DEMOGRAPHY AND DESIGN IN AN R&D ORGANIZATION

By

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Master of Science in Electrical Engineering
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Abstract

In the research and development (R&D) organization of a firm in a high technology industry, because of the needs for innovative and complex tasks in the rapidly changing environment of technology and market, the design of efficient organization would be one of the most important things. Many researchers have concentrated on the questions: How should teams or unit organizations be organized in terms of demographic diversity? What are the key variables associated with better performance? More technically, should a functional team be formed by the people who have similar experience and tenure, or, alternatively, should it be composed of people with a wide range of demographic characteristics?

In this perspective, using the data collected from the 31 project teams and 191 individuals at four corporate-level research and development laboratories at a global electronics company in Korea, this study investigates the impact of demography diversity on project team performance. Particularly, this study moves beyond previous research by broadening the demographic variables to the education characteristics such as major, school, and educational level as a group.

The results of the study suggest that, like the other demographic variables, the educational background also is strongly related to the team level performance. While each demographic variable has a certain operating direction, in this unique organization, the more homogeneous team in terms of diversity of school is likely to have better performance through the group process.

Thesis Supervisor: M. Diane Burton
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Chapter 1. Introduction

1.1 Overview

In a given organization, there are a lot of variables such as demographic diversity and organizational structure that influence the performance of the organization at large. Especially, in the high technology industry and in the research and development organization in a firm, because of needs for its innovative and complex tasks, as well as its rapidly changing environment in technology and market trends, many studies have concentrated on the questions: How should teams or unit organizations be organized in structure and in demographic diversity? How do those variables affect the performance? What are the key variables associated with better performance? In addition, more technically, should a functional team be formed by the people who have similar experience, tenure, and skills, or, alternatively, should it be composed of people with a wide range of demographic characteristics? The conventional wisdom suggests that teams be composed of more diverse members as the teams increasingly get called upon to do more complex tasks and to cross functional boundaries within the organization. Furthermore, there is an increasing evidence that demographic characteristics of cohorts within a population can significantly influence a wide range of variables (Ancona and Caldwell, 1992). For example, the size of age and sex cohorts within a population can influence diverse outcomes, including economic well-being (Easterlin 1980), mobility patterns (Reed 1978; Stewman and Konda 1983), crime rate (Maxim 1985), and marriage practices (Guttentag and Secord 1983). This concept has begun to be applied to organizational phenomena. For instance, the

demographic composition of groups has been related to turnover among university faculty (McCain, O'Reilly and Pfeffer 1983), top managers (Wagner, Pfeffer and O'Reilly 1984), and nurses (Pfeffer and O'Reilly 1987); to performance ratings of subordinates (Tsui and O'Reilly 1989); to executive succession (Pfeffer and Moore 1980); to firm-level performance (Wagner, Pfeffer, and O'Reilly 1984); and to innovation in organizations (O'Reilly and Flatt 1989). These studies suggest that it is the distribution of people within a group across variables such as age or tenure that influences behavior, rather than simpler descriptions of the same variables such as the mean age of the group or the group with the particular tenure (Ancona and Caldwell 1992).

The available research evidence seems compelling that although, demography is not destiny, there are important compositional effects on perseverance and conservatism in decision-making, interpersonal conflict and turnover, and social integration and communication (Pfeffer 1997). Compositional effects constrain the operation of network processes, as the literature on women and minorities in organizations nicely illustrates (Pfeffer 1997). One's social network is affected, although not completely determined, by the comparative availability of different types of individuals in the immediate environment.

In this sense, the study of organizational demography complements the social model of behavior, with its emphasis on social influence, which often operates through interpersonal networks or structural equivalence (Pfeffer 1997). Composition helps to determine the content of those influences and the composition of the networks through which social influence travels (Pfeffer 1997).

This paper is a study of how demographic variables influence the performance of both product development and research teams in a large technology firm. These teams work independently in the organizations, but highly interdependently among each team members. In this study, group demography is integrated with the aspects of group theory to predict perceived performance of project teams within four corporate-level research and development laboratories at a global electronics company in Korea.

1.2 Company History

The company that this study focused on is a major global player in electronics and telecommunications in Korea, operating 72 subsidiaries around the world with over 56,000 employees worldwide and focusing on a wide range of digital consumer products such as digital TV, CD-RW, DVD, CD-ROM, DVD-ROM drives, PCs, Monitors, Mobile Handsets, CRTs and PDPs. The company is strengthening core competencies even more to further its reputation as the "Digital Leader" in electronic products and equipment in the digital era. It generated $12.5 billion sales revenue and $0.6 billion profits in fiscal year of 2000. The company also teams up with four sister companies sharing vision of "Digital Leader" and shaping the future together through cross-border cooperation. Those companies are liquid crystal display manufacturing company regarded as the leader in capacity and technology, precision devices manufacturing company, electronics parts and integrated solution provider performing in a wide range of industrial sectors, and developing integrated IT systems.

1.2.1 Establishment

In 1958, the modern era of the electronics industry begins in Korea, a country suffering from the vestiges of the Korean War. The new 'rising star' of the Korean electronics industry is born. The strong commitment for promoting growth of electronics, one of essential part of public life by an ambitious entrepreneur, the first Chairman of the company, became the guiding light for fostering electronics industry in Korea. By the following year of 1959, it was reborn as a stock company. Armed with pioneer spirit, it began to open new horizons for the Korean electronics industry. In November 15, 1959, the first Korean made radio was born. The birth of Korean-made-radio not only signaled that electronics industry in Korea was on a path of accelerated growth, but also heralded the beginning of broadcasting service in Korea. With radio as a start, the company began to lay the groundwork for continuing growth of electronics industry in Korea.

In 1962, in preparation of more diversified business management, the company recruited seasoned business professionals to run the company to lead the company's expanded growth in the 1960s. With increase of number of staff members, company organization was restructured to be in line with establishing mass production structure. Also in 1962, sales began to improve and production started to pick up resulting in substantial growth in number of employees.

1.2.2 Growth

In 1966, five years after TV broadcasting service was introduced to Korea, the company succeeded in introducing first Korean made black and white TV set. A

domestically manufactured TV was a fresh shock to consumers used to foreign made ones. Despite the expensive price of a TV set, the TV set was a home run hit even requiring raffles for purchase due to short supply.

To produce precision machines, which require highly sophisticated and advanced technology, the company became the first private company to establish a central R&D center in January 1976. The research center lead the development efforts for color TV, VCR and computer in 1970s to serve as the birth place of many R&D projects that promoted growth of not only itself, but also the international competitive strength of Korean businesses.

After successfully combating the second oil crisis and economic recession of the late 1970s with "slimed down" and profit-oriented operation, in early 1980s, the company opted for a series of organizational restructuring to mount effective response against increasing competition and efforts toward globalization.

By 1980s, with rapid changes in the international trader order, securing an overseas production base became essential. It also began to aggressively pursue international markets by establishing a manufacturing subsidiary in Huntsville, Alabama, U.S. in 1982 followed by establishment of other manufacturing and sales subsidiaries in Germany and other countries to serve as international gateways as well as broaden its business area to semiconductor and communications such as all cutting-edge information and communications products including switching system, transmission equipment and communication devices.

1.2.3 Globalization

July 14, 1999, the company held vision declaration ceremony and unveiled the direction and objectives of Electronics CU's management to challenge the new Digital Age. With core values of Innovation, Openness and Partnership along with core competencies of Marketing, Design, Technology and Networking, it declared its commitment to become the model company for the Digital Age by realizing "Digital Leader." To ensure effective response in the rapidly changing Digital Age, the company is enhancing synergy through strategic alliances and networking. In particular, with becoming first mover in the market and adherence to standards being identified as the essence of digital management, the company is strengthening strategic alliances with foreign companies such as GE for LWO (optical wave microwave), with JBL for next generation audio, with PBS for digital data broadcasting service, Coca-Cola for joint marketing, and with Philips for TFT-LCD.

Development of high quality products was identified as priority number 1. During organizational restructuring, the organization responsible for both technology research and development of product was separated into two major functional structures to improve professional expertise and efficiency of corporate R&D efforts. Based on the R&D strategy, the company have kept its leading position through introducing the world's first chip set for digital TV, developing the first Korean standard 64 inch digital TV set in 1997, succeeding in transmitting a 384 Kbps video message, and developing asynchronous IMT-2000 system in 2001.

1.3 Management and Culture

In 1989 with worsening labor strife, the firm leaders faced the biggest challenge in its history. The firm was losing sales, at the same time it was facing rising labor cost and increase import restrictions by industrialized countries. The firm, however, soon regained stability through active efforts to realize harmony in labor relations and cultivate management based on respect. As such, the hierarchical relation of labor-owner was readjusted to more cooperation between labor and management. The efforts also gained external recognition, resulting in the firm winning the Gold Tower for Industrial Harmony in 1994.

