improve the newly equipped production system. The validity of my application of a learning by doing perspective to the industry is supported by seeing the trend of the automakers' average cost productivities in the time period I observe. Based on the data I have collected, I plot the cost productivity trend graphs of six automakers that operate their engine manufacturing plants in North America in Figure 2.

The cost productivity, on the y -axis, is measured by "the hours of actual working effort required to build a vehicle at a given plant, with adjustment for vertical integration, production size differences, and absenteeism" (MacDuffie et al., 1996, p.355), which is widely used in the industry (*The Harbour Reports*). Smaller figures here signify better productivity. On the x -axis, I place time to see the yearly trends of productivity. However, in many studies of learning curves, time is regarded as a crucial proxy variable to capture the accumulated experience of a given organization (Argote, 1993, 1999).

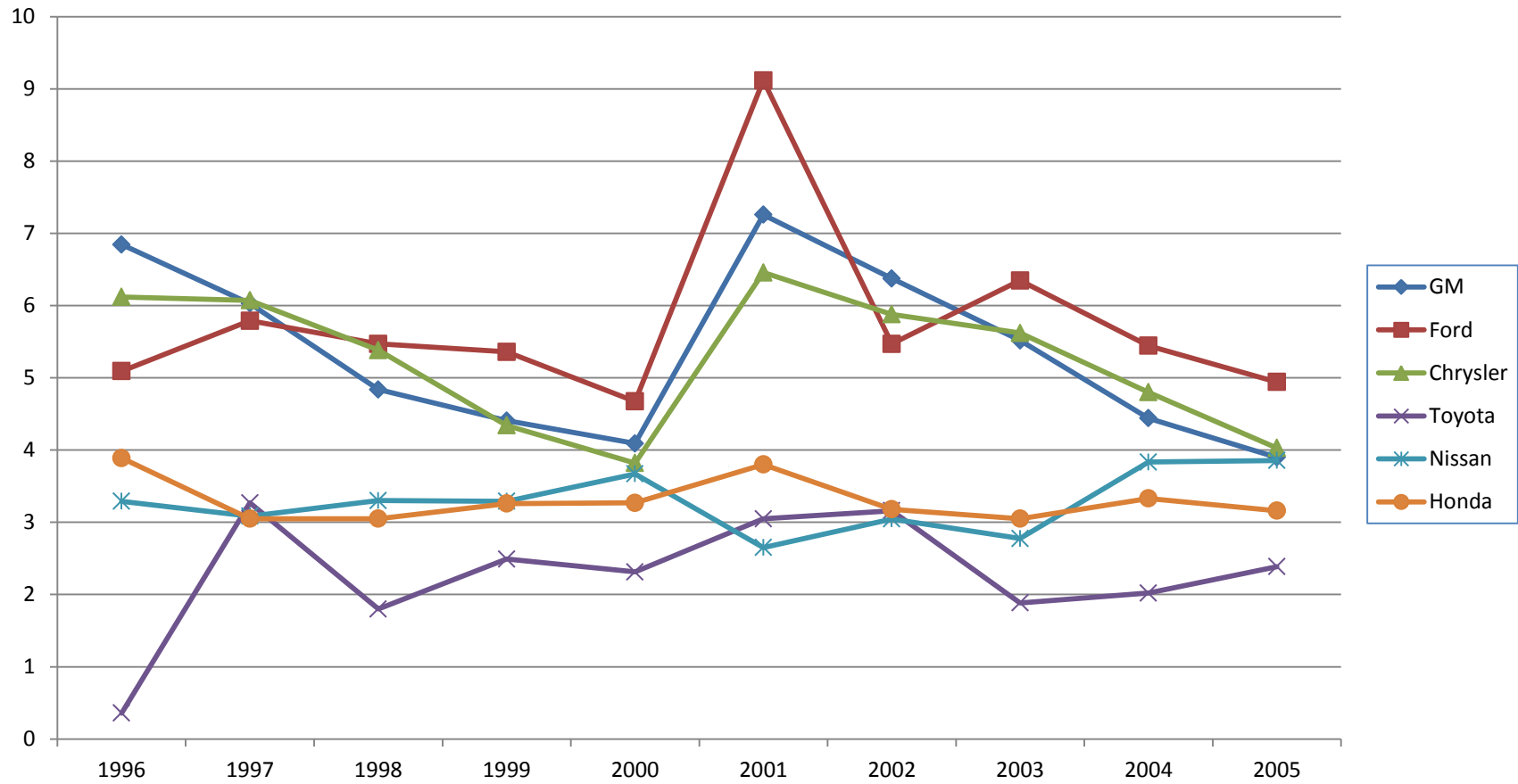


Figure 2. Average HPE productivity per auto makers 1996–2005

Given this, I argue that the graphs are also of learning curves. As the figure shows, for all of the U.S.-origin automakers, their average cost productivity takes the pattern of a learning curve (compare with Figure 1) over the period, except for the leap between 2000 and 2001. The average cost productivity of the remaining automakers, which are of Japanese origin, is conspicuously lower than that of the U.S. automakers, which supports the common idea that Japanese automakers are far ahead of U.S. ones owing to their advanced production processes. The patterns of Japanese automakers' productivity look rather flat, but this is because they have already achieved cost productivity at the level that the increase of cost productivity has reached to the most decreasing rate of it. What can be identified by these trend plots is that automotive engine plants make efforts to enhance their cost productivity behind the learning curve.

My interest in this study is to see what lies behind the learning curve phenomenon of automotive engine plants. In other words, what contributes to the productivity reduction of engine plants as shown in Figure 2? According to the learning curve literature, this question is very important because organizations in the same area clearly vary even if they share the general pattern of the learning curve (Adler & Clark, 1991; Argote, 1999; Lapré & Nembhard, 2010). By identifying the underlying factors that directly influence productivity enhancement, scholars can also investigate how an organization reaches the goal of productivity as effectively and efficiently as possible. In this vein, I present several factors that have the potential to affect the extent to which productivity is enhanced. However, before I move on the hypotheses on these factors, which are largely internal to the plants, I will discuss another important perspective in which learning by doing is understood to be affected by a broader spectrum of factors.

As argued in Section 2.2, an organization does not exist alone, but is located in a broader social context. In many industries, this is witnessed in industrial conditions as well as managerial practices. The automotive industry, in its manufacturing processes, is one of the industries that utilize network types of production systems. As the industry has expanded over many decades, its production processes have become very complicated by including some of the most advanced technologies ever introduced. For example, the well-known production system of huge scale of supply chains in which a great number of contracted producers of components are involved is found in the automotive industry. Thus, to understand the industry in depth, it is necessary to examine the learning by doing activities of the industry in this broader context because the opportunities to enhance experiential learning can also be found in extended contexts. However, the broader context that the current study is interested in is the inter-plant networks, rather than the supply chain networks, which have been paid a great deal of attention in previous research.

Just as production-related knowledge can be created and obtained by the relations between contracted suppliers of auto parts and the automotive plants, knowledge that is more closely relevant to the production processes can be exchanged through the relations between the engine plants, which conduct their operations in very similar manners. Despite extensive investigation on the supply chain-based networks, such as the Japanese *keiretsu*, there are few studies that look into the inter-plant networks of the industry. I argue that to see the dynamics of inter-plant networks is very relevant, because the patterns of learning from others through network relations are very likely to differ from those of supply chain networks and because network structures involving the same kind

of actors gives researchers theoretically more refined measures to see network dynamics. In identifying the inter-plant networks, I defined the relations between plants according to whether a pair of plants applies their engine products to the same auto models that sell in the market.

To give a better understanding of how I construct the inter-plant network, I present a network graph of the engine plants owned and operated by the U.S. automaker Ford in 1999 (Figure 3). The rounded squares represent the engine plants of Ford operated in 1999. As shown in the figure, eight engine plants were operated in the North American region to produce engines for Ford brand autos. Each solid line between the rounded squares indicates the co-application relations that a pair of plants shares with one another. For example, *Cleveland #2* plant (FD03) is linked to *Chihuahua* plant (FD01) in the graph, because both plants apply their engine products to the *Contour*, a family-purpose sedan, and the *Cougar*, a two-door coupe. The isolated square without any link is *Cleveland #1* (FD02), which focused on the production of a 5.0 liter sized engine to equip SUV vehicles such as the *Explorer* and the *Mountaineer*. In this way, the inter-plant network is constructed for each year in this study. This way of constructing the network matrices is based on two-mode matrix manipulation, widely used by previous studies investigating the network structure of various industries (Faust, 2005; Wasserman & Faust, 1995).

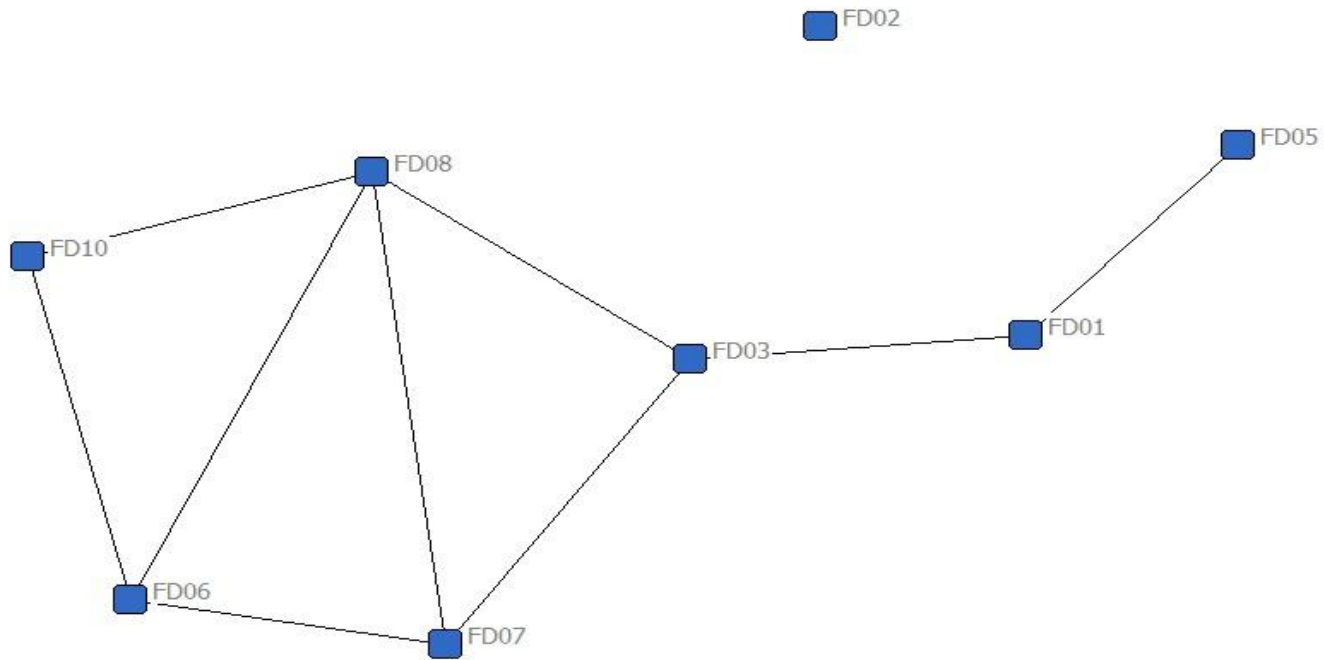


Figure 3. Auto model application network, Ford 1999

3.1 Effects of network properties on productivity enhancement

As discussed in Section 2.2, organizations have certain characteristics given by their positions in a network structure. Network positions are defined by how social actors are linked to others. By taking a network position that provides connections to others, an organization may have benefits or constraints. Previous studies of organizational network characteristics have focused mostly on the beneficial side of social networks, so they tend to call the network characteristics of organizations “social capital” or “network resources.” However, given the fact that the idea of the social network was originally established on a somewhat strong structuralistic viewpoint that social structure may encourage or discourage the actors in terms of their behaviors, I call the network characteristics “network properties,” taking a neutral position. No matter what terms are used, it is obvious that the ways network properties influence organizations may be beneficial or the opposite under certain conditions.

Based on the analytical convention of the social network perspective, the current study identifies the network properties of each engine plant by how they are located in the interlinked relational structure. It is worth noticing that the network structure of interest here is captured by the shared application of two plants’ engine product to the end product, auto models. That is, the sharing of the same auto model is a relationship that provides opportunities to obtain knowledge that may be useful for each party of relations to internally enhance its learning by doing. This knowledge benefit is primarily due to the features of the definition of relations in this study. Given that the outcome of learning by doing here is productivity enhancement measured by cost reduction, it is very

likely that the independent effects of network properties would be beneficial because the definition of network is based on a production-oriented concept.

In social network analysis, connectivity—how a social actor is connected to others—is a crucial feature by which the extent of benefits can be investigated.

Technically, this feature of how connected an actor is can be redefined as how central it is in a given network. Based on this, there are several network indices introduced by social network analysts. This study uses network properties interchangeably with network connections or network centralities. Therefore “better network properties” does not necessarily mean that the network properties function in better ways. Regardless of other conditions, it refers to the extent to which an actor (here, an engine plant) is centrally positioned in technical terms.

From the learning by doing perspective, certain positions with better connections would contribute to organizations’ learning by doing processes. The learning process of this is that through the relations of the auto model application network, engine plants may have chances to see how other plants work, and so to be given knowledge that the focal plant had not yet captured within its own boundaries. Returning to the illustration of the Ford engine plants network (Figure 3), *Cleveland #2* plant shares auto model application relations with all other Ford plants except for the isolated one, directly or indirectly. Technically, this means that *Cleveland #2* is more central than other plants, and therefore it should have more chances to learn from the others for its learning by doing activities. Conversely, *Dearborn* plant (FD05) has only one direct relation, with *Chihuahua* plant (FD01), and is also located at the periphery. Thus, *Dearborn* plant is likely to have fewer opportunities to benefit by its network properties. In sum, given that the auto model

application network is by its nature production related, an engine plant located more centrally than others would be benefited by its network properties, with other things being equal. Therefore, I propose my first hypothesis as follows:

Hypothesis 1. The more centrally an engine plant is located in auto model application networks, the more it is benefited by its network properties in its learning by doing activities in terms of knowledge flow.