The CEO of the company is respected for his in-depth knowledge and experience in business management, particularly in international business operations including international finance and overseas investment. He is also recognized for his expertise in the electronics business and his insight into future industries. His capability as a business leader is also evident in his close ties with the top management of the world's leading electronics companies such as GE, Microsoft, Motorola, Hitachi and Sony.

The talented people in the company, in hopes of helping people enjoy easier, happier, and more exciting lives, are taking on all challenges head on. The leader aims for perfection, drawing strength from his powerful capabilities in planning and his attention to detail. At the same time, he is known for his decisiveness and driving force. He values commitment and integrity in his employees and avoids those without the will power to stand up for, that which is right and good. His attention to the "field workers" and taking

the initiative in setting an example for his employees to follow are the twin foundation of his management style.

1.4 Vision

They set their vision to help customers realize their dreams, delivering affluence and happiness through versatile digital ware. Since setting foot in the field of electronic appliances in 1958, they have worked with all our might and main to get where they are today. With the short slogan, "Digital Leader", they sum up their unflagging will to stay the course as a digital leader. "With digital products and services that are more innovative, interactive, sweeping, and functional to realize a people-friendlier digital world."

To realize the vision, they have infused their minds with the three core values of Innovation, Openness, and Partnership. This is the manifesto: non-stop transformation, listening to people attentively and conducting business transparently, and establishing a more reliable partnership with customers and shareholders to share with them the fruits of our labors. And they believe that proficiency in marketing, technology, design, and networking are the indispensable competences for delivering speedy solutions to the dazzling demands of the digital era.

1.5 Business Organization

The company has six large business units-companies, being categorized according to technology and products each company focuses on. One of the six companies is the digital display company, which conducts R&D and manufacturing in digital display products and their core components such as PDP, CDT, and CPT with 7,500 employees at

its four domestic and 19 overseas subsidiaries. Having a vision of becoming a No.1 global player that provides cutting-edge display products leading the digital era, it has its own research lab and marketing networks at home and abroad. In terms of strategy, while fostering its world-acclaimed full-flat display devices and unsurpassed digital technology, the company seeks strategic alliances with the global leaders. Continuously introducing follow-up models in the world market, the company is strengthening its brand identity to establish an impressive global presence. Around its pivot in Korea, the company has important depots in Europe, North America, Australia, and China, which can provide coverage of their neighbors in the CIS, South America, Central Asia, and India. The management and digital culture of the company are constantly being freshened up.

Another important business area of the company is the home appliance. With the vision of becoming global leader in digital home appliances such as refrigerators, washing machine, and microwave oven, the company uses diverse technologies to make its products high-performance, noise-free, low-cost, and energy saving. In addition, they are employing digital signal processing and inverter technologies and internet networking in order to cope with changing preferences in the future. To realize its vision, the company puts its energy into developing brand-new products and strengthening its competitive power and marketing skills to penetrate into more markets overseas. Its constant R&D activity constantly turns out low-noise, high-performance, cost-effective, and feature-rich products on the basis of the Six Sigma initiative for innovation in quality and productivity.

The digital media company focuses on manufacturing in multifunctional and

multimedia products and core components such as digital TV, CD-Read/Write, PC, VCR and monitor. Its digital technology leadership and management skills enable diversified multimedia solutions worldwide with a total of 5,300 employees at home and abroad and operates three domestic plants. To be the multimedia leader of the world, the company is lifting its technological and managerial competence to a higher level. The company also is trying to team up with the global leaders in diverse fields, including IBM, SONY, Dell, Apple, JBL and Compaq, and to spin off hybrid multimedia products that are multifunctional beyond anyone's imagination. These initiatives aim at developing resources and promoting close relationships vertically and horizontally with other companies within the cultural unit, speeding up business processes and sharing knowledge while inspiring capable employees to do their utmost by performance-based merit incentives and ample rewards.

To meet the upcoming information and communication era, they have a business unit manufactures and develops telecommunication switches systems along with the world's first commercialization of CDMA digital mobile systems, various personal mobile communication devices, and optical switching systems. From the late 1960s when transmission technology was still a foreign territory for Koreans, the company has been developing various fixed and mobile transmission system, contributing to the growth of the Korean communication industry.

In terms of mobile handset business, they introduced the world's first commercialized digital handset based on the best of breed CDMA technology. The

company is also opening a new chapter in the world handset market through continuing research and investment in new products. At the same time, to maintain leadership in the information age, they will strengthen their brand image with technologies and products that are always a step ahead along with introducing handsets for satellite, mobile multimedia and IMT-2000 services.

The network business is the gathering of information processing, communication and video image technology. Based on its leading-edge technology for office automation and building automation, the company is leading not only the IBS and system integration businesses, but also in the network business for building an integrated information network - the core of the information ear.

As is evident from this abbreviated corporate history, the firm under investigation has a long record of financial success through technological innovation. The research and development organization has played a critical role in the firm's success.

1.6 Research and Development Organization

The company has concentrated its resources and competencies in businesses areas identified as core and main to secure its own differentiated unique leading-edge technologies. As a result, it has succeeded in obtaining world-class technology in the areas of digital TV, next generation displays of PDP and LCD, and in optical storages. Technology Leadership campaign* - a R&D efforts to achieve global technology leadership in selected business areas and technologies - is the technology management strategy

* Technology Leadership campaign was declared in 1995.

adopted by them to position its self as a Global Market Leader by imbuing business and profit oriented approach in R&D activities and by facilitating early realization of futuristic cutting-edge technologies.

The company has a company-level R&D organization that covers all its business areas. With around 350 of Korea's most qualified engineers, the organization is concentrating on research on basic technology, research on quality inspection and standards fulfillment to improve its product quality along with research on production related basic technologies and design. In addition, it has 12 regional research centers in domestic, which are dedicated to their business units and more focus on development rather than research, and 11 overseas research centers worldwide to carry out projects focusing on specific business areas to develop product related application technology and many others. The corporate level institute consisting of 2 research labs, 2 development centers and 3 overseas technology centers is currently focusing on; creating the future business opportunities through the development of new core competence; increasing their competitiveness through the intensification of core ability in the existing business fields; and increasing synergetic effect of the R&D among the its business-cultural units. Among those research and development centers, not only because the four laboratories at the corporate institute have a wide range of projects from basic research to development projects, but because they cover diversified R&D areas such as material science, advanced display device, integrated circuit design, and software in the same research complex, they seem to be excellent organizations to study various relationships between demography and performance. The laboratories that this study focuses on are summarized as follows:

1.6.1 Material Science Lab

The Materials Science Lab (M_Sci) is committed to developing core devices for next generation products in the digital multimedia industry. The major activities of the lab are research and development of high-density optical storage, high-speed communication device, and new functional devices. In order to satisfy the growing need for handling vast amount of information in multimedia and network environment, the optical data storage area focuses on the development of high density optical recording materials for optical rewritable discs as well as research on next generation optical discs. In addition, semiconductor laser diodes such as high-power red laser diodes are being extensively pursued as light sources for the high-density storage systems. In the area of high-speed communication, where the communication mode is being digitized and the bands increased to higher frequencies to accommodate the ever-increasing communication capacity, there is a demand for high frequency devices with superior performance. In response to the demand, the material science lab has concentrated on the development of super-high frequency devices with exceptional high frequency quality, minimum variance in signal magnitude and high integration rate. In particular, active research in the field of 30 GHz and higher millimeter wave is also being supported. In the optical communication area, research on photo diodes and optical modules for large-scale optical subscriber network (LAN, CATV, VOC), optical interconnection and WDM system is under way. Devoted to the development of novel electronic, memory, communication and bio-electronic devices, the field of new functional devices embodies research in micro-system, superconductivity and bioelectronics as well as display. The micro-system area is a core

technology for the applications of the next generation optical communication and high density data storage system. Technological development of low priced, high speed and miniaturized micro Optical Devices are being vigorously pursued. In the area of superconductivity research, the development and application of superconducting quantum interface devices and microwave filters for PCS base station are being carried out based on our accumulated technology on high temperature super-conducting films and Josephson devices. The area of bioelectronics is actively engaged in the research to realize biochips through the development of information processing devices using biomaterials. Furthermore, the area of display is dedicated to the technological development of hologram-based LCD screen and high efficient ACPDP Cell as well as electro-chromic display.

1.6.2 Information Technology Lab

The Information Technology Lab (Inf_Tech) is concentrating its research forces on core and leading technology developments in the fields of intelligent interface, media processing, and network communication. The laboratory has been developing various intelligent interface technologies that will enable a computer to communicate naturally with its user, and to do secretarial jobs such as extracting new significant information from large data repositories for its user. The laboratory also is carrying out researches in digital media processing technologies especially for audio and video. As a result of an intensive effort, the laboratory has built cutting-edge technology and products such as HDTV Processors and software modules.

1.6.3 Innovation Center

Innovation Center (Inv_Ctr) focuses its efforts on the commercialization projects to help the company hold market leadership by maximizing synergy effect among the cultural units, and on overcoming the innovation gaps between the business divisions and the research divisions. Innovation center also plays a role of development of fusion-technologies by joint researches. Its current major research areas are in the field of flat panel display, multimedia software in the network environment, and biometrics.

1.6.4 System IC Center

Established in October 1992, the System IC* Center (S_IC), through the accumulated advanced technology and experiences in the field of semiconductors, developed such key products to digital systems as Advanced VSB Receiver, HDTV Video Decoder, Format Converter for HDTV Monitor, and Analog Intellectual Properties such as ADC, DAC, and DSPs, and has contributed to strengthening system technology competency of the company's subsidiaries. Its main role is to develop technologies in semiconductor design of new, complex, and multi-functional systems, and to supply system-on-chip technologies to clients, designing the circuit services and test services to the market.

1.7 Project Team Organization

1.7.1 Team Organization

Every laboratory has four to nine groups within each organization, and then each group has almost same range of number of project teams depending on its research area.

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* IC: Integrated Circuit

However, while most project teams are normally composed of around 5 to 10 engineers according to the scope and schedule of the project, some special project is assigned a couple engineers, and the other opposite cases need much more than 10 people even though some of them have somewhat different skills and knowledge in a project team. For example, LCD display development team consisted of 25 engineers for more than three years, having five functionally different sub-teams such as circuit design, wafer process, test, optic development, and system integration team within the team. Each sub-team had two to ten engineers. On the other hand, some projects such as PLL is consisted of just 2 engineers with short project period, less than six months. In this study, the project either that has less than three team members or that has less than one-year project period is excluded. Usually, as project leader, the most senior team member takes a charge of leading the project team, but in some special case, the most experienced does.

Hierarchically, engineers are categorized as four groups of ranks according to their seniority and experience: engineer, junior engineer, senior engineer, and principal engineer. But, neither the seniority nor experience necessarily guarantees promotion. Performance is an important component; thus some engineers are promoted faster than others.

1.7.2 Hiring

The firm in this study, like most Korean companies, has historically been conservative in its hiring practices. The firm used to hire a large number of people at a time at the end of fiscal year, based on their next year plan rather than sporadically according to their needs, without using a range of innovative channels to bring them in and having a

complete organizational commitment to getting the best. The firm typically does not consider many factors in hiring new people either, except for educational background and schools, nor does it specify in detail the background, or experiences that would be exactly fitted in its needs. Therefore, it is getting important to hire right people in a right time to meet rapidly changing environment, especially in the research and development organization in firms in which more innovative work is asked to do, this hiring practice is likely to become more critical factor to the product development, combined with organizational structure itself.

In the hiring practice perspective, up to the around 5 years ago, all the new comers who passed the entrance examination that the company provides once a year are assigned to each organization, based on both evaluation of applicants and their desire. However, because both a strong preference to the highly reputed schools and male and prescreening the applicants in recruiting practice, most engineers were heavily concentrated on graduates from those couple of schools and male. For example, in 1984, 13 engineers out of 15 new comers assigned to a certain group were from Seoul National University. Nowadays, those trends weaken not only due to wider job opportunities attracting talented people but also change of recruit system as well as reinforced equal opportunity by regulations. The most significant change in hiring practice is to hire people at times through either internet or other media for their needed position and to emphasizing on both more abstract characteristics such as challenge, creativity, and team playing and on more specific skills, knowledge, and experience for each team's unique needs rather than describing just majors in education.

1.7.3 Project

The projects being done in each R&D laboratory can be categorized both by its characteristics of technology and funding source. The former are classified into three groups such as research project, development and revision or improvement, the latter are self-funded projects within each laboratory and out-sourced ones from companies that need a certain technology or new products. The ratio of the self-funded to the out-sourced is usually kept between 30% and 20%. Recently, because of tight budget control and the requirement of faster output in R&D activity from companies, the number of research projects decreases. The ratio of research projects to the others in the sample of this study is 32 %.

Table 1 shows the classification of 31 projects used in this study. While Information Technology Lab has only research projects, most of the projects in System IC Center are development type.

Table 1. Classification of Projects by Lab*

			LABs			
			Inf_Tech	Inv_Ctr	M_Sci	S_IC
Projects	Total Number		3	8	5	15
	Type	Research	3	3	3	0
		Development	0	5	2	14
		Revision	0	0	0	1
	Stage	Beginning	2	5	0	2
		Middle	0	2	4	6
		End	1	1	1	7

* Projects are categorized by survey results in March, 2001.

1.8 Summary

To understand organizations, it is important to consider the locus of causality and whether that is located in individuals, situations, or some combination (Pfeffer, 1997). The locus of causality directs where we place our research emphasis and how we go about understanding and affecting behavior, especially in fast moving organization. And it is the case that scholars, managers, and casual observers approach the analysis of organizations with a set of implicit or explicit models of behavior. These models both structure what we observed and learned and also affect the choice of how to intervene to change organizations and their members. Chapter 2 will discuss the demography in terms of variables, process, and performance. Chapter 3 will discuss the method used in this study concerning sample data, demographic variables, and measures of process and performance. Chapter 4 presents results of analysis on the demographic composition and its affects on an organization. Chapter 5 identifies demographic variables and effects on the performance at team level. And conclusion and plans for future research are presented in Chapter 6.

Chapter 2. Demography

In a recent review of the literature on groups and teams in organization, Guzzo and Dickson (1996) concluded that, in spite of its recent popularity, there is little consensus on what constitutes "diversity" and how it affects group performance. They suggest that "there is a real need to develop theory and data on the ways in which dissimilarity among members contributes to task performance". For example, Jackson, Stone, and Alvarez (1993) use diversity "to refer to situations in which the actors of interest are not alike with respect to some attribute(s)." They further differentiate between demography and personal attributes. The former being immutable characteristics such as sex, race, or age, while the latter are subjectively construed characteristics such as status, expertise, or style. Konrad and Gutek (1987) focus on characteristics of group composition that are salient, have some social meaning, and elicit predictable reactions from others. Decision-making process researchers typically define diversity in terms of variation in expertise or information (Wittenbaum and Stasser 1996), but not demographic or group affiliation. However, organizational demography researchers have concentrated mainly on characteristics that are visible, such as age, race, or sex, or job-related attributes such as functional background and tenure (Bantel and Jackson 1989; Wagner, Pfeffer, and O'Reilly, 1984; Wiersema and Bird 1993). In this study, therefore, the concept that the most salient and visible demographic diversity, regardless of how task-relevant they are, may lead to in-group/out-group distinctions and potentially affect group functioning (Ethier and Deaux 1994; Mullen 1983) will be focused.

Many researches show that increased diversity, especially in terms of age, tenure, and ethnicity, typically has negative effects on social integration, communication, and conflict (Chatman 1997, K. Williams and C. O'Reilly 1998). Diverse groups are more likely to be less integrated, less communication, more conflict. Interestingly, the one exception to this pattern is with regard to functional diversity or educational background. For this variable, increased diversity has been shown under some circumstance to increase communication (Ancona and Caldwell 1992). On the other hand, at the micro level, increased diversity typically has negative effects on the ability of the group to meet its members' needs and to function effectively over time. The thesis shows clearly individuals are affected by the demographic composition of their work groups. The preponderance of evidence shows that increased diversity within a group can be associated with lower levels of satisfaction and commitment, lower performance evaluations for those who are different, and higher levels of absenteeism and turnover (Ancona and Caldwell 1992).

Among a lot of demographic variables such as organizational and group tenure, background differences, including functional specialty and education, age, sex, race and ethnicity, which variables will have major effects on the team performance. Then how do those variables interact one another in the process within an organization? Based on the extant research, group process is most frequently investigated in terms of three primary dimensions: social integration, communication, and conflict (K. Williams and C. O'Reilly, III 1998). These three constructs are the most widely mentioned processes that are proposed to intervene between diversity and performance.

Using the survey results from the 31 new project teams at 4 high-technology research and development laboratories, this study investigates the impact of diversity on team performance. One well-known study (Ancona and Caldwell 1992) shows that functional and tenure diversity each has its own distinct effects. The greater functional diversity, the more team members communicates the outsider the team's boundaries such as marketing, manufacturing, and top management. The more the external communication, the higher the managerial ratings of innovation. And this also shows that tenure diversity had its impact on internal group dynamics rather than external communications. Tenure diversity is associated with improved task work such as clarifying group goals and setting priority. In turn, this clarity is associated with high team ratings of overall performance.

To move beyond the previous research, this study examines the effects of team demography on the team performance with more diversified demographic variables such as major, school, degree, and title in the culturally different settings. Each project team consists of people having same project goal as a team member and different functional skills for the given task respectively. Each team member works interdependently to complete their assignment within given schedule and budget, yet must work extensively with members across the team boundary. The most of them work as core members who create strategy for team and make key decisions as well as manage and carry the history and identity of the team, but some of them work as net team members (Ancona 2001) who have unique, but partially needed skills.