3.2 Change of part-time worker ratio

From the perspective of experiential learning, the people in an organization are the actual entities who learn from their experience at the workplace. Despite the tremendous speed of the introduction of high technologies to organizations as potential substitutes for comparatively expensive workers, a great number of organizations still maintain a certain degree of human resources for the tasks that are not replaceable in terms of the learning agency. Although the organizational learning idea assumes that an organization—a collective body of people—can be the single agency responsible for its own learning, it is not deniable that the real agents for learning activities are still people, human resources, to a certain point. That is, how an organization deals with its workforce is a crucial factor by which it can enhance its learning by doing (Argote, 1999; Cyert & March, 1963; Epple et al., 1991; Huber, 1991; March & Simon, 1958).

However, to organizations, human resources are a very expensive input for their operational process from an economic viewpoint. And when organizations undergo economic recessions, they cannot but modify their workforce composition. For example, many organizations, regardless of their industries, were enthusiastically participating in the bandwagon-like business practice of downsizing in the 1980s. While they temporarily

enjoyed the profits that were solely derived from the adjustment of their financial ledgers by eliminating the relatively high costs of human resources, this kind of practice, which creates dramatic changes in a workforce, is very problematic from an organizational learning perspective. The automotive industry was not an exception in this kind of human resource-related practice. Figure 4 illustrates the change of total workers in automotive engine manufacturing plants by auto makers, and the worker downsizing trend is clearly visible over this period.

Despite the fact that the downsizing practice is still in use, the importance of the workforce cannot be neglected in terms of organizational learning by doing activities. As March (1991) shows in his legendary simulation study, a high level of worker turnover does significant damage to the effectiveness of exploitative learning activities, which are conceptually aligned with learning by doing. In addition, scholars in learning by doing research commonly point out the importance of the workforce as a factor positively affecting organizational experiential learning as a whole (Adler & Clark, 1991; Argote, 1993, 1999; Epple et al., 1991). Given this, I argue that the change of worker composition is an important factor to affect the extent to which the level of learning by doing is effectively enhanced.

Assuming that downsizing practices may contribute to organizations in terms of financial adjustment as well as achievement of an optimal point of the workforce size, the direct effect of reducing the number of workers almost disappears, in the case of managerial intention to change the workforce composition by increasing the ratio of part-time workers to full-time workers because this would seriously affect the effectiveness of learning by doing.

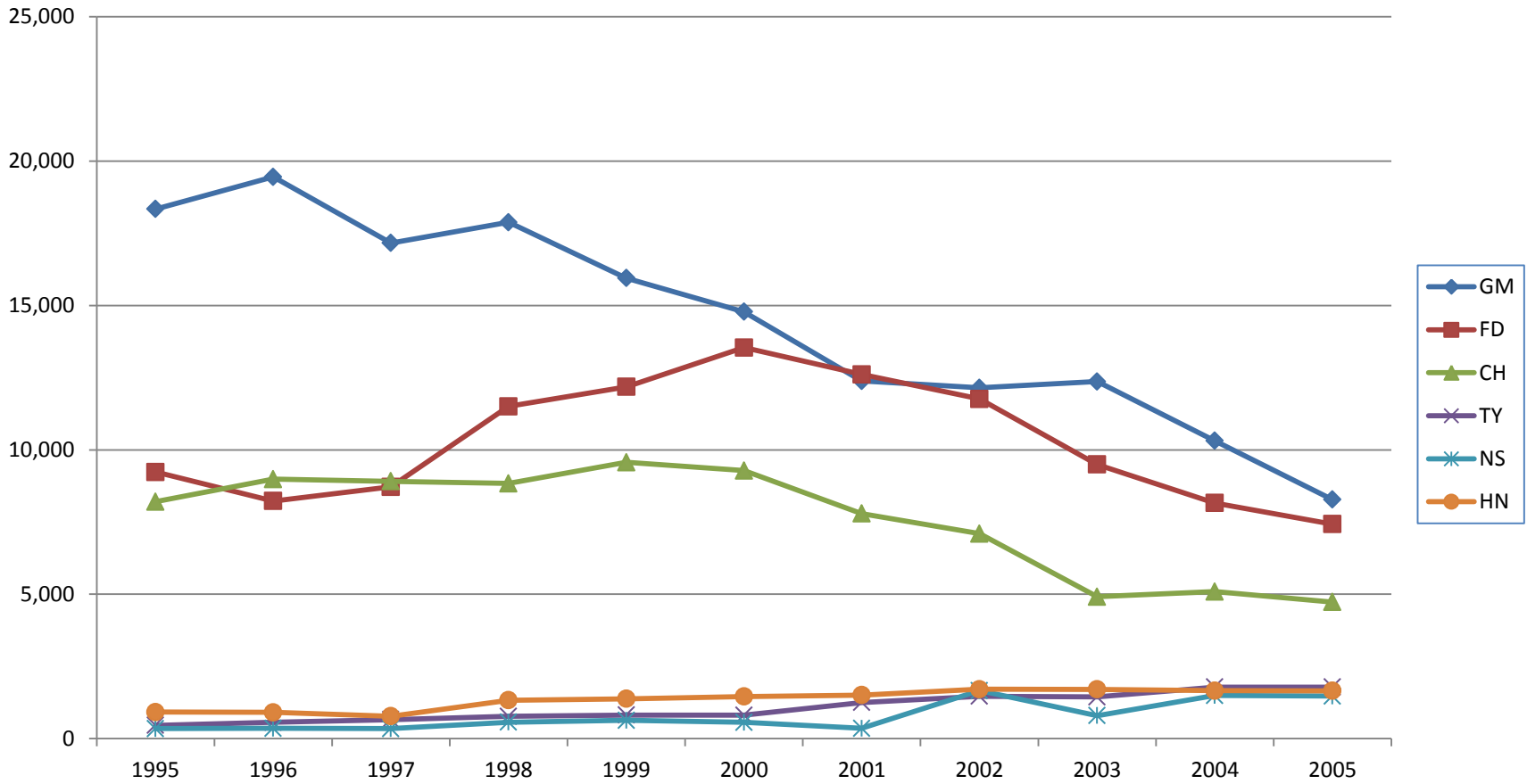


Figure 4. The change of total number of workers of engine plants, 1995–2005

In addition, based on the argument of organizational learning that organizational experience can be transformed into relevant knowledge contributing to organizational learning by doing by stabilized workforces, I also argue that the rapid change of workforce composition would do damage to the effectiveness of learning by doing.

According to the knowledge accumulated by human resource management studies, the contribution of workers to organizations in terms of knowledge creation or innovative actions is triggered by the high motivation of workers who are satisfied with their workplaces. In addition, trustful relationships among workers are a crucial element for the working environment in which workers are motivated to participate in organization-level collective learning. That is, the full-time workers with a satisfactory level of job security derived from their employment conditions would willingly participate in knowledge creation activities, which are part of organizational learning by doing, better than the part-time workers without it. In addition, the workforce composition reflected by the ratio of part-time to full-time workers would affect the trust among workers in that different types of employment conditions between these two groups would damage their trust when the ratio of part-time workers increases. Several empirical studies support this argument. For example, Argote et al. (1990b) reported that turnover of highly skilled workers negatively affects productivity. George (2003) found that a high degree of externalization of workers shows a significant detrimental effect on the internal workers' attitudes toward the workplace. Davis-Blake and Uzzi (1993) showed that the tasks requiring highly skilled knowledge about operations have a negative association with using temporary workers. Therefore, based on my argument along with the empirical findings, I propose:

Hypothesis 2. The increase of the part-time worker ratio has a detrimental effect on the effectiveness of learning by doing, because it may hamper the workforce's willingness to participate in learning activities.

However, it is also obvious that the change of workforce composition is a crucial part of complex managerial decisions regarding the overall activities of organizations due to various reasons. Therefore, an organization may be in a situation where it has to increase the ratio of part-time workers. Here, I pay attention to the contribution of structural conditions within which an organization is located. As earlier argued, the most salient benefit of network properties is the opportunities they provide for knowledge acquisition from outside of organizations. Assuming that the most important role of workforces is to engage in knowledge-intensive tasks, I argue that the proposed detrimental effect of the increase of part-time workers who are unlikely to contribute very much to organizational learning may be compensated for by using good network properties. I argue so because in the knowledge-based view of workforces, taking a good position with relations through which relevant knowledge for the focal plant's operations can flow is very likely to function to compensate for the loss of chances to create internal knowledge. In sum, the effects of a change in workforce composition, captured here by the change of part-time worker ratio, can be contributed to by network properties, even when it is a change in a negative direction. Therefore, I propose my third hypothesis as follows:

Hypothesis 3. The detrimental effect of the increase of the part-time worker ratio on the effectiveness of learning by doing is likely to be compensated for by a use of network properties that provides knowledge benefits.

3.3 In-house manufacturing ratio

As I argued in Section 2.4, another important part of learning by doing is process improvement. In automotive engine manufacturing, process improvement can be identified in a variety of managerial practices. However, in this study, I pay special attention to the externalization of manufacturing as a way of outsourcing the component production to suppliers with which, presumably, the focal organization has trustful relationships. In the automotive industry, one of the most innovative process improvements was made by Japanese car makers such as Toyota (Liker, 2004). Unlike the U.S. automakers that continued to rely on the traditional mass production process until the early 1990s, Japanese automakers had, by the early 1960s, already begun to improve on that traditional mass production, which inevitably increases the level of complexity of the production process by keeping everything within one plant (Womack et al., 1990). The solution Japanese car makers chose was to externalize production processes to suppliers based on long-term stabilized supply contracts. Obviously, this solution was possible because the standardization of production had reached externalizable levels. The principal outcome of externalized production is productivity improvement (Liker, 2004; Womack et al., 1990). This outcome can be recognized by the clear difference between the U.S. automakers and the Japanese automakers in their average productivity, presented in Figure 2. It is generally accepted by industry practitioners that this noticeable difference mainly resulted from Japanese carmakers' production practices, which relied on trustful supply chains. Figure 5 illustrates the trend plots of in-house manufacturing ratios, measured as the ratio of the number of engine components manufactured in-house to the total number of components, by automaker,

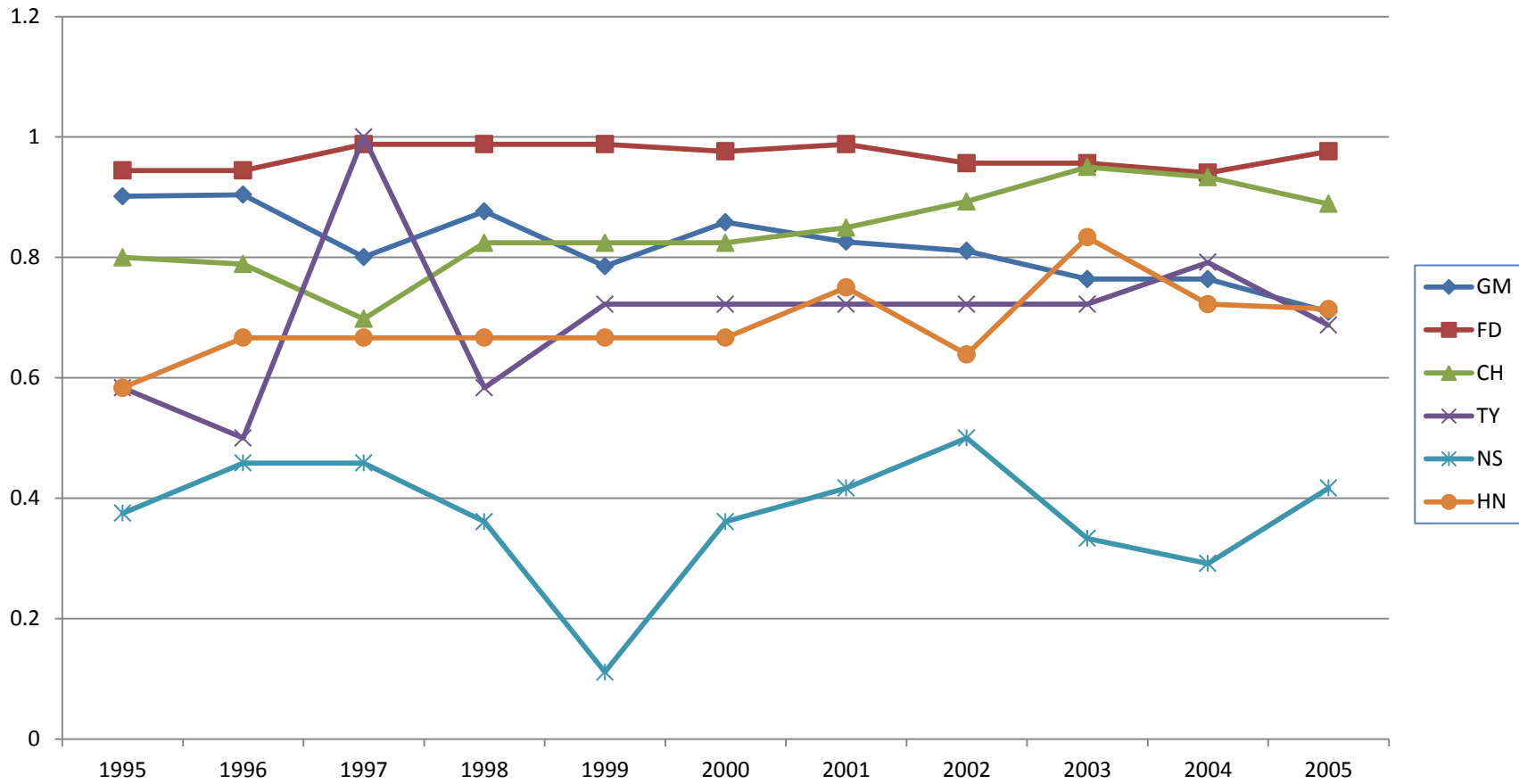


Figure 5. Average in-house manufacturing ratio, 1995–2006

over the observation period of this study. Intriguingly, it supports the common idea that U.S. automakers tend to maintain in-house production while Japanese automakers utilize outsourced production.