2.1 Demographic Variables

In order to analyze the effect of diversity on group performance, this study focuses on the effect of the distribution of more salient demography variables such as sex, tenure, age, as well as educational background including major, school, degree, and job title. The key research question is whether these variables are associated with the outcomes of a group or a team. In the high technology industry, or research and development area, for product development teams three variables, educational and functional diversity, and tenure of team members, are likely to be of particular importance. First, there is little variation in age or gender. Second, there is only modest diversity in university major. For this reason, this context represents a unique opportunity for evaluating one type of functional diversity - that of training. Third, the company recruits from a small number of academic institutions. Again this provides an interesting way to measure educational background diversity beyond simply level of highest degree. Fourth, there is great variation in the length of service of project team members. The firm has historically hired at the entry-level and promoted from within, given several years of both high growth and high turnover. Finally, while the institute has much less diversified in sex in general, almost all the people have same major in education, electrical engineering, in one laboratory. While useful, many organizational demography researchers do not provide a common metric from which to judge the effects of diversity on groups. What is clear is that diversity is not a unitary construct (Phinney 1996; Smith, Olian, Sims, O'Bannon, and Scully 1994). Zenger and Lawrence (1989) argue convincingly that individuals who join an organization at the same time develop similar understandings of its events and of the technology for

accomplishing work. This tenure homogeneity has been related to frequency of communication (Zenger and Lawrence 1989), social integration within a group (O'Reilly, Caldwell and Barnett 1989), and some measures of performance (O'Reilly and Flatt 1989). Given the technical nature and complexity of the project, this tenure diversity is likely to influence the process of the task and operation. However, the performance of a research and development team or individuals may be affected more by functional diversity of team members than any other demography variables.

2.2 Performance

Hackman (1987) suggests that "work group" is composed of individuals who both see themselves and are seen by others as an interdependent social entity embedded in a larger organization whose performance affects others, such as suppliers or customers. Task interdependence among group members is a necessary condition. In Hackman's (1987) view, "group performance" is defined by three criteria: (1) the productivity output of the group meets or exceeds the performance standards of the customer; (2) the social process used in carrying out the work maintain or enhance the capability of the members to work together on subsequent team tasks; and (3) the group experience satisfies rather than frustrates the personal needs of the group members. This definition calls attention to the fact that when considering group performance one must consider not only group-produced outputs, but also the consequences the group has for its members, and the capacity of the group to perform in the future (Gladstein 1984). This definition is important when reviewing the research on diversity since it calls attention to the fact that in

organizations "group performance" includes the expectation that the group will function over a long period of time. This means that research based on artificial, short-lived groups with intellective tasks requiring a decision but on sustained interdependence, while useful for testing some theories, is not a complete foundation for judging the effects of diversity in an organizational context. Such groups might be appropriate for assessing theories of information use and decision-making but do not permit an assessment to be made of the effects of processes such as conflict and cohesion on the long-term viability of the group. For these purpose, research needs to focus on intact working group in which members are interdependent over extended periods. In this sense, based on the field study how the diversity affects on group process and performance will be explored.

2.3 Process

There are lots of studies that have examined the relationship between demography and various outcomes; O'Reilly, Caldwell, and Barnett (1989) demonstrate that within a sample of work teams, homogeneity of tenure on the job is positively related to social integration. They further show that the aggregate social integration of the group is related to individual turnover. This suggests that demography influences turnover through the development of cohesive groups, which, in turn, reduce the likelihood of individual departure. O'Reilly et al. speculate that tenure similarity facilitates social integration by increasing both the opportunities for integration and the attractiveness of members to one another. In addition, researchers have used a number of theories to explain the effects of diversity on organizational process and performance. Different theories often lead

researchers to offer plausible but contradictory predictions of the effects of diversity on groups and individuals. In the large, there are three most common theoretical basis for investigating diversity: social categorization, similarity and attraction, and informational diversity and decision-making. While not comprehensive, these theories, or their variants, are used in the majority of studies of organizational demography and diversity and are important for interpreting the empirical evidence (Williams and O'Reilly 1998). Social Categorization theory most often used by demography researchers asserts that variations in the demographic composition of work groups or teams affects group processed such as conflict, cohesion, and communication, and that this process, in turn, affects group performance. The majority of this research is predicted on the logic of social categorization theory (Tajfel 1981; Turner 1987) and social identification theory (Hogg and Abrams 1988; Turner, 1982).

While the demography literature has emphasized social integration or cohesiveness as an intervening variable between demographic characteristics and outcomes, the group literature suggest task processes as an alterative mediating variable. Task processes are those behaviors aimed at organizing members to get work done as opposed to those that influence affect or the team's ability to maintain itself as a group over time (Philip and Dunphy 1959; Schein 1988). For example, goal setting is a task process. While group cohesiveness may, in fact, mediate the relationship between demographic dispersion and turnover, its link to performance is less clear (Lott and Lott 1965). Goodman, Ravlin, and Schminke (1987) suggest that there is no proof that cohesiveness is related to performance. While cohesiveness is related to conformity and adherence to group norms, those norms

may or may not facilitate performance. Instead, Goodman at al. suggest, processes related to task accomplishment will be more predictive of performance in work groups.

Demographic diversity increases conflict, reduces cohesion, complicates internal communications, and hampers coordination within the team (Dougherty 1987; Kiesler 1978; Shaw 1971; Pfeffer and O'reilly 1987). The conflict literature predicts intensified intra-group conflict when interdependence exists among parties with different goals (Schmidt and Kochan 1972). The group literature points to the difficulty of merging different cognitive styles, attitudes, and values (Bettenhausen and Murnighan 1985; Shaw 1971), such as those found on teams with diverse members. If not managed effectively, this diversity can create internal processes that slow decision-making and keep members from concentrating on the task.

The demography literature has concentrated on the negative relationship between tenure diversity and cohesiveness. Members arriving in an organization at different times do not have many opportunities for interaction, undergo disparate experiences, develop different perspectives, and are not as attracted to one another as members who arrived as the same time. These varying perspectives are also predicted to impede a group's ability to set common goals and priorities. In the realm of product development, for example, an individual who joined the organization at a time of market expansion will have a different scenario for how to meet customer demands than will someone who joined during a market contraction. Reconciling divergent scenarios often impedes a group's ability to negotiate roles, goals, and priorities (Bettenhausen and Murnighan 1985; Souder 1987).

In a similar vein, teams made up of individuals form different "thought worlds" (Ancona 1992) may find it difficult to develop a shared purpose and an effective group processes (Dougherty 1987). Research documented that categorizing people into groups, even on trivial criteria, can lead members to perceive out-group members as less trustworthy, honest, and cooperative than members of their own (arbitrary) group (Brewer 1979; Tajfel 1982). For example, Stephan (1985) has shown that once the categorization has occurred, positive behaviors of in-group members and negative behaviors of out-group members are attributed to stable, internal causes. Representatives form marketing, manufacturing, and engineering often have different time orientations, and even different definitions for basic terms such as "product" and "market" (Dougherty 1987; Lawrence and Lorsch 1969). The innovation literature readily acknowledges that functionally diverse groups have difficulties reaching agreements integrated programs of action (Souder 1987).

Hypothesis 1. The variation in organizational tenure and diversity in school and major will negatively impact on the internal processes.

Another theoretical perspective on the effects of diversity on group process will be how information and decision-making can be affected by variations in-group composition (Gruenfeld, Mannix, Williams, and Neale 1996; Wittenbaum and Stasser 1996). For example, given that there is a propensity for individuals to communicate more with similar others, individuals in diverse groups may have greater access to information networks outside their work group. This added information may enhance group performance even as the

diversity has negative impacts on group process (Williams and O'Reilly 1992). Zenger and Lawrence (1989) suggest that external communication is a second mediator of the relationship between demography and performance. In a study of research teams they found that technical communication between team members and non-project engineers were related to similarity in organization tenure. Although they do not test this idea, Zenger and Lawrence (1989) suggest that this communication is related to team performance. Similarly, the same tendency to seek similarity within a group can lead the group to fail to capture all information possessed by group members, either through the isolation of members who are different or the emphasis on common knowledge (Gigone and Hastie 1993). Based on Information and decision-making theory, variance in group composition can have a direct positive impact through the increase in the skills, abilities, information, and knowledge that diversity brings, independent of what happens in the group process (Tziner and Eden 1985). Demographically diverse individuals in a group are expected to have a broader range of knowledge and experience than homogeneous individuals. From this perspective, diversity is valuable when it adds new information to the group. Clearly, this positive impact of diversity can be expected when the task can benefit from multiple perspectives and diverse knowledge, such as innovations, complex problems, or product design. Researchers largely agree that functional or background diversity provides the range of knowledge, skills, and contacts that enhances problem solving (Ancona and Caldwell 1992; Bantel and Jackson 1989; Pelled, Einsenhardt, and Xin 1997). "Members who have entered the organization at different times knows a different set of people and often both different technical skills and different perspectives on the

organization's history" (Ancona and Caldwell 1992).