From an organizational learning perspective, the externalization of production processes can be conceptually understood as giving focal plants extra resources by which the plants can pay more attention to the unexploited parts of internal production processes. Conversely, I argue that because plants that maintain more production processes within their boundaries still have to deal with various production-related problems that otherwise would be externalized, they may not have opportunities to focus on new knowledge creation. As previous learning studies argue (Adler & Clark, 1991; Argote, 1999; Argote et al., 1990a; Epple et al., 1991; Lapré & Nembhard, 2010), the improvement of managerial practices regarding production is an important factor. I argue that in the automotive manufacturing context in particular, this improvement can be accomplished by the externalization of production. Given this, I also argue that a plant maintaining its production processes within its boundaries is more likely to find it difficult to utilize its opportunities of internal learning. Therefore I propose my fourth hypothesis as follows:

Hypothesis 4. An engine plant with a higher level of in-house manufacturing is more likely to suffer difficulties in enhancing the effectiveness of learning by doing, because it has less chances to focus on yet unexploited areas of experiential learning.

As discussed above, I argue from the viewpoint of organizational learning that the problems that a plant with a high level of in-house manufacturing may have are primarily

due to its lack of opportunities to carry out appropriate learning by doing activities. To look into the possible interaction effect of the in-house manufacturing ratio and network properties, I assume that knowledge that may be more exploited inside of the plant through the externalization of production processes is clearly production-oriented knowledge. As argued in Section 2.2, whether or not network properties contribute to the productivity improvement of the focal plant depends on the contingent characteristics of the processes. In the externalization of production processes, one contingent feature is the relevance of knowledge to productivity. Also, as discussed above, by externalizing parts of production processes, a plant is given opportunities to focus on the remaining areas to be exploited. Therefore, I argue that an engine plant that still maintains a large portion of the production within its boundaries is likely to seek externally for knowledge it would otherwise easily obtain within its boundaries. So this effort of knowledge seeking in the network seems aligned with the contingent network feature of knowledge relevance.

Hence, I here propose:

Hypothesis 5. The difficulty of enhancing the effectiveness of learning by doing due to a high level of in-house manufacturing is likely to be overcome by network properties that may provide opportunities to obtain knowledge from networks.

3.4 Quality control

As discussed in Section 2.5, organizations tend to set multiple goals. In the automotive manufacturing context, great attention is also paid to quality control. In particular, to achieve market success, quality control may be the most important goal for automakers to try to accomplish. As Rhee and Haunschild (2006) examine in depth, automakers' overall quality control over their products is responsible for a great part of

their reputations in the market. In addition to internal assessment of products by the automaker, many quality assessment systems exist in the automotive industry. Therefore, the goal of maintaining good quality products in the automotive manufacturing context is a far too complicated goal for engine plants to cope with. Given this, I pay attention to quality control as another goal that plants must deal with along with productivity enhancement. Much previous research examining quality control in the automotive industry points out the distinctive characteristics of quality control, particularly compared with productivity enhancement (Levin, 2000; Li & Rajagopalan, 1998; MacDuffie et al., 1996).

In the automotive industry, the ways to assess how well a manufacturing plant deals with quality control vary. In this study, I mainly focus on quality as it is perceived by the market because quality assessment by external institutions with authority in the market provides a good gauge with which different plants can be fairly assessed and compared (MacDuffie et al., 1996; Rhee, 2009; Rhee & Haunschild, 2006). Because this kind of quality is also used by engine plants to learn the extent to which they reach a satisfactory level, market-perceived quality is also a good measure to see the actual quality of products as the outcome of internal quality control processes. Considering that the market assessment of quality is conducted on an auto model basis, I define the overall quality of an engine plant based on how the qualities of each product are dispersed, on the assumption that a plant with good quality control tends to acquire even quality assessment at a higher level.

According to attention allocation theory, which is part of the behavioral theory of the firm (Cyert & March, 1963), an organization has to choose which goals are allocated

more attentions, due to its feature of bounded rationality and given multiple goal situations (Ocasio, 1997, 2010). In terms of attention, it is very hard for an organization to be a jack of all trades because attention is also a very limited resource. However, it has actually been witnessed in the automotive industry that Japanese automakers do better on both quality control and productivity enhancement. Figure 6 illustrates how each automaker was assessed on its product quality over the observation period. As the figure shows, the extent to which the U.S. automakers' average quality control is achieved is lower than that of Japanese automakers.

Given this industry's characteristics regarding quality control, I pay particular attention to the failure of quality control. As argued above, multiple goals compete for organizational attention. In the case that a goal is not well achieved and the organization recognizes that the failure is not easy to recover in the short term, I argue that the organization is likely to allocate the attention that would have gone to the failed goal to other goal-achieving activities. It is known that quality perceived by markets is not easily recovered by enhancing the internal processes regarding quality, particularly in the automotive industry (Rhee & Haunschild, 2006). Given this hardship, an engine plant with lower quality assessment from the market is likely to pay more attention to productivity enhancement to compensate for the failure in quality control. This logic of attention allocation is supported by research at the individual level on behaviors in a multiple goal situation (Kernan & Lord, 1990). Therefore, I propose:

Hypothesis 6. An engine plant having trouble in quality control is more likely to pay attention to productivity enhancement activities, because it would allocate its attention to productivity enhancement to compensate for the failure in quality control.

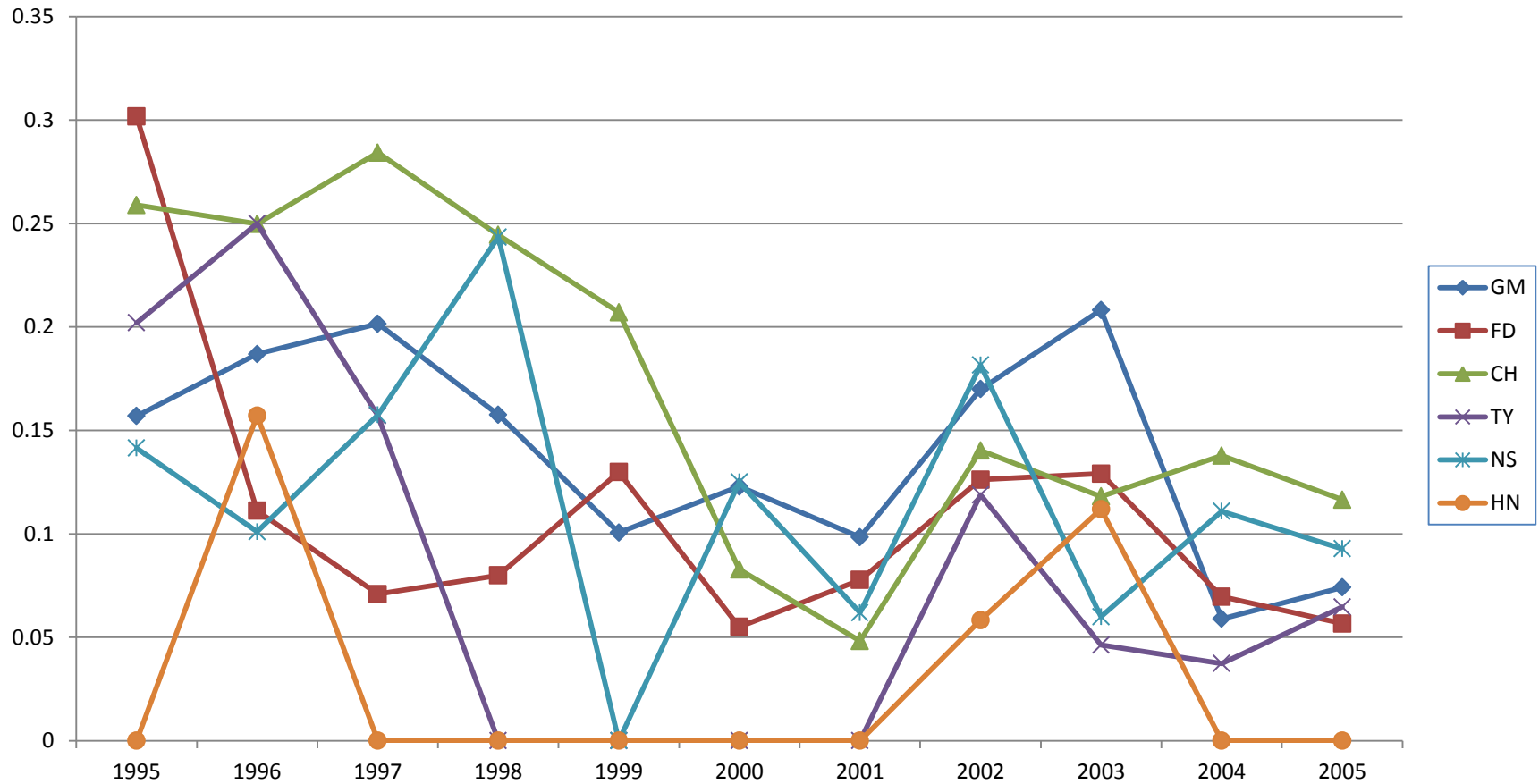


Figure 6. Average CV of consumer ratings, 1995–2005

In this study, to see the effect of network properties on the association between internal activities and learning by doing, I pay attention to the contingent features of each internal activity. Unlike the previous two factors, workforce composition ratio and in-house manufacturing ratio, which are closely related to productivity enhancement, quality control has distinctive characteristics in terms of purpose-based contingency. Due to this, the effect of network properties on the extent to which quality control is achieved may differ from their effect on the other two factors. As argued above, quality control is different from productivity enhancement in various ways.

Therefore, assuming that an organization having good connections in the network of current interest tends to focus on productivity-related knowledge and the network contributes in such ways, network properties that are good for production-related knowledge are likely to function in the opposite way for quality control. For example, the knowledge that flows through the network of production tends to be irrelevant to quality control, and overflow knowledge about production would distract the plant, such that the attention removed from a quality control failure cannot transfer smoothly to productivity-enhancing activities. Therefore, I propose:

Hypothesis 7. The focus on productivity enhancement activities that results from a failure of quality control is likely to be distracted by network properties due to the goal difference contingencies.

Because of the different effects of network contingencies on productivity goals and quality control goals, attention to productivity enhancement activities is likely to be lower if it is available as the result of a failure of quality control; likewise, productivity-related knowledge made available through network relations is likely to be less valuable for quality control.

CHAPTER 4

METHODS

4.1 Data and sample

The data of this study is based on information about automotive engine manufacturing plants operated in the North American region from 1995 to 2006. The data was collected primarily from *The Harbour Report*, an in-depth report about automotive manufacturing plants in North America that has covered worker involvement, technology, level of product complexity, process design, layout, and so forth, from a multi-year perspective since 1981 (<http://www.theharbourreport.com>). It comprehensively provides useful information not only for practitioners in the automotive industry who conduct “meaningful analysis to benchmark performance, develop strategies, and improve operations, but also for academics who conduct academic research in the context of the automotive industry” (<http://www.theharbourreport.com>). Other recent empirical studies conducted in an automotive manufacturing setting have used this report (Cachon & Olivares, 2010; Levin, 2000), and the present study also uses it as a main source for operation-related information and data regarding the manufacturing processes of automotive engine plants. In this study, the research period begins in 1995 mainly to make sure of the continuity of data over the years, because the report substantially changed its data collecting scheme beginning in 1995 (*The Harbour Report*, 1995).

Additionally, to collect information about quality control, this study uses *Consumer Reports* (<http://web.consumerreports.org>), a magazine widely used in previous research that focuses on product quality (Rhee, 2009; Rhee & Haunschild, 2006). In particular, *Consumer Reports* annually publishes a special issue about car products

selling in American markets, which includes comprehensive consumer rating scores specifically on the engine parts applied to the auto models on the market. This rating information is a good source to see how well the quality control of engine manufacturing plants was accomplished in the given research period.

The sample includes 41 engine manufacturing plants in the target region from 1995 to 2006. Among the engine plants in the sample, 31 engine plants are owned and operated by the so-called “Big Three” automakers of American origin (12 GM plants, ten Ford plants, and eight Chrysler plants), and the rest are owned by automakers of foreign origin (four Toyota plants, three Nissan plants, two Honda plants, and one Volkswagen plant). As the data is from the plant level over 12 years, the sample consists of panel data in which the unit of analysis is defined as year-plant. Given that some plants discontinued operation and others began to operate during the research period, the actual sample size used in the analysis is 364 year-plant units, which is lower than the simple product of 41 by 12 (= 492). Thus, the data for this study is in an unbalanced longitudinal panel.

4.2 Dependent variable: Productivity

Following the tradition of the learning curve literature that explores experiential learning processes by focusing on cost-related productivity (Argote, 1999; Argote & Epple, 1990), I measured productivity as hours per engine (HPE, hereafter) as reported by *The Harbour Report*. Previous research on automotive manufacturing plants tends to use labor-oriented cost productivity as a proxy for cost productivity, due to the difficulty of directly identifying manufacturing cost in a more comprehensive way (Epple et al., 1991; Epple et al., 1996; Lapré & Nembhard, 2010). However, labor cost productivity, usually calculated as total employment by production, has the shortcoming that it fails to account

for overtime labor, which often occurs in the automotive manufacturing industry (Goyal et al., 2006).

To overcome this, this study uses the HPE provided by *The Harbour Report*, which is the total actual hours paid divided by the actual units produced in a year. This measure is more advantageous than the total employment per production measure for capturing cost productivity, and therefore is well-accepted by the industry as well as in academic research (MacDuffie et al., 1996). As this measure is cost based, a smaller figure represents higher productivity.

4.3 Independent variables

4.3.1 Part-time worker ratio change

The numeric information of the workers for each plant was obtained from *The Harbour Report*. To examine the effect of change in the workforce composition in terms of the ratio of the number of part-time workers to that of total workers in a given year, I measured the change of the ratio as follows:

$$\text{Change of part-time worker ratio} = \frac{PR_t - PR_{t-1}}{PR_{t-1}},$$

where PR refers to the ratio of the number of part-timer workers to that of the total workers (including both full-time and part-time workers) of a plant; t refers to the given year and $t-1$ stands for the previous year. The arithmetic rate of change is widely used in previous research as a measure of the change of a target construct over time, and therefore my measure of part-time worker ratio change is appropriate to see how a plant revises its workforce in terms of part-time to full-time workers compared to the previous year. A positive sign in this measure means that the part-time worker ratio of a plant

increases compared to the previous year, while a negative sign means that the part-time worker ratio decreases compared to the previous year.

4.3.2 *In-house manufacturing ratio*

The information on how a plant produces its products in terms of the extent to which it manufactures components of a product within its boundaries is also based on *The Harbour Report*. The report conducts yearly surveys of each plant, recording whether it relies on in-house manufacturing processes or outsourcing for the strategic components of engine products, which are classified into six categories (assembly and test, cylinder block, cylinder head, camshaft, conn rod/cap, and crankshaft). The information was collected by the report in a systematic manner over the years covered by this study. Using this information, I first constructed a quantified measure for each subprocedure of engine production by allocating the value of 1 if a subprocedure of production is done in house or 0 if it is not. Next, to capture the extent to which a plant relies on in-house manufacturing processes in producing the components of engine products as a whole, I constructed a ratio measure in which the number of components produced in house is divided by the total number of the components applied to the final engine product. For example, if a plant operates three production procedures in house, it is given the value 0.5 (= 3/6). The greater this measure, the more a plant relies on in-house manufacturing.

4.3.3 *Quality control*

To measure the extent to which quality control is accomplished by a plant, I used the information of consumers' ratings on engine products provided by *Consumer Reports*. *Consumer Reports* annually conducts a comprehensive survey on the quality satisfaction of consumers in the North American market from the overall quality of each auto model

to the more specific quality of the parts of the model, such as the engine and transmission. These ratings are published as *Consumer Reports: Buying Guide*, which contains the very detailed results of the consumer survey on most auto models that sell in the American market.

The size of the survey in terms of the number of respondents in 2006, for example, was around 800,000, and it covered more than 200 auto models. Among consumers' ratings on specific parts of each auto model, I chose to use the consumers' ratings on engine quality, as the focus of this study is on the engine products. This annual report is a reliable source used not only by consumers to make judgments on whether or not to purchase a particular auto model, but also by both practitioners and academic researchers to conduct empirical research about product qualities (MacDuffie et al., 1996).

The rating scheme of *Consumer Reports* is as follows. *Consumer Reports* first collects the quality information by asking if the respondents experienced serious problems on the target parts of the cars they used over the past year and giving the results as percentage-based categories of 2.0% or less, 2.0–5.0%, 5.0–9.3%, 9.3–14.8%, and more than 14.8%. The way the report presents consumers' rating scores is similar to that of a five-point scale with a different graphical symbol for each category. Given this, this study reconceptualizes the rating score as a five-point scale with the value of 5 as the highest.

The rating scores of engine products given by the report are basically auto model based. Therefore, I match the rating scores of the models to the engine plants by using *The Harbour Report's* information on which models use which engine plant's products.

In this data arrangement, each plant is given multiple scores for the consumers' ratings on the products it produces.

Based on these rating scores, I measured the extent of successful quality control of a plant as the coefficient of variation of the rating scores that the plant obtained from consumers because the evenness of quality control of multiple products is a crucial goal of quality control. Coefficient of variation is a well-accepted measure to see how dispersed a construct of interest is in the distribution of the construct (Harrison & Klein, 2007), so it is also appropriate for this study to capture how evenly a plant achieves quality control over the products it produces. Unlike the quality control measures that each plant may arbitrarily set, which would be inappropriate to apply to all the plants, the quality measure of the current study is more valid, in that it is both systematically collected by a reliable institution over all products on the market, and comparable among the plants included in the study.

4.3.4 *Network properties*

To compute the network measures of interest, I first constructed a set of two-mode matrices in which engine plants take one side and the auto models to which the plants applied their engine parts take the other side. The information for the two-mode matrices was from the yearly issues of *The Harbour Report* that specifically report to which auto models each plant applies its engine products. By using UCINET IV (Borgatti, Everett, & Freeman, 2002), I converted the two-mode matrices into one-mode adjacency matrices in which engine plants are identified as nodes and the auto models to which a pair of plants commonly apply engine products are identified as relations. The adjacency matrices were constructed for each year over the observation period of 1995 to 2006;

therefore, each yearly matrix represents the model co-application network structure for each year. Prior to computing the following centrality measures to see how a plant is positioned in the network, I also dichotomized the adjacency matrices, so the relations between plants in each yearly matrix are coded as 1 if a pair of plants shares at least one auto model, and is otherwise coded as 0. I did so primarily because the following centrality measures are originally constructed on the basis of binary relations and also because the current study pays particular attention to the presence of a relation between plants, not to the strength of the relations.

4.3.4.1 Degree centrality

The first network property of interest is degree centrality, or how a plant is positioned in a model co-application network in terms of connectivity. Formally, degree centrality is computed as the number of direct relations that a node has in a local ego-centered network (Wasserman & Faust, 1995). Previous research has extensively used this measure to see how well connected a social actor is within the local context of a network (Powell et al., 1996), so it is also relevant for the present study to use, given that the study focuses on the positional properties of networks in terms of connectivity. I again used UCINET IV to compute degree centrality. This measure is also one year lagged to make sure that the time-based causality is incorporated in the following analysis.

4.3.4.2 Closeness centrality

In addition to degree centrality, by which the positional property of a plant can be measured in a local context, I also used closeness centrality in the analysis in order to effectively see the connectivity of a plant in a broader context of relations. Closeness

centrality is a measure suggested by Freeman (1979) that can investigate how closely a social actor is connected to other actors in a global network, both directly and indirectly. According to Wasserman and Faust (1995), closeness centrality is a good measure to see the effectiveness of knowledge flow in network structures. Previous research also confirms the validity of this measure of how well social actors are connected in broader network contexts with the purpose of knowledge flow (Gulati, 1999; Powell et al., 1996).

4.4 Control variables

I controlled for several factors that may affect an engine plant's labor hour per product and its change, as follows. First, I included a dummy variable that indicates *left-censored* cases in the data (1 refers to left-censored cases). As already explained, the research period is limited by the change of *The Harbour Report's* data collecting scheme. Some engine plants began to operate before my observation begins, so I controlled for this by including this indicating variable. Second, to capture any time trend effect associated with the change rate of labor hour per product, I included a variable measuring *years elapsed* from the beginning year of observation, 1995. Third, I created a dummy variable for the engine plants operated by *foreign automakers* with the plants of the U.S. automakers, because foreign automakers' engine plants may apply different managerial skills than domestic plants would.

Fourth, I also controlled for *age* because prior research has examined the effects of aging on the behavioral processes of organizations (e.g., Sorenson & Stuart, 2000). An engine plants' age was measured as the difference between the current year and the year the plant was founded. Fifth, I included the plants' *size* because size is also a well-

established factor that affects various behaviors of organizations. Size was measured as the number of employees in the current year.

Fifth, I included the *number of engine products* manufactured by the plants (Kekre & Srinivasan, 1990). Sixth, the *number of auto models* to which products are applied was controlled, based on the findings of previous empirical research that product variety affects productivity outcome (MacDuffie et al., 1996). Seventh, I controlled the *number of yearly production*.

Finally, I included the *number of cumulative production* not only because it is consistently used as a proxy of the extent that organizations learn from their operational experience but also because it affects organizational productivity (Argote, 1999). Following the convention of organization learning curve literature that extensively investigates this variable, I took the natural logarithm of the variable.

4.5 Model specification and estimation

To examine the effects of the proposed factors on the experiential learning outcome, which is defined as cost productivity enhancement in this study, I model the change rate of an engine manufacturing plant's productivity by using the following power function:

$$HPE_{i,t} = HPE_{i,t-1}^{\alpha} \exp(\gamma' INF_{i,t-1} + \delta' NTF_{i,t-1} + \lambda' INT_{i,t-1} + \beta' CTRL_{i,t-1}) \varepsilon,$$

where, $HPE_{i,t-1}$ is the hour per engine productivity of engine plant i at year $t-1$; $INF_{i,t-1}$ refers to the internal factors affecting productivity change, which are part-time worker ratio change, in-house manufacturing ratio, and quality control; $NTF_{i,t-1}$ refers to the network properties, which are degree centrality and closeness centrality in this study;

$INT_{i,t-1}$ designates a set of interaction terms between each internal factor and network property; $CTRL_{i,t-1}$ is a vector of control variables; ε is a log normal error term.

To effectively conduct the estimation, I transform the power function by taking the natural logarithm on the function, and obtaining the following linear equation with a normally distributed error term, μ :

$$\ln(HPE_{i,t}) = \alpha \ln(HPE_{i,t-1}) + \gamma' INF_{i,t-1} + \delta' NTF_{i,t-1} + \lambda' INT_{i,t-1} + \beta' CTRL_{i,t-1} + \mu$$

I estimate the parameters of this logarithm transformed equation by using the unbalanced panel data of the engine plants with yearly based periods. Following recent analyses of longitudinal data (e.g., Boone, Carroll, & Van Witterloosetuijn, 2004; Dobrev et al., 2001; Rhee, 2009; Rhee & Haunschild, 2006; Sullivan, Haunschild, & Page, 2007), this study chooses generalized estimating equations (GEE) in the following analyses to make use of a widely accepted merit of the method, which is that it gives robust estimators that see both inter- and intra-plant variation over multiple years by suggesting a set of solutions that are consistent and asymptotically Gaussian, even when the time dependence is not properly specified (Frees, 2004; Hardin & Hilbe, 2000; Liang & Zeger, 1986). This method also uses the quasi-likelihood approach to analyze the longitudinal data, which specifies the relationship between the mean and the variance of the dependent variable, rather than the full distribution of population.

Technically, I use the XTGEE function included in STATA 10 to conduct the analysis based on the GEE method. To appropriately conduct GEE estimation, several options should be set according to the characteristics of the structure of longitudinal panel data. The first option, about the distribution of the dependent variable, is set as Gaussian because I assume the dependent variable of the present study has a distributional shape

close to that of normal distribution. The next option to set is about the link function, and I choose identity in this option because the dependent variable also is continuous. Lastly, GEE estimation allows the researcher to consider different serial correlation structures and requires the specification of a working correlation matrix. I set this option as independent after close observation of the serial correlation structure of the data.

CHAPTER 5

RESULTS

Descriptive statistics and correlations for the variables used in the analyses of this study are presented in Table 1 and Table 2, respectively. Because the model of the current study is constructed with one year lagged treatment in explanatory variables, the number of the data that is actually used in the analyses decreases to 291. Additionally, due to the occurrence of missing values in the procedure of calculation, the number of some variables included in the analyses is smaller than 291 (see the notes of Table 2 for details). Table 2 shows that there are some fairly high correlations. For example, size has high correlations with other variables such as age, number of products, number of auto models, and production-related variables. This is not very difficult to understand, given the well accepted fact that size tends to interact with these variables.

To check whether there is any multicollinearity problem in the following analyses, I conducted a variance inflation factor (VIF) test. The VIF scores for each variable ranged from 1.05 to 8.22, indicating that the variables have relatively weak multicollinearity. The average VIF score for the main models reported in Table 3 to Table 6 ranges from 3.42 to 3.56, all of which fall below the threshold of serious multicollinearity (typically 10). Thus, multicollinearity does not appear to be problematic in this analysis.

Table 1. Descriptive Statistics

Variables	N	Mean	S.D.	Min	Max
Logged HPE productivity	291	1.50	0.44	-0.21	3.65
Elapsed years	291	6.05	3.15	1	11
Left censoring	291	0.91	0.29	0	1
Foreign automaker	291	0.17	0.38	0	1
Size	291	1,303.84	808.09	83	4,022
Age	291	34.74	24.93	2	101
Number of products	291	2.23	1.45	1	8
Number of auto models	291	6.89	4.75	1	26
Annual production (in thousands)	291	490.65	340.63	10.25	1,899.57
Logged cumulative production	291	14.37	1.05	9.24	16.65
Change of part-time worker ratio	252	0.00	0.03	-0.11	0.11
In-house manufacturing ratio	286	0.82	0.23	0.00	1.00
CV of consumer ratings on products	254	0.13	0.12	0.00	0.71
Degree centrality	291	2.41	1.83	0	8
Closeness centrality	291	3.48	1.46	0	5

Notes: All variables are one year lagged except for Logged HPE productivity, the dependent variable in the analysis.