While tenure and functional diversity may make it more difficult for group members to get along and set goals and priorities, this same diversity provides the group with a broad set of external networks. Given the lack of kindred sprits within the group, members often seek outsiders with whom to communicate. Ancona and Caldwell (1990) found that communication with a functional area went up dramatically when someone from that area joined the new product team. In fact, one reason for creating a cross-functional or multi-tenured team is to create easier access to multiple functional areas and historical perspectives (Calantome and Cooper 1981; Voss 1985).

Hypothesis 2. The variation in tenure and educational diversity will positively affect on the communication with external networks.

2.4 Process-Performance Relationship

Many of the group process researchers have studied individual turnover as an important outcome affected by demographic variables and group process. In contrast, this study will focus more on finding the composition and process variables that affect performance based on self-evaluations by team members and managers. This section identifies the key components of performance as well as those between process and performance. Performance often has multiple dimensions, and ratings vary across constituents (Tsui 1984). For example, several studies of group performance have uncovered differences between individual performance evaluations in a team and

managerial performance evaluations (Ancona 1990, Gladstein 1984). It may be that each constituent group has different interesting and different data, i.e. team members may be more interested in creating productive environment, while team leaders and managers may be more interested in direct outputs of the project. Team members may be more interested in day-to day information on team activities as a basis for evaluating their performance, while managers hope to see more quantitative data such as schedule and budget adherence of the project (Ancona and Caldwell 1992). This study will use the multiple dimensions of performance such as number of innovation, adherence to schedule, etc. as well as comprehensive evaluation done by each team members including team leader to find the relationship among demographic variables, process, and performance. Each performance rating is the subjective-based gathered through questionnaires. In addition to the subjective ratings, a subset of the projects will be assessed by objective ratings.

To get the information needed to complete their task, a project team shall interact with people out of their team as well as among internal members. Those activities may increase aggregated knowledge and skills of team and team members by adding new information. A number of studies have examined the communication patterns of these groups (Allen 1984; Ebadi and Dilts 1986, Utterback 1984; Katz 1982; Tushman 1977, 1979). From these studies, it is clear that the amount and patterns of communication within team and with outsiders are closely related to performance. For example, high-performing teams have more communication between team members and outsiders in the organization than low-performing teams in general (Allen 1984). Tushman (1979) found that communication

in high-performing development teams followed a two-step process; communication "star" first obtained information from outside the group, then transmitted it to the rest of the group. The findings suggest that high levels of external communication and internal interaction are positively related to group performance in new product teams.

Hypothesis 3. Internal processes and external communications are positively related to team-rated performance.

In addition to the indirect relationship between demographic variables and performance, the direct effect of demographic variables on the team performance can be observed. In a project team, different composition of individuals may provide different sets of skills, abilities, information, contacts, and knowledge that can help the group to be productive, independent of how those resources are transformed through group process (Tziner and Eden 1985). Those diversities are assumed to increase the resource available. For example, the tenure diversity may increase the information pools, provide the team with a wider range of experiences, and diversify contacts in the organization because individuals who join the organization at different time may have different sets of skills and knowledge as well as different perception on the project and the organization. Those diversities will increase the probability of the team to be more innovative (Souder 1987) and have higher overall performance (Ancona 1991).

Hypothesis 4. Tenure diversity will affect positively on the team performance.

Another variablc-functional diversity or major in education-will also bring different sets of knowledge and skills to the team helping it be more productive. Here, to see if how the variable affects on the team performance;

Hypothesis 5. Educational diversity is positively related to the team performance.

Chapter 3. Method

This study relies on the data collected through electronic questionnaires from team members and team leaders as well as internal progress reports. These subjective measures were linked to personal data obtained from the human resources department.

3.1 Sample

The data for this study consist of two parts: evaluation data from the questionnaires responded by individuals and basic demography data from the human resources department. Data were collected from 31 project teams in 4 research and development (R&D) laboratories, which have done a wide range of research areas such as material science, soft ware, advanced display devices, and integrated circuit designs. As each laboratory has its unique research field, when needing outsider's technology or cooperation for their projects, they used to do it as an independent project team rather than as a co-project team. However, new product teams must obtain information and resources from other parts of the organization, both at the beginning and the end of project period, there should be enough interactions between teams or laboratories at individual and team level. Each team is responsible for developing new products. However, some teams build prototypes of the products in their labs and then transfer their outputs to manufacturing departments. Each team member was asked to indicate the nature of project: along two dimensions, project type (research, development, incremental improvement or revision), and project type (beginning, middle, end). This is for more accurate assess because member's evaluation or perception would be affected the by those two characteristics of

project. In addition, to assure the consistency in comparison, data are aggregated by the team. For the performance evaluation, all the team members, team leader and group leader were asked a set of questions about their perception of internal and external relationships, team functioning, and performance. (In the organizational perspectives, each laboratory consists of quite number of groups, and then each group has a couple of project teams according to its mission). Responses were collected from individuals, thus assume assessments were made independently without any intervention from peers or boss. For the team level analysis of performance and outcomes, individual answers to the questionnaires were aggregated by the each items according to the questionnaire's attributes.

3.2 Measures of Group Demography

In the demography perspective, unlike the one from companies in other western countries, the data shows less diversified in several demographic variables such as sex and majors in education. Especially, the ratio of male to female in number is much smaller than that in the other research (Ancona: Demography and Design 1992). Whereas education level is relatively high. Thus, in this study the three most important demographic variables are focused, such as the coefficient homogeneity of variation of team members' tenure in each laboratory, the amount of diversity in educational backgrounds such as majors of team's constituents, schools from which individual graduated, and degree. The degree is coded as four categories: doctoral degree - 4, master - 3, bachelor - 2, and associated level 1, and then averaged by team. Thus, the higher mean scores, the higher education a team has,

3.2.1 Tenure Diversity

For an interval data such as age or tenure, Allison (1978) and Pfeffer and O'Reilly (1987) suggest that the coefficient of variation, the standard deviation divided by the mean, provides the most direct and scale invariant measure of dispersion. Thus, to obtain the value of the relative homogeneity of team's tenure, the standard deviation of each team's tenure was divided by the team's mean (Ancona 1992). The average of the coefficient across the organization is 0.84.

3.2.2 Educational Diversity

The functional diversity in a team comes from two backgrounds of individuals: individual's education and previous experience regardless of educational background. However, sometimes it looks hard to tell what one's background is. Thus, the people who have less than two years experience in current area would be reasonable to be categorized by his or her education in college or upper level institute. On the other hand, some people look more appropriate to be grouped by their previous experience rather than by education. To assess the educational diversity in both major and school, using an entropy-based diversity index suggested by both Taagepera and Ray (1977) is appropriate. This measure is defined by Teachman (1980) as:

$$H = - \Sigma \ P_i(\ln P_i) \quad i = 1, 2, 3, \ldots S$$

As Pfeffer and O'Reilly (1987) show, if there are N possible states in which the system can be, P_i is the probability that the system will be found in state i, then this formula can be used to index the heterogeneity in the system. In this study, P represents the

fractional share of team members assigned to each member's professional background. The only exception occurs when an area has no value. In that case, the value assigned that state is zero. Using this formula, if a team was made up of nine individuals from electrical engineering background, one from physics, on one from chemistry, the educational diversity index for that team would be 0.325.

3.3 Group Measures

In this study, group processes are categorized into three variables: measures of team functioning; measures of relationship; and communication with outsiders.

3.3.1 Measures of Team Functioning

To assess team members' perceptions of group process, four different perspectives were investigated: setting goal, developing plan, prioritizing work, and efficiency. All the scores rated by team members according to 5-point Likert scales, were averaged at team level to be compared. The high score meant that the team could do well the team process related to its given task. Average score across the laboratories is 3.84 (sd = 0.435).

3.3.2 Measures of Relationship

To gather data for assessing a team, each team was asked about two major activities: internal and external process, from the questionnaire completed by team members and team leader. Internal process of a team is described in a set of questions related to the team decision-making, perception of team level activities within the given team, and external process means the team's activities with the outsiders of the team both in individual level and team level.

3.3.3 Communication with Outsiders

Another factor to be compared each other at the team level is the information and cooperation seeking activities through communication with outsiders at either individually or as a group. Each member was asked how many times he or she talk to the people in out of team boundary. The aggregated average is 1.99 (sd = 0.506)

But in the data's reliability point of view, it seems to be somewhat arguable in that how accurately each people assesses his or her communication with others, for example, how can he or she count the numbers of talks with the person who he or she gets help from it. Bernard, Killworth, and Sailer (1980) and Bernard, Killworth, Kronenfeld, and Sailer claim that asking people whom they talk to, how much, produces totally inaccurate results. Other researchers have countered by showing that while people may not reproduce communication exactly, their bias is in the direction of long-term patterns (Freeman, Romney and Freeman 1987). In this study, to get more general form of response, each people was asked of how many times did he or she talked with outsiders in past two weeks, in stead of being asked with whom or what they discussed about. As predicted, there was wide variety of dispersion among the respondents by the organization of which is concerned in the their project characteristics. The more the project oriented in the research, the less communication.