Table 2. Pearson Correlation Coefficients

(N = 291)

Variables	1.	2.	3.	4.	5.	6.
1. Logged HPE productivity						
2. Elapsed years	-0.35					
3. Left censoring	0.18	-0.27				
4. Foreign automaker	-0.55	0.10	-0.24			
5. Size	0.23	-0.21	0.24	-0.38		
6. Age	0.16	-0.02	0.38	-0.38	0.48	
7. Number of products	0.01	0.13	0.18	0.14	0.48	0.14
8. Number of auto models	0.05	0.16	0.19	-0.25	0.63	0.29
9. Annual production (in thousands)	-0.13	-0.01	0.14	-0.08	0.81	0.34
10. Logged cumulative production	-0.29	0.60	0.21	-0.10	0.44	0.38
11. Change of part-time worker ratio ^a	0.14	-0.24	0.03	0.02	0.06	-0.09
12. In-house manufacturing ratio ^b	0.34	-0.01	-0.09	-0.47	0.24	0.24
13. CV of consumer ratings on products ^c	0.12	-0.25	0.09	-0.23	0.21	0.04
14. Degree centrality	0.20	-0.06	0.12	-0.44	0.55	0.32
15. Closeness centrality	0.14	0.06	-0.02	-0.43	0.29	0.26

(continued.)

Variables	7.	8.	9.	10.	11.	12.
8. Number of auto models	0.48					
9. Annual production (in thousands)	0.57	0.74				
10. Logged cumulative production	0.47	0.53	0.60			
11. Change of part-time worker ratio ^a	-0.05	-0.06	-0.02	-0.15		
12. In-house manufacturing ratio ^b	-0.07	-0.03	0.05	0.15	0.06	
13. CV of consumer ratings on products ^c	0.08	0.16	0.11	-0.04	-0.06	0.02
14. Degree centrality	0.14	0.65	0.50	0.23	0.02	0.12
15. Closeness centrality	-0.13	0.32	0.12	0.09	0.04	0.11

(continued.)

Variables	13.	14.
14. Degree centrality	0.04	
15. Closeness centrality	0.07	0.63

Notes: All variables are one year lagged except for Logged HPE productivity, the dependent variable in the analysis. *N* for the correlation scores of some variables differs from 291 due to missing cases in each variable (^a *N* = 252, ^b *N* = 286, ^c *N* = 254). All correlations are significant at the $p < 0.05$ level, except that the score is lower than 0.11.

It is worth noting that my three main variables (change of part-time worker ratio, in-house manufacturing ratio, and CV of consumer ratings on products), which were earlier proposed to affect experiential learning processes, have saliently lower correlations in each pair. This supports my assumption that each factor is conceptually independent from each of the others. Thus, the hypotheses developed about each variable do not overlap, at least in terms of the empirical approach. Likewise, each factor affecting internal learning processes has a notably low correlation with both degree centrality and closeness centrality. This can be interpreted to mean that a plant's capabilities regarding internal learning processes do not directly correlate with its network positional characteristics, supporting the assumptions that the capabilities accumulated through internal efforts to enhance productivity are theoretically independent from those provided by social conditions.

5.1 Network properties

Model 1 in Table 3 is the basic model that contains control variables. The plants owned and operated by foreign auto makers, most of which are of Japanese origin, are better at enhancing cost productivity than the American automakers, so this confirms the commonly accepted belief about the automotive industry that Japanese automakers are ahead of American automakers in their practices of productivity management. A noteworthy finding from Model 1 is that the logged cumulative production significantly contributes to productivity enhancement. As mentioned in Section 4.4, this variable is that which most learning curve studies have generally used as a crucial proxy variable by which they examine the effect of operation-related experience due to the difficulty of

Table 3. GEE Estimates of Productivity, 1995–2006 (Network Properties)

Variables	Model 1	Model 2	Model 3
Logged HPE productivity	0.28** (0.03)	0.29** (0.03)	0.27** (0.03)
Elapsed years since 1995	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)
Left-censored cases	0.18** (0.07)	0.17** (0.07)	0.16* (0.07)
Foreign automaker	-0.39** (0.05)	-0.41** (0.05)	-0.40** (0.05)
Size	0.00** (0.00)	0.00** (0.00)	0.00** (0.00)
Age	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Number of engine products	0.06** (0.01)	0.06** (0.01)	0.06** (0.01)
Number of auto models	0.00 (0.01)	0.01 (0.01)	0.01 (0.01)
Annual production	-0.00† (0.00)	-0.00† (0.00)	-0.00* (0.00)
Logged cumulative production	-0.26** (0.03)	-0.27** (0.03)	-0.26** (0.03)
Degree centrality		-0.02* (0.01)	
Closeness centrality			-0.02* (0.01)
(Constant)	4.38** (0.37)	4.53** (0.37)	4.50** (0.37)
<i>N</i>	291	291	291
Wald chi-square	625.33**	638.20**	637.59**
<i>d.f.</i>	10.00	11.00	11.00

Notes: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$ (two-tailed tests). Robust standard errors are in parentheses. All the variables in models are one year lagged.

identifying the direct factors absorbed in various types of operational experience (Argote, 1999; Argote & Miron-Spektor, 2010). The consistent significance of cumulative production over most of the following models confirms the findings of previous research again in the analyses of the current study.

Models 2 and 3 in Table 1 present the results of the main effect of network properties measured by degree centrality and closeness centrality, respectively. The negative significance of each variable shows that the more centrally a plant is positioned in its co-application network structure, the more likely it is to enhance its cost productivity, given that the smaller figure of the dependent variable implies better productivity. This supports Proposition 1 that network properties, by providing opportunities to access relevant knowledge that resides in network conduits, may contribute to organizations' learning by doing activities. Based on this support for Proposition 1, Hypothesis 1, regarding the beneficial effects of network properties on the effectiveness of engine plants' learning by doing, is also supported by Models 2 and 3, where both degree centrality and closeness centrality are included.

5.2 The change of part-time worker ratio

In Table 4, to test the hypotheses regarding both main effect of the change of part-time worker ratio and the interaction effects of the part-time worker ratio and the network properties, I present the results from GEE estimators of HPE productivity by including the explanatory variables regarding the hypotheses. *N* here becomes a bit smaller (*N* = 252), due to some missing cases in the process of generating the change of part-time worker ratio, which includes two continuous years' information of the ratio in calculation.

Table 4. GEE Estimates of Productivity, 1995–2006 (Part-timer Ratio)

Variables	Model 4	Model 5	Model 6
Logged HPE productivity	0.92** (0.02)	0.91** (0.02)	0.92** (0.02)
Elapsed years since 1995	-0.01 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Left-censored cases	0.03 (0.03)	0.05 (0.03)	0.04 (0.03)
Foreign automaker	-0.01 (0.02)	-0.01 (0.02)	-0.00 (0.03)
Size	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Age	0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)
Number of engine products	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)
Number of auto models	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Annual production	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Logged cumulative production	0.00 (0.02)	-0.01 (0.02)	-0.00 (0.02)
Change of part-time worker ratio	0.44 [†] (0.25)	1.37** (0.36)	1.59** (0.56)
<i>Network properties</i>			
Degree centrality		-0.00 (0.00)	
Closeness centrality			0.00 (0.01)
<i>Interaction terms</i>			
Change of part-time worker ratio X Degree		-0.58** (0.16)	
Change of part-time worker ratio X Closeness			-0.36* (0.16)
(Constant)	0.04 (0.22)	0.18 (0.22)	0.11 (0.22)
<i>N</i>	252	252	252
Wald chi-square	4461.99**	4717.43**	4565.99**
<i>d.f.</i>	11.00	13.00	13.00

Notes: [†] $p < 0.10$, * $p < 0.05$, ** $p < 0.01$ (two-tailed tests). Robust standard errors are in parentheses. All the variables in models are one year lagged.

As discussed in Proposition 3 and presented in Hypothesis 2, the result of Model 4 shows that HPE productivity becomes lower when a plant changes its workforce composition in the direction that the workforce consists of more part-time workers than before, at a mild significance level of $p < 0.10$.

In Models 5 and 6, I include the interaction terms of the change of part-time worker ratio and degree centrality and closeness centrality, respectively, to test Hypothesis 3, which is developed based on Proposition 3. As shown, both interaction terms of the centralities have significant negative effects at the level of $p < 0.05$, at least. I interpret the findings of Models 5 and 6 to indicate that network properties lead the plants to overcome the detrimental effects of the increase of the part-time ratio by making them willing to utilize the relational properties of their networks. To make the findings easier to understand, I draw the interaction graphs of the change of part-time worker ratio and each centrality in Figures 7 and 8, respectively. In both figures, the solid line represents the smaller extent of network connectivity (degree centrality = 1 and closeness centrality = 1), the long dashed line the medium extent (degree centrality = 4 and closeness centrality = 3), and the short dashed line the larger extent (degree centrality = 8 and closeness centrality = 5). The choice of each extent is based on the descriptive statistics of each centrality (minimum value as the smaller and maximum as the larger). The range of the change of part-time worker ratio on the x -axis is decided by its minimum and maximum values. As the smaller extent of both centralities, the increasing trend of the solid lines confirms the negative effect of the increase of part-time worker ratio, as examined in Model 4 as well.

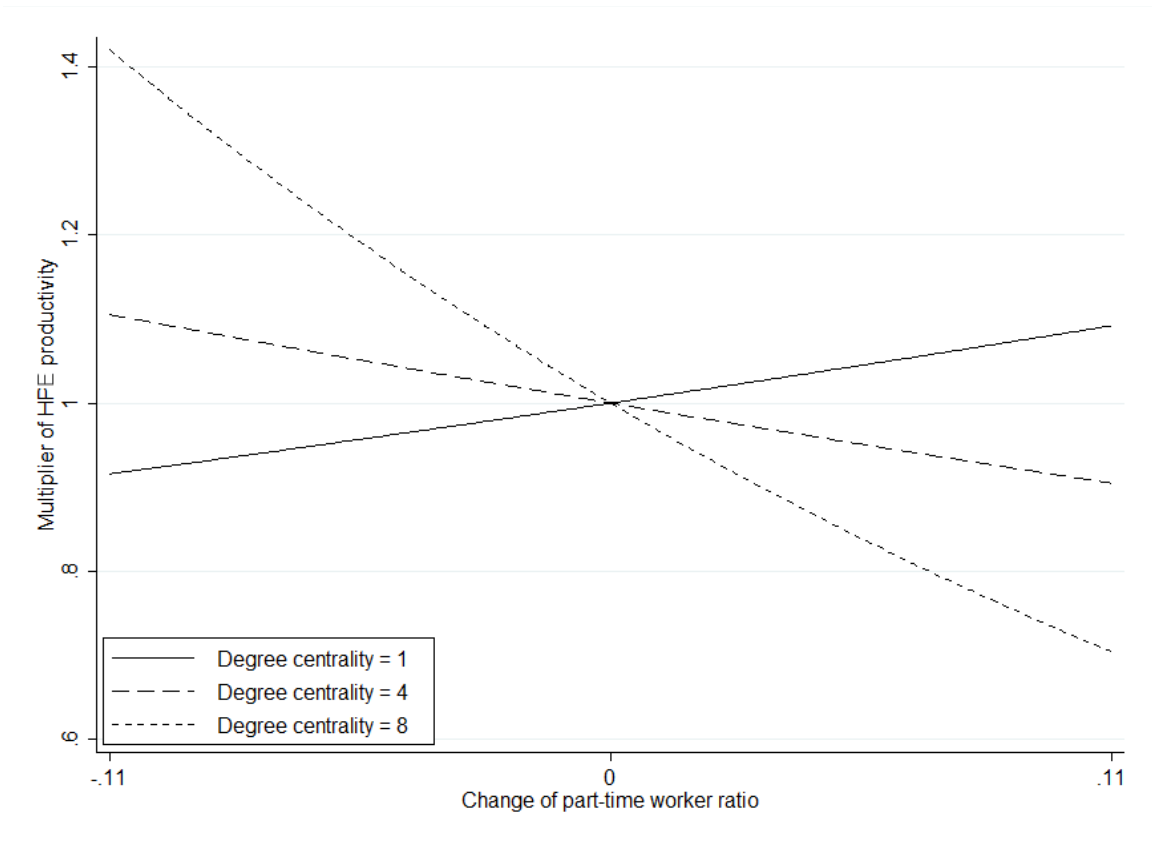


Figure 7. Interaction graphs of change of part-time ratio and degree centrality

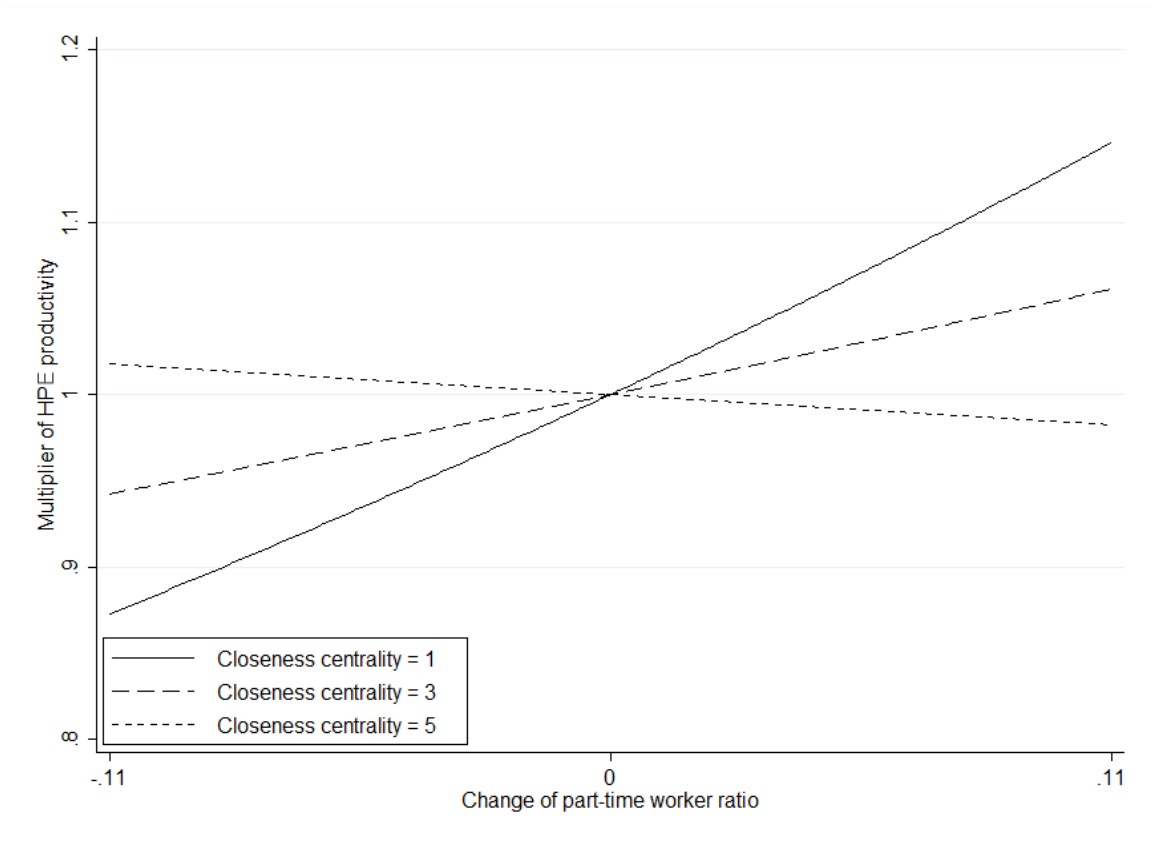


Figure 8. Interaction graphs of change of part-time ratio and closeness centrality

However, as both centralities increase, the slope of the lines changes in the decreasing direction, which means that HPE productivity becomes better as centralities increase. In sum, the findings of the models in Table 4 support the hypotheses regarding the change of part-time worker ratio and the interaction effects of network properties.

5.3 In-house manufacturing ratio

Table 5 shows the results of the effects of the in-house manufacturing ratio and its interaction effects with each centrality. First, I include the in-house manufacturing ratio in Model 7 to see the main effect of it on the effectiveness of learning by doing, measured by HPE productivity enhancement. Model 7 shows that the main term of in-house manufacturing ratio has a significant positive association with HPE productivity at the $p < 0.01$ level, which means that HPE productivity becomes worse as the in-house manufacturing ratio increases. With this finding, I confirm the statistical support of Hypothesis 4, developed from Proposition 5, that underusing improved production processes is likely to deprive the engine plants of opportunities to focus more on learning by doing activities.

Next, I include the interaction terms of degree centrality and closeness centrality in Models 8 and 9, respectively, to test Hypothesis 5, developed from Proposition 6. While the interaction term of degree centrality does not show significance, that of closeness centrality has a significant negative effect at the $p < 0.05$ level. The finding shows that network properties, including both direct and indirect connections in a broader network context, are likely to compensate the plants with a high in-house manufacturing ratio for the loss of internal learning chances by providing them with other chances to learn from the network structure in which they are connected to other plants.

Table 5. GEE Estimates of Productivity, 1995–2006 (In-house Manufacturing Ratio)

Variables	Model 7	Model 8	Model 9
Logged HPE productivity	0.27** (0.02)	0.27** (0.02)	0.26** (0.02)
Elapsed years since 1995	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Left-censored cases	0.27** (0.06)	0.26** (0.06)	0.26** (0.06)
Foreign automaker	-0.27** (0.05)	-0.27** (0.06)	-0.28** (0.05)
Size	0.00** (0.00)	0.00** (0.00)	0.00** (0.00)
Age	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Number of engine products	0.06** (0.01)	0.06** (0.01)	0.06** (0.01)
Number of auto models	0.01 (0.00)	0.01* (0.01)	0.01† (0.01)
Annual production	-0.00 (0.00)	-0.00 (0.00)	-0.00† (0.00)
Logged cumulative production	-0.30** (0.03)	-0.30** (0.03)	-0.29** (0.03)
In-house manufacturing ratio	0.39** (0.07)	0.48** (0.10)	0.76** (0.21)
<i>Network properties</i>			
Degree centrality		0.03 (0.03)	
Closeness centrality			0.09 (0.04)
<i>Interaction terms</i>			
In-house manufacturing ratio X Degree		-0.05 (0.04)	
In-house manufacturing ratio X Closeness			-0.11* (0.06)
(Constant)	4.49** (0.34)	4.49** (0.36)	4.19** (0.38)
<i>N</i>	286	286	286
Wald chi-square	727.90**	744.76**	742.64**
<i>d.f.</i>	11.00	13.00	13.00

Notes: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$ (two-tailed tests). Robust standard errors are in parentheses. All the variables in models are one year lagged.

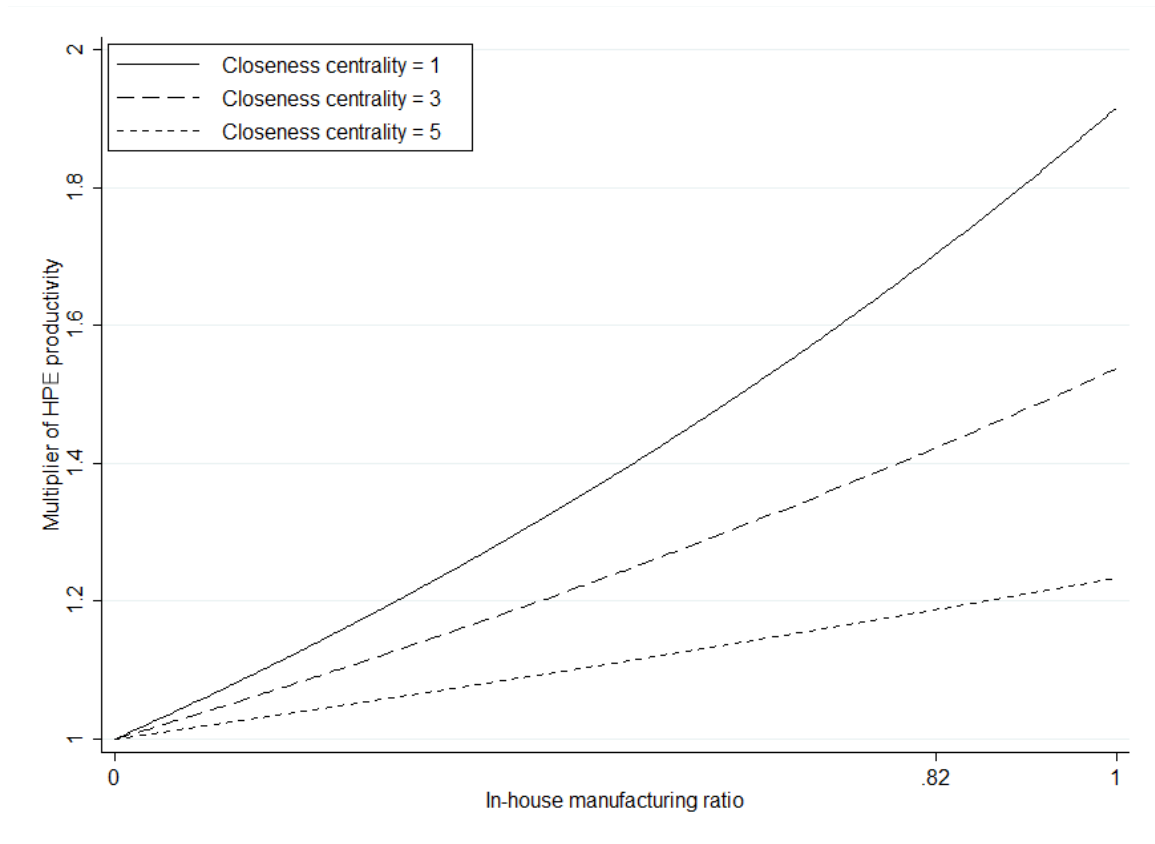


Figure 9. Interaction graphs of in-house manufacturing ratio and closeness centrality

Thus, Hypothesis 5 is supported by the analysis in Model 9. Figure 9 presents the interaction graphs of the in-house manufacturing ratio and closeness centrality. The range of the in-house manufacturing ratio on the x -axis is decided based on its minimum and maximum values.

As the figure shows, the lines are all on the increasing trend, which shows that the detrimental effect of a higher degree of maintaining in-house manufacturing processes is relatively strong. However, as the level of closeness centrality increases, the steepness of the slope is mitigated, which I interpret to mean that an engine plant can obtain chances to focus more on productivity enhancement with the help of better network properties.

5.4 Quality control

In Table 6, I report the results of GEE estimators of HPE productivity including the extent of quality control measured by the coefficient of variation of consumers' ratings of engine products and its interaction terms of each centrality measure. To test Hypothesis 6, developed from Proposition 7, I first include the main term of CV of consumers' ratings in Model 10. As shown in the model, the effect of CV of consumers' ratings is significantly negative at a mild level ($p < 0.10$). Given that a larger figure for this variable implies that quality control over the products is not well achieved, this result can be interpreted to mean that engine plants suffering bad quality tend to pay more attention to productivity enhancing activities. Thus, Hypothesis 6 is supported by this analysis.

To examine how network properties affect the association between quality control and productivity enhancement, I include the interaction terms of CV of consumers' ratings and each centrality measure in Models 11 and 12.

Table 6. GEE Estimates of Productivity, 1995–2006 (Quality Control)

Variables	Model 10	Model 11	Model 12
Logged HPE productivity	0.22** (0.02)	0.23** (0.02)	0.20** (0.02)
Elapsed years since 1995	-0.02* (0.01)	-0.02* (0.01)	-0.01† (0.01)
Left-censored cases	0.10 (0.06)	0.08 (0.06)	0.07 (0.06)
Foreign automaker	-0.31** (0.05)	-0.37** (0.05)	-0.40** (0.05)
Size	0.00** (0.00)	0.00** (0.00)	0.00** (0.00)
Age	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Number of engine products	0.04** (0.01)	0.03** (0.01)	0.02* (0.01)
Number of auto models	0.00 (0.00)	0.01* (0.00)	0.01* (0.00)
Yearly production	-0.00** (0.00)	-0.00** (0.00)	-0.00** (0.00)
Logged cumulative production	-0.15** (0.03)	-0.16** (0.03)	-0.16** (0.03)
CV of consumer ratings on products	-0.19† (0.12)	-0.45** (0.17)	-0.68** (0.25)
<i>Network properties</i>			
Degree centrality		-0.05** (0.01)	
Closeness centrality			-0.08** (0.02)
<i>Interaction terms</i>			
CV of consumer ratings on products X Degree		0.10 (0.07)	
CV of consumer ratings on products X Closeness			0.14* (0.07)
Constant	3.33** (0.38)	3.56** (0.38)	3.74** (0.38)
<i>N</i>	254	254	254
Wald chi-square	581.85**	628.29**	669.56**
<i>d.f.</i>	11.00	13.00	13.00

Notes: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$ (two-tailed tests). Robust standard errors are in parentheses. All the variables in models are one year lagged.

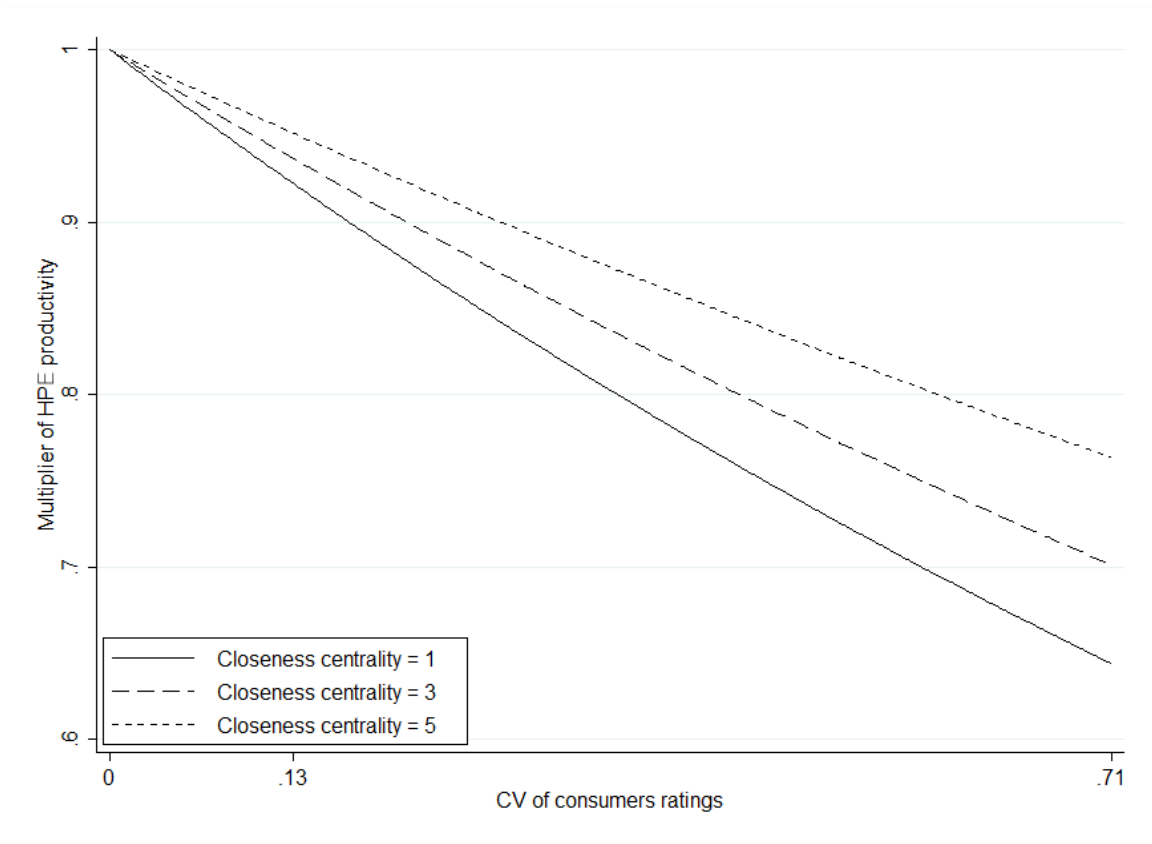


Figure 10. Interaction graphs of CV of consumers' ratings and closeness centrality

The findings show that the effect of closeness centrality along with CV of consumers' rating is positive at a significant level ($p < 0.05$), while that of degree centrality is insignificant. To provide better understanding of the findings, I also present the interaction graph of CV of consumers' ratings and closeness centrality in Figure 10. The range of CV scores is also decided based on its minimum and maximum values obtained from descriptive statistics. As the support of Hypothesis 6 demonstrates, an engine plant is more likely to pay attention to productivity enhancing activity when it suffers poor quality control. The downward slope of all lines confirms this, as a large figure for CV of consumers' ratings implies worse quality control over engine products. However, as closeness centrality of the plant increases, the steepness of the lines becomes milder. This can be interpreted as indicating that having better connections in a network makes the plant have more trouble in focusing on productivity enhancing activity. As argued in Section 2.2 and Section 3.4, this negative effect of network property is due to the contingent characteristics of knowledge relevance. The finding confirms Proposition 8 and Hypothesis 7 that the same kind of network properties may become harmful depending upon the contingent aspects of internal factors. In the current case, knowledge relevance is suggested as the contingency.