3.4 Measure of Team Performance

To explore the relation between demography variables and performance in a team, by using 5-point Likert scales, each individual including team leader and group leaders

was asked to evaluate his or her team's qualitative performance (adherence to schedule and budget, reputation, and comprehensive performance), quality (work quality provided and number of innovations or new ideas introduced by the team), and efficiency (operation, coordination, ability to resolve conflict within the team). And then team performance ratings were grouped into three dependent variables such as quantitative, qualitative, and overall performance. To analyze the team performance, the performance ratings completed by the individuals were averaged to form a single performance rating. And the ratings made by more than one person in a team were also averaged. Averages for each variable are 3.5 (sd =0.572) for the quantitative, 3.7 (sd = 0.464) for the qualitative, and 3.8 (sd = 0.492) for the overall.

3.5 Control Variables

Group researchers argue that group size is an important variable that may influence indirectly the potential magnitude of the coefficient of variation and affect the group process and communication. In this study, the team size was included in analyzing (mean = 6.194, sd = 1.600)

In addition, other variables such as the nature of the project, previous experience, and resource availability can also be factors influencing both the group process and performance of the team. Of course, beside the above, there would be many other variables such as the degree of competition among rivals having impact on a team's outputs. But beside the team size, this study will focus on the above three variables as controllers because of the limitation of data to be fully assessed. Firstly, according to the nature of

project, different models may be necessary to explain radical and incremental innovations (Dewar and Dutton 1986). When a product is revolutionary, the team may have different patterns of external communications that when it uses a known technology (Brown and Utterback 1985). This was sorted by using 3-point scale (mean = 1.69, sd = 0.495). Secondly, previous experience in developing similar products or similar technology will be another important control variable because it may influence internal process and team performance in general. The third one is resource availability. If the resources are limited in any way, the group process and communication patterns will be needed and developed in different way compared with the situation they can be widely available and then eventually performance may be affected. The data related to the resource availability were gathered through survey to the team members and averaged to single score (mean = 3.436, sd = 0.718).

3.6 Analysis

In analyzing the effect of demography on process and performance, this study involves three step regressions: The first step entails computing correlation between the demography and performance variables to ascertain the total association between each combination. The second is the multiple regression steps to regress each demographic variable against process mediators such as external communication, external relationship, and team functioning, and then the process mediators including the demographic variables are regressed against the performance. In the third step, using the dummy variable regression, relationships between key demographic variables and performance are further

examined according to the project types, project stages, and laboratories .

Chapter 4. Results

4.1 Correlations among Demography, Process, and Performance Variables

Table 2 reports the descriptive statistics and correlation coefficients for all variables in this study.

Table 2. Means, Standard Deviations and Correlations

	Variable	Mean	StdDev	1	2	3	4	5	6	7
1	team_size	6.194	1.600	1.000						
2	f_ratio	10.239	12.314	0.227	1.000					
3	tenure_avg	5.096	2.610	-0.075	-0.001	1.000				
4	age_avg	31.465	2.121	-0.320	-0.247	0.647***	1.000			
5	major	0.491	0.434	0.234	0.034	-0.269	-0.027	1.000		
6	school	1.311	0.330	0.730***	0.194	0.140	-0.198	0.106	1.000	
7	degree_avg	3.006	0.332	-0.070	-0.053	-0.449*	-0.023	0.402*	-0.150	1.000
8	title	2.267	0.368	-0.245	-0.179	0.626***	0.794***	0.010	-0.107	0.170
9	team_funct	3.814	0.435	0.112	0.050	-0.257	-0.139	0.377*	0.004	0.268
10	com_ext	1.977	0.506	0.063	-0.060	0.119	0.090	-0.044	-0.130	-0.262
11	rel_ext	3.810	0.345	0.116	-0.074	-0.149	-0.140	0.332	-0.049	0.320
12	pf_quantity	3.473	0.572	-0.119	-0.170	-0.275	0.031	0.119	-0.214	0.415*
13	pf_quality	3.674	0.464	0.165	0.059	-0.360*	-0.273	0.288	-0.035	0.220
14	pf_overall	3.782	0.492	-0.012	-0.181	-0.226	-0.042	0.332	-0.207	0.266

	Variable	Mean	StdDev	8	9	10	11	12	13	14
8	title	2.267	0.368	1.000						
9	team_func	3.814	0.435	-0.192	1.000					
10	com_ext	1.977	0.506	0.092	-0.305	1.000				
11	rel_ext	3.810	0.345	-0.185	0.196	0.169	1.000			
12	pf_quantity	3.473	0.572	-0.031	0.731***	-0.346	0.143	1.000		
13	pf_quality	3.674	0.464	-0.387*	0.892***	-0.311	0.174	0.632***	1.000	
14	pf_overall	3.782	0.492	-0.039	0.745***	-0.308	-0.093	0.659***	0.740***	1.000

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

In the table, of some interest, several factors are strongly correlated. The relationship between ratings of quantitative performance (adherence to budget and schedule) and

average degree of engineers was positively strong ($r = 0.415$, $p \leq 0.05$), even though not strong enough to be redundant measure. That means that while school diversity is negatively related to the quantitative performance, the team consisted of higher educated people shows better performance. Whereas the higher tenure averaged, the lower qualitative performance ($r = -0.360$, $p \leq 0.05$). Many researchers argue that functional diversity is negatively related to team-rated performance (Ancona and Caldwell 1992). Similarly, school diversity has negative impact on the all team-rated performances, even though statistically not significant. The relationship between ratings of qualitative performance including technical innovation, quality of work and efficiency of team operations and tenure also was strong, but to the opposite direction. As expected, the demographic measures, title, tenure, and age, were closely and positively related to each other. That result is consistent with the general perceptions of both employers and employees in Korea that most employees expect to have a lifetime engagement with one company. As Ancona and Caldwell (1992) suggest that internal task processes are positively related to team-rated performance, the team functioning process is the most closely related variable to all the performance ratings ($r > 0.73$, $p \leq 0.001$). Thus, most demographic variables is likely to affect the on the performance mainly through the mediating variables rather than directly affecting on the performance. Hypothesis 2 posits the positive relationship between tenure and educational diversity and with external networks. But the data show nothing to do with it. Whereas major diversity has a strong positive relation with team functioning ($r = 0.377$, $p \leq 0.05$).

4.2 Demography and Performance

Table 3 presents multiple regression results, with performance variables as the dependent variables. The results show that with the exception of major, most of demographic variables are not directly related to the performance outcomes. The more a team has diversified educational background by major, the higher the ratings of performance in schedule and budget adherence. It supports the hypothesis 5 that posits major diversity is positively related to the team performance in the research and development organization.

Table 3. Regression Results of Demography and Dummy Variables on Performances

	Quantitative		Qualititative		Overall	
Variable	Coef.	StdErr.	Coef.	StdErr.	Coef.	StdErr.
female_ratio	-0.014*	0.007	-0.001*	0.007	-0.010	0.008
tenure_dispersion	0.017	0.329	0.124	0.324	0.246	0.404
tenure_avg	0.087	0.090	0.003	0.089	-0.079	0.109
age_dispersion	-1.318	1.514	-1.631	1.491	-1.052	1.859
age_avg	0.083	0.078	0.094	0.078	0.078	0.094
major	0.624*	0.356	0.185	0.354	0.643	0.431
school	-0.231	0.356	-0.263	0.354	-0.547	0.431
degree_avg	0.114	0.378	0.212	0.376	0.104	0.457
title	-0.647	0.441	-0.562	0.439	0.134	0.534
team_size	0.049	0.079	0.033	0.078	0.042	0.095
research	0.740*	0.393	-0.508	0.390	-0.615	0.475
revision	1.231*	0.451	0.717	0.448	0.357	0.545
beginning	0.062	0.250	0.044	0.249	0.111	0.303
end	-0.061	0.199	-0.063	0.198	-0.057	0.240
inf_tech	0.820*	0.409	1.437***	0.407	1.314**	0.495
inv_ctr	-0.103	0.415	0.294	0.413	-0.332	0.502
m_sci	-0.648	0.487	0.610	0.485	0.171	0.590
_cons	1.188	2.315	1.201	2.303	1.439	2.802
* $p \leq 0.1$	F = 3.04		F = 1.82		F = 1.10	
** $p \leq 0.05$	R^2 = 0.799		R^2 = 0.704		R^2 = 0.591	
*** $p \leq 0.01$	d.f = 17		d.f = 17		d.f = 17	

By using the dummy variable regression, this study investigated the relationship among the project types, project stages, and laboratories. Drawing upon the result in the table 3, revision or improvement project is predicted to achieve higher performance that development. And Information Technology Lab has the highest scores in all the performance ratings.

4.3 Demography and Team Process

Table 4 reports the regression results of team processes such as internal team functioning, the frequency of communication with other teams, and external relationships against demographic variables.