CHAPTER 6

CONCLUSION AND DISCUSSION

6.1 Summary

In this study, I investigate the effectiveness of organizations' learning by doing activities by paying attention to not only the effect of comparatively internal factors on learning by doing, but also the effects of social conditions that organizations may have in terms of their relationships with other organizations. Building upon the theories of learning by doing and social network perspectives, I first proposed three internal factors that potentially have direct effects on organizations' learning by doing: workforce composition, amount of in-house manufacturing, and quality control (Adler & Clark, 1991; Argote, 1993; Argote & Miron-Spektor, 2010; Epple et al., 1991). I then expanded my arguments by looking into how certain social conditions influence the impacts of these internal factors on learning by doing effectiveness (Borgatti & Halgin, 2011; Burt, 1992, 2005). Specifically, I examined the effects of these factors in the context of automotive engine manufacturing plants over a period of about twelve years, a context that is very relevant to an investigation of my hypotheses.

First, by focusing on the importance of the workforce composition, which is well-supported theoretically as both the entity that learns from organizational experience and develops new knowledge about operational processes and the repository in which the obtained knowledge is stored and even refined by collaboration between workers, I argued that change of part-time worker ratio would affect the effectiveness of learning by doing. In particular, I developed a hypothesis, relying on the consistent findings of previous empirical studies, that increasing the temporary workers in the workforce

composition would do damage to not only individual workers' motivation to learn from operational procedures but also the collective workforce's trustful working attitudes (Argote, 1993; Harvey & Denton, 1999; March, 1991; Pucik, 1988; Sterman et al., 1997). As demonstrated in Section 5.2, this argument is supported by the current analysis. However, I proposed that the detrimental effect of the increased part-time worker ratio in the workforce is likely to be mitigated when an engine plant has good connections to others as its network properties. The relevance of knowledge that may flow in the production-based network structure would enable an engine plant with an increase of part-time workers to compensate for the loss of opportunities to benefit its learning by doing process by utilizing the chances to obtain knowledge from other plants linked to it. In the analysis, I examined the proposed mitigating effect of network properties on the detrimental association of the increase of part-time worker ratio and productivity enhancement, confirming the benefit of network properties in this regard.

Next, I moved on to investigate how an engine plant's manufacturing process improvement would affect the overall effectiveness of learning by doing (Adler & Clark, 1991; Argote, 1999). Based on the automotive industry's characteristics, I focused on the extent to which a plant externalizes its manufacturing process to its supply chains, which is a well-established manufacturing practice in the automotive manufacturing context. My argument is that the considered utilization of refined, well-controlled manufacturing processes makes it possible for engine plants to focus more on the improvement of internal production processes, consequently acquiring more knowledge about these processes. This argument is also supported by the current analysis, as reported in Section 5.3. However, for reasons derived from managerial practices, some plants still maintain

in-house manufacturing processes within their boundaries, therefore losing chances to exploitatively focus on operational experience. I argued that the drawbacks of not using improved production processes by relying on externalized production can be compensated for by having opportunities to learn from others in a broader network context. My argument for this is based on the knowledge flow benefits provided by networks, which is also theoretically well-elaborated by previous network theories and research. The analysis confirms this argument as it is proposed in the current study.

Lastly, I turned my attention to the effects of the extent of accomplishing other goals, quality control in this study, on the production-related goal of cost productivity enhancement. Based on the attention allocation argument in organizational learning theory (Cyert & March, 1963; March, Schulz, & Zhou, 2000; Ocasio, 2010), I proposed that the conspicuous failure of an engine plant's quality control makes the plant focus more on its productivity enhancing activities in that lower quality assessment from the market is more difficult to enhance in the short term than production-related productivity, which is relatively easy to control internally. This argument is also supported by the analysis. In considering the effect of network properties on the effect of quality control on productivity enhancement, I proposed that the contingent factor of knowledge relevance may function differently from the two other factors—workforce composition and amount of in-house manufacturing—in utilizing network properties. Given that the production-related network tends to be the channel of production-focused knowledge, having good connections in this kind of network may keep engine plants from recognizing the seriousness of poor outcomes of quality control, and thus the network properties here work unfavorably (Hansen et al., 2001).

In addition to the internal factors that affect the effectiveness of learning by doing, I also included comparatively social and external factors that are very likely to affect learning by doing, based on previous studies (Adler & Clark, 1991; Argote, 1999; Argote & Miron-Spektor, 2010; Epple et al., 1996; Ingram, 2005). These are degree centrality and closeness centrality. The findings of the current study confirmed that the network properties that define how well connected an organization is in a given network would contribute to the effectiveness of learning by doing activities when investigated as independent effects. However, as for the moderating effects of network properties with each internal factor proposed in this study, the effects may differ according to the contingent characteristics of the factors considered in the interaction effects, as reported in Section 5.4.

6.2 Contributions

This study, first, expands the learning by doing research by suggesting factors that may affect the effectiveness of learning by doing and investigating their effects in a well-designed empirical analysis. Despite the extensive body of learning by doing studies, there are very few studies that look at specific factors that directly or indirectly affect the effectiveness of learning by doing. For example, while many learning curve studies, which form a great part of organizational learning by doing activities research, have examined experience effects, most of them only capture the experience by a proxy variable of cumulative production due to the difficulties of identifying closer factors that may consist of the experience itself. Based on the suggestions about closer factors made in previous studies (Adler & Clark, 1991; Argote, 1999; Epple et al., 1991; Lapré & Nembhard, 2010), I theoretically identified potential factors by which the underlying

processes of learning by doing can be examined in depth, and then I empirically examined the effect of those factors. Despite the limited theoretical elaboration of the factors composing experiential learning, Levy (1965), for instance, suggested a framework with which the inside of learning by doing can be explored. According to him, organizations' learning from their experience may be divided into two categories: autonomous learning and deliberate activities of learning. The former is experience accumulated in the workforce of organizations, while the latter is embodied as technology-based operational procedures. In my study, both are specifically investigated as workforce composition and process improvement. In a similar vein, other studies have suggested lists of factors of learning by doing; these suggestions can be reclassified as human embodied knowledge, technology-oriented knowledge, and opportunities to learn from others (Adler & Clark, 1991; Epple et al., 1991). Because the current study's identified factors are aligned with the suggestions of previous studies, it can be evaluated as a solid attempt to comprehensively explore all these aspects of learning by doing.

In addition, this study is compelling in its expansion of the learning by doing research because it sees the opportunities to learn from others in terms of network configuration. Despite the aforementioned suggestions of the previous learning curve literature, there have been very few studies conducted in such a manner as to inclusively see the possibilities of learning from others (Darr et al., 1995). While the learning by doing literature often emphasizes the importance of external opportunities to learn from others for the purpose of enhancing internal experience and has suggested ideas for future research into this aspect, there are still few studies that actually incorporate it. This study, therefore, is one of the first studies to investigate the effectiveness of learning by doing

by incorporating a social network perspective, which has a strong implication of knowledge flow between organizations. Because the social network perspective has consistently provided a solid foundation on which various types of learning can be examined (Borgatti & Halgin, 2011; Ingram, 2005), the social conditions under which an organization may benefit from the opportunities to enhance its experiential learning are best investigated from the network perspective. Furthermore, the current study also examines the contingency of network properties by identifying knowledge relevance as a crucial factor by which an organization may obtain benefits or be constrained.

6.3 Implications

This study has some important implications for business practitioners who are concerned with aspects of their organizations' learning by doing activities. First, it provides a noteworthy insight on the importance of how an organization manages its workforce to encourage effective experiential learning. As the results of this study show, an increase of the ratio of part-time workers in the total number of workers may do damage to the effectiveness of learning by doing at the organizational level. It is undeniable that managers consider the layoff of their full-time workers or the replacement of full-time workers with temporary workers in unfavorable economic conditions. The results of this study suggest that they should not make such a change in workforce composition to an extent that would cause the workforce to lose the motivation to contribute to overall experiential learning at the organizational level. Nonetheless, if they cannot resist making such a dramatic change in workforce composition, managers should take into consideration how their organizations may have opportunities to learn from other organizations to compensate for the loss of their valuable individual learners

in the workforce. Given the fact that many organizations operate multiple departments or plants, a network-oriented configuration in which they consider the connectivity between their subdivisions has to be taken into serious consideration, so that loss of workforce in certain subdivisions can be compensated for by good operation-related relations with other divisions.

In a similar vein, managers are encouraged to utilize improved operational processes as much as possible, given that the improvement of processes may provide extra resources with which their organizations can pay more attention to the possibilities of extracting more knowledge from their operation. As the findings of this study suggest, the externalization of production processes to the external suppliers with which the organization has built trust-based relations may contribute to productivity enhancement. In addition, by utilizing their network properties in a case in which they still have to maintain the externalizable processes within their boundaries for some reason, the organizations should consider a well-developed network composition with other organizations, so that they may minimize the loss of opportunities to encourage the internal creation of knowledge.

Overall, this study emphasizes the importance of social networks even in the internally oriented aspects of learning by doing. Considering the current industrial trends in which many organizations are somehow interrelated to one another, experiential learning, which used to be considered solely as an internal matter of an organization, is no longer so. To effectively enhance internal learning, external factors such as relations with other organizations must also be taken into consideration.

6.4 Limitations and future study

Despite the promising contributions that this study makes, it also has some limitations. Most of the limitations of the current study derive from the limited nature of the data. First, this study uses cost-based productivity to capture the extent of organizations' learning by doing. However, this variable is a single factor productivity, which follows the tradition of the extant cost productivity studies. Because the research setting of this study is one of the labor-intensive manufacturing industries, the current measure of productivity is still usable. However, it could contribute more if data allowing a more comprehensive measure of productivity, such as Total Factor Productivity (TFP), were to be collected (Adler & Clark, 1991; Lapré & Nembhard, 2010).

Second, the network structure used in this study is also a one-dimensional structure in which only production-related relations among plants are identified. It is often said in social network studies that network structures among social actors are usually multi-dimensional, and a more compelling study could be developed if the multi-dimensional nature of network structures could be captured (Emirbayer, 1997; Podolny, 1993). In the current study's setting of the automotive industry, there may be other network structures than the production-related network, such as worker-level collaboration networks or other activity-based networks.

Lastly, the current study includes only the characteristics of connectivity between plants as a way to incorporate possible knowledge flow. This analytic tendency is mostly due to that of network analysis, which focuses on linkage benefit. However, a future study could contribute more if it were able to include what sorts of knowledge are

actually transferred between organizations in terms of the quantity-based measure of the knowledge that flows between organizations.

BIBLIOGRAPHY

- Adler, P. S., & Clark, K. B. 1991. Behind the learning curve: A sketch of the learning process. *Management Science*, 37(3): 267-281.
- Adler, P. S., & Kwon, S. 2002. Social capital: Prospects for a new concept. *Academy of Management Review*, 27: 17-40.
- Argote, L. 1993. Group and organizational learning curves: Individual, system and environmental components. *British Journal of Social Psychology*, 32: 31-51.
- Argote, L. 1999. *Organizational learning: Creating, retaining and transferring knowledge*. Boston, MA: Kluwer Academic Publishers.
- Argote, L., Beckman, S. L., & Epple, D. 1990a. The persistence and transfer of learning in industrial settings. *Management Science*, 36(2): 140-154.
- Argote, L., & Epple, D. 1990. Learning curves in manufacturing. *Science*, 247(4945): 920-924.
- Argote, L., Epple, D., Devadas, R., & Murphy, K. 1990b. The acquisition and depreciation of knowledge in manufacturing: Turnover and the learning curve, *ORSA/TIMS*. Philadelphia.
- Argote, L., & Ingram, P. 2000. Knowledge transfer: A basis for competitive advantage in firms. *Organizational Behavior and Human Decision Processes*, 82: 150-169.
- Argote, L., & Miron-Spektor, E. 2010. Organizational learning: From experience to knowledge. *Organization Science*, 22: 1123-1137.
- Banker, R. D., Chang, H., & Natarajan, R. 2005. Productivity change, technical progress, and relative efficiency change in the public accounting industry. *Management Science*, 51(2): 291-304.