Table 4. Regression Results of Demography and Dummy Variables on Team Processes

	Team_Funt'ng		Com_External		Rel_external	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
female_ratio	-0.002	0.008	-0.004	0.006	-0.005	0.005
tenure_dispersion	0.056	0.387	0.053	0.306	0.068	0.239
tenure_avg	0.000	0.105	0.145*	0.081	0.215***	0.064
age_dispersion	-1.367	1.784	0.455	1.408	-0.281	1.103
age_avg	0.070	0.091	-0.161**	0.071	-0.087	0.055
major	0.467	0.415	0.543	0.322	-0.019*	0.252
school	-0.061	0.415	-1.056***	0.323	-0.238	0.252
degee_avg	0.121	0.440	-0.216	0.342	0.466*	0.267
title	-0.339	0.514	0.708*	0.400	-0.743**	0.312
team_size	0.002	0.092	0.273***	0.071	0.058	0.056
research	-0.225	0.457	0.334	0.356	0.518*	0.278
revision	0.623	0.525	0.677	0.408	0.726**	0.319
beginning	0.165	0.292	-0.575**	0.227	0.066	0.177
end	-0.030*	0.231	0.054	0.180	0.043	0.140
inf_tech	0.921*	0.476	-0.517	0.370	-0.424	0.289
inv_ctr	-0.036	0.483	0.562	0.376	0.581*	0.293
m_sci	0.202	0.568	-1.295***	0.442	0.116	0.345
_cons	1.762	2.698	4.978**	2.097	5.429***	1.638
* $p \le 0.1$	F = 0.82		F = 2.69		F = 1.84	
** $p \le 0.05$	R^2 = 0.518		R^2 = 0.778		R^2 = 0.707	
*** $p \le 0.01$	d.f = 17		d.f = 17		d.f = 17	

As is shown in the Table 4, while the diversity of tenure has no significant impact on the internal team functioning, it is positively related to both external communication and external relationship. This partially supports hypotheses 1 and 2 that tenure variation will negatively affect internal processes and positively affect communication with external network. Of some interests, the results show that the diversity in educational institute has quite a strong negative effect on the external communication. One plausible interpretation is that teams consisting of members from a variety of schools may need to devote more time to communicate internally so that they are limited in their ability to communicate externally.

4.4 Demography, Process and Performance

Table 5 presents the results of regression on performance against both demographic variables and process variables. From the result, it appears that team functioning is significantly positively related to the performance ratings. That supports hypothesis 3 that internal processes and external communications are positively related to team-rated performance.

The some of regression results such as female ratio and school diversity show strong negative relationship between demographic variables and performance. This also supports the hypothesis 2. In terms of project type, research and revision or improvement projects have better quantitative performance ratings than development project. Most development projects are likely to be carried out under more pressure than the others regarding the

budget and schedule.

One interesting finding is that communication with outsiders as a mediator seems to statistically have nothing to do with any of performance ratings. This may mean that the sample teams in this study do not have much need to interact with outsiders.

Table 5. Regression Results of Team Process, Demography and Dummy Variables on Performances

	Quantitative		Qualititative		Overall	
Variable	Coef.	StdErr.	Coef.	StdErr.	Coef.	StdErr.
team_function	0.693***	0.120	0.761***	0.105	0.659***	0.198
com_external	-0.181	0.162	-0.095	0.141	-0.152	0.267
rel_ext	-0.314	0.207	-0.100	0.180	-0.595	0.341
female_ratio	-0.014***	0.004	0.000	0.003	-0.012*	0.006
tenure_dispersion	-0.024	0.185	0.095	0.158	0.259	0.299
tenure_avg	0.180**	0.065	0.038	0.057	0.071	0.108
age_dispersion	-0.403	0.876	-0.608	0.746	-.2516	1.412
age_avg	-0.023	0.050	0.017	0.044	-0.045	0.083
major	0.393*	0.221	-0.121	0.193	0.406	0.364
school	-0.454*	0.253	-0.342	0.220	-0.809*	0.417
degree_avg	0.138	0.233	0.146	0.203	0.268	0.384
title	-0.517	0.324	-0.311	0.282	0.022	0.534
team_size	0.115*	0.060	0.063	0.052	0.116	0.099
research	1.119***	0.238	-0.252	0.207	-0.107	0.392
revision	1.150***	0.300	0.381	0.261	0.481	0.495
beginning	-0.135	0.167	-0.129	0.146	-0.046	0.276
end	-0.017	0.108	-0.031	0.094	-0.004	0.178
inf_tech	-0.045	0.266	0.645**	0.231	0.376	0.438
inv_ctr	0.206	0.258	0.433*	0.224	0.123	0.425
m_sci	-0.985**	0.342	0.344	0.298	-0.090	0.563
_cons	2.572	1.728	0.879	1.505	4.267	2.849
* $p \leq 0.1$	F = 9.76		F = 8.82		F = 2.42	
** $p \leq 0.05$	R^2 = 0.951		R^2 = 0.946		R^2 = 0.829	
*** $p \leq 0.01$	d.f = 18		d.f = 18		d.f = 18	

Table 6 and 7 show the mean and standard deviation of each variables by laboratory and project type respectively. Because of a small number of sample projects in each

laboratory, it is not easy to draw any conspicuous trends out of data. However, there are a couple of intriguing results. System IC center has more development projects than any other laboratory and the highest average tenure and team experiences, but it shows the lowest performance ratings and team functioning scores.

Table 6. Mean and Standard Deviation of Demographic Variables by Laboratory

	Inf_Tech(Obs=3)		Inv_Ctr(Obs=8)		M_Sci(Obs=5)		S_IC (Obs=15)	
Variable	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev
pf_quantity	4.417	0.382	3.542	0.496	3.500	0.612	3.239	0.444
pf_quality	4.361	0.337	3.785	0.325	3.867	0.385	3.413	0.395
team_function	4.327	0.431	3.893	0.305	4.027	0.358	3.597	0.412
com_external	1.238	0.297	2.128	0.525	1.757	0.451	2.118	0.415
rel_ext	3.631	0.398	3.963	0.421	4.014	0.255	3.696	0.276
prj_type	1.000	0.000	1.625	0.518	1.200	0.447	2.133	0.352
prj_stage	1.667	1.155	1.500	0.756	2.200	0.447	2.200	0.561
team_exp	1.500	2.179	0.750	1.035	1.000	1.061	4.237	1.956
female_ratio(%)	18.453	22.041	9.896	14.763	5.716	7.827	10.287	10.353
sex_avg	1.185	0.221	1.099	0.148	1.057	0.078	1.103	0.104
tenure_avg	2.923	1.476	2.254	0.846	5.891	2.809	6.781	1.667
tenure_dispersion	0.845	0.632	1.177	0.480	0.860	0.444	0.656	0.184
age_avg	29.293	1.032	30.993	2.523	31.936	2.515	31.995	1.727
age_dispersion	0.139	0.061	0.155	0.048	0.126	0.014	0.132	0.091
major	0.228	0.394	0.801	0.228	1.078	0.146	0.183	0.234
school	1.393	0.088	1.216	0.456	1.412	0.272	1.312	0.311
degree_avg	3.229	0.206	3.215	0.396	3.196	0.223	2.787	0.194
title	1.994	0.134	2.080	0.425	2.497	0.357	2.345	0.317
team_size	6.667	1.528	5.875	2.167	7.400	1.140	5.867	1.302

Total Observations = 31

On the other hand, having only research projects, Information Technology Lab shows the lowest external communication measures but highest ratings of team performances and team functioning in average. Therefore, based on the data on Table 6 and 7, the person who is doing development project is likely to be less satisfied with the

project.

Table 7. Mean and Standard Deviation of Demographic Variables by Project Type

	Res (Obs=10)		Dev (Obs=19)		Rev (Obs=2)	
Variable	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev
pf_quantity	3.983	0.543	3.208	0.423	3.438	0.088
pf_quality	3.911	0.467	3.534	0.438	3.813	0.265
team_function	4.051	0.401	3.674	0.423	3.958	0.194
com_external	1.660	0.396	2.196	0.464	1.494	0.160
rel_ext	3.928	0.315	3.803	0.332	3.286	0.101
prj_type	1.000	0.000	2.000	0.000	3.000	0.000
prj_stage	1.700	0.823	2.105	0.658	2.000	0.000
team_exp	0.850	1.395	3.117	1.897	5.667	4.714
female_ratio(%)	10.061	13.611	11.411	12.123	0.000	0.000
sex_avg	1.101	0.136	1.114	0.121	1.000	0.000
tenure_avg	4.111	2.789	5.371	2.487	7.400	1.131
tenure_dispersion	0.940	0.518	0.794	0.375	0.806	0.000
age_avg	31.679	2.697	31.023	1.477	34.600	2.546
age_dispersion	0.140	0.048	0.141	0.080	0.098	0.060
major	0.702	0.436	0.431	0.405	0.000	0.000
school	1.228	0.261	1.353	0.376	1.332	0.000
degree_avg	3.331	0.256	2.888	0.220	2.500	0.141
title	2.361	0.377	2.204	0.374	2.400	0.283
team_size	6.200	1.476	6.316	1.734	5.000	0.000

Total Observations = 31

Chapter 5. Discussion

Many researchers have studied the effects of demographic variables on the performance of R&D teams to find answers to the questions: how the teams should be formed or how the variables affect the group performance. Many studies have found that some of the demographic variables have strong positive impacts, but others find negative, in a certain environment of teams or organization. However, despite those findings, because of the complex relationship between the variables and performance, which would be differently shaped by the type of work, people, and culture in organizations , still there is not a golden rule for designing organization.

5.1 Demography Variables

The proposition that diversity in both tenure and educational background will affect negatively on the internal process performance was supported only partially by the regression results. That is, the more heterogeneous team in terms of school, the lower the interaction with others. And each demographic variable seems to have a certain operating direction. For example, the higher average age within a team, the less number of interaction the team members. In addition, tenure average is strongly positively related to both of external communication and external relationship. Therefore, in the organization this study concerned, the older team, the better relationship team members have with other teams. One of the most interesting things is the relationship between school and performance. The diversity in school has most significant negative impact on the performance, combined with the strong negative impact on the group process. In this unique organization, the

more homogeneous team in terms of diversity of school is likely to have better performance through the group process. Therefore, this finding, unlike the functional diversity supported by Zenger and Lawrence (1989), the diversity in school is negatively related to external communication is quite interesting. This is likely to be explained in part by Hackman's argument that the social process used in carrying out the work maintain or enhance the capability of the members to work together on subsequent team task. On the other hand, even though the female ratio across the laboratories is small, it also negatively affects the team-rated performance. Contrary to a lot of findings by researchers, the other most demographic variables have nothing to do with either group process or performance ratings by team members in this sample.

5.2 Mediating Variables

One of the process variables is the internal team functioning. Stogdill (1959) has argued that the primary demand on a team is the resolution of internal conflict, referred to as group maintenance, and that groups cannot operate efficiently until this internal conflict is resolved. Regression results show that while external communication has negative impact on performance, internal team functioning is strongly positively related to the team-rated performance ($P > 0.65$, $p \leq 0.01$). This complements those of Ancona and Caldwell (1992), who found that internal task processes are positively related to team-rated performance but external communication is not. This can be explained by the argument that members may label their team high performing if it exhibits the processes thought to be linked to performance (Calder 1977, Gladstein 1984, Staw 1975).

Chapter 6. Conclusion

Even though this study used the survey data from 191 individuals of 31 project teams, because of relatively small of the number of projects to be tested, readers should use caution when interpreting results. Because many of correlation coefficients and regression coefficients among variables were located around the statistical border, some of relationships could not be easily assessed. In addition, the aggregation of individual data to form scores may also have the risks of producing aggregation biases and statistical artifacts that mislead the teams' behaviors. These limitations suggest several directions for the future studies. First, these studies could broaden the scope of project teams across the companies to get more generalized phenomena in causal relationships among demography, group process, and performance. Second, to reduce the aggregation and response bias coming from differences in personal perceptions, these studies may also include outsider's ratings such as assessments from other people in the "value chain". Finally, more objective evaluations on performance such as time to market, budget and schedule adherence based on initial project plan should be obtained to alleviate potential misrepresentation of team's performance.

Through this study, despite these limitations, this study finds some important things. First, diversity in major and school are closely associated with both group process and performance. Second, each demographic variable has a distinct way affecting other variables. Third, this study shows that the person who is doing development project is likely to be less satisfied with the project and work under high pressure from the budget

and schedule. Fourth, the result supports the findings by other researchers that demography has impact on the performance both directly and indirectly.

Appendix

Interview Protocol

I. Demographic Variables

I would like to know how your project team consists of in terms of demography and diversity.

Name of Project:

Project Schedule:

Project Budget:

Demography Data Form:

Lab	Group	Pjt	Name	Title	Rank	School	Major	Degree	Yr. of Join	Birth

II. Project Team Questionnaire*

Please indicate your name in the space below. Your responses are totally confidential and no individual's responses will be reported. Only aggregated results will be printed so that no individual can be identified. Nonetheless, your name is needed in case we need to clarify any responses.

Name:

1. Project

I would like to know to which category the project you have been working on or had worked might belongs in the following.

① Please indicate "X" in the parenthesis which you feel best describes your project.

② Research ( ), Development ( ), Incremental Improvement or Revision ( )

③ Where is your project going on in the following stage considering the whole project period. Initial( ), Middle ( ), Ending ( )

④ Number of projects done together as a same or a core team with more than 50% of same members( ).

Strongly		.....			Strongly
Disagree (1)	(2)	(3)	(4)		Agree (5)

⑤ This team is able to define its goals. ( )

⑥ Team members have developed effective plans and procedures to coordinate work. ( )

⑦ This team is effective in setting priorities and determines which aspects of the work are important.

* The questionnaire used in this study was made based on the Team Questionnaire of "New Product Team Study" by Ancona and Caldwell (1992).

⑧ This team is able to change the way we work when a problem requires a different approach. ( )

⑨ This team does a good job of trying to ensure that the product being developed meets company demands. ( )

2. Performance

I would like to get the performance evaluations on the each project from the internal team members, team leader, and upper level managers through the following questions.

As a member of the project team or a team leader or a general manager, how would you rate your team on each of the following? Please write a number raging from 1 to 5 in the parenthesis that best shows your evaluation.

Deeply	.....			Exceeds
disappointing (1)	(2)	(3)	(4)	my expectation (5)

① Efficiency of team operations ( )

② Quality of the work we provide ( )

③ Number of innovations or new ideas introduced by the team ( )

④ Our adherence to schedules ( )

⑤ Our adherence to budgets ( )

⑥ Our ability to coordinate with one another ( )

⑦ Our reputation for work excellence ( )

⑧ Our ability to resolve conflicts in a reasonable time period ( )

⑨ Comprehensive Evaluation ( )

3. Team Functioning

I would like to know to what degree you feel the following statements describe your team. Please write an appropriate number in each parenthesis.

Strongly	.....	Strongly
Disagree (1)	(2) (3) (4)	Agree (5)

① This team does a good job obtaining the resources needed to do its work. ( )

② Team members do a good job coordinating their activities. ( )

③ This team establishes clear expectations about how team members should act. ( )

④ Team members take it upon themselves to go to external sources to obtain needed materials, personnel, or information. ( )

⑤ This team is effective in translating broad goals into operational plans. ( )

⑥ This team has done a good job of figuring out how work will flow among team members. ( )

⑦ This team finds ways to minimize tension between team members. ( )

⑧ This team is able to convince others in the company to support our work. ( )

⑨ This team has established an effective process of obtaining feedback from others when we need it. ( )

⑩ This team keeps team members satisfied. ( )

⑪ This team has taken sufficient effort to ensure that the project being developed meets market demands. ( )

⑫ On this team, it is clear who is responsible for various part of the work. ( )

⑬ This team resolves conflicts that exist among team members, in a timely manner. ( )

⑭ Members of this team are good at interacting with outside sources to get information to aid in determining what the product should be. ( )

4. Relations with other teams

This section of the questionnaire asks you to describe the frequency of communication between you and the other area during the past two weeks.

Not at all (1)
Less than once per week (2)
Once per week (3)
Two or three times per week(4)
Once per day (5)
Several times per day (6)

Frequency of communications with other departments and/or teams. Please the number of time you had a communication with followings within last two weeks.

① Manufacturing ( )
② Marketing and Sales ( )
③ Product Design ( )
④ Research ( )
⑤ Service ( )
⑥ Top Management ( )
⑦ Top Corporate Management ( )

Please indicate the extent to which you currently see it as your responsibility to engage in the following activities with individuals outside your team. These "outsiders" may be in other companies or people in your company who are not formally assigned to your team.

Not at all		To some extent		To a large extent
(1)	(2)	(3)	(4)	(5)

① Persuade others to support your team's decisions. ( )
② Review product/project design with outsiders. ( )
③ Acquire resources (e.g. budget, new members, equipment) for your team ( )
④ Develop or improve communications with outsiders, even if there is no immediate or direct payoff for your team. ( )
⑤ Avoid releasing information to others in the company to protect your team's image or product it is working on ( ).
⑥ Find out what competing firms or teams are doing on similar projects. ( )
⑦ Keep other teams in the company informed of your team's activities. ( )
⑧ Protect the team from outside interference. ( )
⑨ Resolve design problems with external teams. ( )
⑩ Persuade other individuals that your team's activities are important. ( )
⑪ Report progress of team to a higher organization level. ( )
⑫ Procure things that your team needs from other teams or individuals in the company. ( )
⑬ Try to find out information on your company's strategy or political situation that may affect the project. ( )
⑭ Keep news about your team secret from others in the company until the appropriate time. ( )

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