- Boone, C., Carroll, G. R., & Van Witterloosetuijn, A. 2004. Size, differentiation, and the performance of dutch daily newspapers. *Industrial and Corporate Change*, 13: 117-148.
- Borgatti, S. P., Everett, M. G., & Freeman, L. C. 2002. *Ucinet iv for windows: Software for social network analysis*. Harvard, MA: Analytic Technologies.
- Borgatti, S. P., & Halgin, D. S. 2011. On network theory. *Organization Science*: orsc.1100.0641.
- Brush, T., & Karnani, A. 1996. Impact of plant size and focus on productivity: An empirical study. *Management Science*, 42(7): 1065-1081.
- Burt, R. S. 1992. *Structural holes: The social structure of competition*. Cambridge: Harvard University Press.
- Burt, R. S. 1997. The contingent value of social capital. *Administrative Science Quarterly*, 42: 339-365.
- Burt, R. S. 2005. *Brokerage and closure: An introduction to social capital*. Oxford: Oxford University Press.
- Burt, R. S., Jannotta, J. E., & Mahoney, J. T. 1998. Personality correlates of structural holes. *Social Networks*, 20(1): 63-87.
- Cachon, G. P., & Olivares, M. 2010. Drivers of finished-goods inventory in the u.S. Automobile industry. *Management Science*, 56: 202-216.
- Chung, W., Mitchell, W., & Yeung, B. 2003. Foreign direct investment and host country productivity: The american automotive component industry in the 1980s. *Journal of International Business Studies*, 34(2): 199-218.
- Cyert, R. M., & March, J. G. 1963. *A behavioral theory of the firm*. Oxford, UK: Blackwell Publishers Ltd.

- Darr, E. D., Argote, L., & Epple, D. 1995. The acquisition, transfer, and depreciation of knowledge in service organizations: Productivity in franchises. *Management Science*, 41(11): 1750-1762.
- Davis-Blake, A., & Uzzi, B. 1993. Determinants of employment externalization: A study of temporary workers and independent contractors. *Administrative Science Quarterly*, 38: 195-223.
- Dekker, H. C., & Van den Abbeele, A. 2010. Organizational learning and interfirm control: The effects of partner search and prior exchange experiences. *Organization Science*, 21(6): 1233-1250.
- Denrell, J. 2003. Vicarious learning, undersampling of failure, and the myths of management. *Organization Science*: 227-243.
- Dobrev, Stanislav D., Kim, T.-Y., & Carroll, G. R. 2002. The evolution of organizational niches: U.S. Automobile manufacturers. *Administrative Science Quarterly*, 47: 233-264.
- Dobrev, Stanislav D., Kim, T.-Y., & Hannan, Michael T. 2001. Dynamics of niche width and resource partitioning. *The American Journal of Sociology*, 106(5): 1299-1337.
- Dutton, J. M., & Thomas, A. 1984. Treating progress function as a managerial opportunity. *Academy of Management Review*, 9: 235-247.
- Emirbayer, M. 1997. Manifesto for a relational sociology. *American Journal of Sociology*, 103: 281-317.
- Emirbayer, M., & Mische, A. 1998. What is agency? *The American Journal of Sociology*, 103(4): 962-1023.
- English, J., & Marchione, A. R. 1983. Productivity: A new perspective. *California Management Review*, 25(2): 57-66.

- Epple, D., Argote, L., & Devadas, R. 1991. Organizational learning curves: A method for investigating intra-plant transfer of knowledge acquired through learning by doing. *Organization Science*, 2(1): 58-70.
- Epple, D., Argote, L., & Murphy, K. 1996. An empirical investigation of the microstructure of knowledge acquisition and transfer through learning by doing. *Operations Research*, 44(1): 77-86.
- Espino-Rodríguez, T. F., & Padrón-Robaina, V. 2006. A review of outsourcing from the resource-based view of the firm. *International Journal of Management Reviews*, 8(1): 49-70.
- Faust, K. 2005. Using correspondence analysis for joint displays of affiliation networks. In P. J. Carrington, J. Scott, & S. Wasserman (Eds.), *Models and methods in social network analysis*. New York: Cambridge University Press.
- Freeman, L. C. 1979. Centrality in social networks: Conceptual clarification. *Social Networks*, 1: 215-239.
- Frees, E. W. 2004. *Longitudinal and panel data: Analysis and application in the social sciences*. New York: Cambridge University Press.
- George, E. 2003. External solutions and internal problems: The effect of employment externalization on internal workers' attitudes. *Organization Science*, 14: 386-402.
- Goyal, M., Netessine, S., & Randall, T. 2006. Deployment of manufacturing flexibility: An empirical analysis of the north american automotive industry, *Working Paper*.
- Granovetter, M. 1973. The strength of weak ties. *The American Journal of Sociology*, 78(6): 1360-1380.
- Granovetter, M. 1983. The strength of weak ties: A network theory revisited. *Sociological theory*, 1(1): 201-233.

- Gulati, R. 1999. Network location and learning: The influence of network resources and firm capabilities on alliance formation. *Strategic Management Journal*, 20: 397-420.
- Hansen, M. T. 1999. The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly*, 44(1): 82-111.
- Hansen, M. T., & Haas, M. R. 2001. Competing for attention in knowledge markets: Electronic document dissemination in a management consulting company. *Administrative Science Quarterly*, 46(1): 1-28.
- Hansen, M. T., Podolny, J. M., & Pfeffer, J. 2001. So many ties, so little time: A task contingency perspective on corporate social capital in organizations. In S. M. Gabbay, & R. T. A. J. Leenders (Eds.), *Research in the sociology of organizations*, Vol. 18: 21-57. New York: JAI.
- Hardin, J. W., & Hilbe, J. M. 2000. *Generalized estimating equations*. New York: Chapman & Hall/CRC.
- Harrington, B. 2001. Organizational performance and corporate social capital. In S. M. Gabbay, & R. T. A. J. Leenders (Eds.), *Research in the sociology of organizations*, Vol. 18: 83-106. New York: JAI.
- Harrison, D. K., & Klein, K. J. 2007. What is the difference? Diversity construct as separation, variety, or disparity in organizations. *Academy of Management Review*, 32: 1199-1228.
- Harvey, C., & Denton, J. 1999. To come of age: The antecedents of organizational learning. *Journal of Management Studies*, 36(7): 897-918.
- Haunschild, P. R., & Rhee, M. 2004. The role of volition in organizational learning: The case of automotive product recalls. *Management Science*, 50(11): 1545-1560.

- Huber, G. P. 1991. Organizational learning: The contributing processes and the literatures. *Organization Science*, 2(1): 88-115.
- Ingram, P. 2005. Interorganizational learning. In J. A. C. Baum (Ed.), *Companion to organizations*: 642-663. Malden, MA: Blackwell Publishing.
- Jiang, B., Belohlav, J. A., & Young, S. T. 2007. Outsourcing impact on manufacturing firms' value: Evidence from Japan. *Journal of Operations Management*, 25(4): 885-900.
- Johanson, J. 2001. The balance of corporate social capital. In S. M. Gabbay, & R. T. A. J. Leenders (Eds.), *Research in the sociology of organizations*, Vol. 18: 231-261. New York: JAI.
- Kekre, S., & Srinivasan, K. 1990. Broader product line: A necessity to achieve success? *Management Science*, 36: 1216-1231.
- Kernan, M. C., & Lord, R. G. 1990. Effects of valence, expectancies, and goal-performance discrepancies in single and multiple goal environment. *Journal of Applied Psychology*, 75: 194-203.
- Kim, J., & Miner, A. S. 2007. Vicarious learning from the failures and near-failures of others: Evidence from the US commercial banking industry. *Academy of Management Journal*, 50(3): 687.
- Labianca, G., & Brass, D. 2006. Exploring the social ledger: Negative relationships and negative asymmetry in social network in organizations. *Academy of Management Review*, 31: 596-614.
- Lapr e, M. A., & Nembhard, I. M. 2010. Inside the organizational learning curve: Understanding the organizational learning process. *Foundations and Trends in Technology, Information, and Operations Management*, 4(1): 1-103.
- Lapr e, M. A., & Tsiriktsis, N. 2006. Organizational learning curves for customer dissatisfaction: Heterogeneity across airlines. *Management Science*, 52: 352-366.

- Lapr , M. A., & Van Wassenhove, L. N. 2001. Creating and transferring knowledge for productivity improvement in factories. *Management Science*, 47(10): 1311-1325.
- Lei, D., & Hitt, M. A. 1995. Strategic restructuring and outsourcing: The effect of mergers and acquisitions and lbo on building firm skills and capabilities. *Journal of Management*, 21(5): 835-859.
- Levin, D. Z. 2000. Organizational learning and the transfer of knowledge: An investigation of quality improvement. *Organization Science*, 11: 630-647.
- Levitt, B., & March, J. G. 1988. Organizational learning. *Annual Review of Sociology*, 14: 319-340.
- Levy, F. K. 1965. Adaptation in the production process. *Management Science*, 11: B136-B154.
- Li, G., & Rajagopalan, S. 1998. Process improvement, quality, and learning effects. *Management Science*, 44(11): 1517-1532.
- Liang, K. Y., & Zeger, S. L. 1986. Longitudinal data analysis using generalized linear models. *Biometrika*, 73: 13-22.
- Lieberman, M. B., & Demeester, L. 1999. Inventory reduction and productivity growth: Linkages in the japanese automotive industry. *Management Science*, 45(4): 466-485.
- Lieberman, M. B., Lau, L. J., & Williams, M. D. 1990. Firm-level productivity and management influence: A comparison of u.S. And japanese automobile producers. *Management Science*, 36(10): 1193-1215.
- Liker, J. 2004. *The toyota way: 14 management principles from the world's greatest manufacturer*. Madison, MI: McGraw-Hill.

- MacDuffie, J. P., Sethuraman, K., & Fisher, M. L. 1996. Product variety and manufacturing performance: Evidence from the international automotive assembly plant study. *Management Science*, 42(3): 350-369.
- March, J. G. 1991. Exploration and exploitation in organizational learning. *Organization Science*, 2: 71-87.
- March, J. G., Schulz, M., & Zhou, X. 2000. *The dynamics of rules: Change in written organizational codes*. Stanford, CA: Stanford Univ Press.
- March, J. G., & Simon, H. A. 1958. *Organizations*: John Wiley & Sons Inc.
- Mikkola, J. H. 2003. Modularity, component outsourcing and inter-firm learning. *R&D Management*, 33: 439-454.
- Mizruchi, M. S., Stearns, L. B., & Fleischer, A. 2011. Getting a bonus: Social networks, performance, and reward among commercial bankers. *Organization Science*, 22(1): 42-59.
- Nonaka, I. 1994. A dynamic theory of organizational knowledge creation. *Organization Science*, 5: 14-37.
- Nooteboom, B. 2001. The management of corporate social capital. In S. M. Gabbay, & R. T. A. J. Leenders (Eds.), *Research in the sociology of organizations*, Vol. 18: 185-207. New York: JAI.
- Ocasio, W. 1997. Towards an attention-based view of the firm. *Strategic Management Journal*, 18: 187-206.
- Ocasio, W. 2010. Attention to attention. *Organization Science*: orsc.1100.0602.
- Owen-Smith, J., & Powell, W. W. 2004. Knowledge networks as channels and conduits: The effects of spillovers in the boston biotechnology community. *Organization Science*, 15: 5-21.

- Podolny, J. M. 1993. A status-based model of market competition. *American Journal of Sociology*: 829-872.
- Podolny, J. M. 2001. Networks as the pipes and prism of the market. *American Journal of Sociology*, 107: 33-60.
- Porth, S. J., McCall, J., & Bausch, T. A. 1999. Spiritual themes of the “learning organization. *Journal of Organizational Change Management*, 12: 211 - 220.
- Powell, W. W., Koput, K. W., & Smith-Doerr, L. 1996. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, 41: 116-145.
- Prahalad, C. K., & Hamel, G. 1990. The core competence of the corporation. *Harvard Business Review*, 68: 79-93.
- Price, J. L. 1972. The study of organizational effectiveness. *The Sociological Quarterly*, 13: 3-15.
- Pucik, V. 1988. Strategic alliance, organizational learning and competitive advantage: The hrm agenda. *Human Resource Management*, 27: 77-93.
- Rhee, M. 2009. Does reputation contribute to reducing organizational errors? A learning approach. *Journal of Management Studies*, 46: 676-703.
- Rhee, M., & Haunschild, P. R. 2006. The liability of good reputation: A study of product recalls in the u.S. Automobile industry. *Organization Science*, 17(1): 101-117.
- Rhee, M., Kim, Y.-C., & Han, J. 2006. Confidence in imitation: Niche-width strategy in the uk automobile industry. *Management Science*, 52(4): 501-513.
- Schulz, M. 2005. Organizational learning. In J. A. C. Baum (Ed.), *Companion to organizations*. Malden, MA: Blackwell Publishing.
- Simon, H. A. 1964. On the concept of organizational goal. *Administrative Science Quarterly*, 9(1): 1-22.

- Sorenson, J. B., & Stuart, T. E. 2000. Aging, obsolescence, and organizational innovation. *Administrative Science Quarterly*, 45: 81-112.
- Srinivasan, R., Haunschild, P. R., & Grewal, R. 2007. Vicarious learning in new product introductions in the early years of a converging market. *Management Science*, 53(1): 16-28.
- Sterman, J. D., Nelson, P. R., & Kofman, F. 1997. Unanticipated side effects of successful quality programs: Exploring a paradox of organizational improvement. *Management Science*, 43(4): 503-521.
- Stuart, T. E. 1998. Network positions and propensities to collaborate: An investigation of strategic alliance formation in a high-technology industry. *Administrative Science Quarterly*, 43: 668-698.
- Sturgeon, T. J. 2002. Modular production networks: A new american model of industrial organization. *Industrial and Corporate Change*, 11(3): 451-496.
- Sullivan, B. N., Haunschild, P. R., & Page, K. 2007. Organizations non grate? The impact of unethical acts on interorganizational networks. *Organization Science*, 18: 55-70.
- Wasserman, S., & Faust, K. 1995. *Social network analysis: Methods and applications*: Cambridge university press.
- Watts, S. 2006. *The people's tycoon: Henry ford and the american century*. New York: Vintage Books.
- Womack, J. P., Jones, D. T., & Roos, D. 1990. *The machine that changed the world*. New York: HarperPerennial.
- Wright, T. P. 1936. Factors affecting the costs of airplanes. *Journal of Aeronautical Science*, 3: 122-128.