A study on the process model of knowledge absorptive capacity for technological innovation capabilities: A content analysis approach

Murad Ali and Kichan Park

Graduate School of Business Administration Inha University Incheon
253 Yonghyun-Dong, Nam-Gu, 402-751, South Korea (corresponding author: muradjee81@hotmail.com)

ABSTRACT

Objective: This study presents the development stages of a theoretical model of knowledge absorptive capacity (KAC) that shows how most, if not all, firms in developing countries initiate, implement, assimilate, improve and develop external knowledge. **Method:** the study reviews the literatures, models and frameworks related to knowledge absorptive capacity. The study utilizes a qualitative content analysis as an explanation method in case study research to validate the proposed model. The study then analyzes Korean firms as a case in point to illustrate how Korean firms have built their knowledge absorptive capacity. **Results:** The model consists four stages: 1) Knowledge initiation, 2) Knowledge imitation, 3) Knowledge improvement and finally 4) Knowledge innovation or 4KI. The framework shows four development stages at Korean firms as: 1) Entrance of foreign companies into the Korean market and their reluctance to transfer their knowledge and information sharing to Korean firms, initiating its knowledge absorptive capacity, 2) Korean firms started knowledge absorptive capacity by means of imitating knowledge from external (especially foreign firms), 3) it then developed knowledge absorptive capacity by means of improving external knowledge and finally 4)) capability to create their own knowledge and becoming one of the leading economy in the world which challenges firms from advanced countries in the global market. The paper also highlights the developmental changes in the electronics industry of Korea. **Conclusions:** Keeping past experiences in consideration, we conclude that this model provides useful implications for developing economies - known as late-comers following the same pattern of KAC.

Keywords: Knowledge absorptive capacity model, developing countries, technological innovation capabilities, latent content analysis, Samsung Electronics Korea

1. INTRODUCTION

The growth of any industrialized economy could be affected by many economic, social, technical and development factors. Knowledge absorptive capacity (KAC) may be one of the most prominent factors which is an integrated outcome of many factors input (Kim, 1995). Both in developed and developing countries, practitioners and academics have mutual consensus that establishing and sustaining competitive advantage no longer merely depends on internal knowledge but rather effectively utilizing external knowledge, and exploiting knowledge to generate new innovation and knowledge (Fabrizio, 2009; Gebauer et al, 2012; Kogut and Zander, 1992; Teece et al, 1997). Also modern economies in the "knowledge society" are not based on factors of production such as capital and labour as much they are based on knowledge, which became the key factors of development and key element in production process (Davenport and Prusak, 1998; Drucker, 1968; 1993; Murovec and Prodan, 2009).

Many prior studies in developed countries (Cohen and Levinthal, 1990; March, 1991; Nelson and Winter, 1982; Nonaka and Takeuchi 1995; Utterback 1994) and developing countries (Kim 1997) have made significant research progress in learning, innovation and technology. While technological development but still research on KM, KAC, learning organization, technological learning, innovation and creativity is limited in those countries (Kim 1997; Nonaka and Takeuchi 1995; Utterback 1994). Most of developing economies - known as late-comers technological capabilities, leapfrogging innovation and catching up process are based on *initiation-imitation-improvement-innovation* of knowledge and technology borrowed from external sources (especially advanced countries). Even technological innovation and capability of many advanced countries is base on the same pattern (Kim, 1980; Ozawa, 1974). Cohen and Levinthal (1990) argue that the external sources of knowledge are often critical to the organization process and innovation capabilities because most of innovation is result from borrowing rather than invention (March and Simon, 1958).

The economic development of a country depends upon the capacities of its individual members and the development of organizations. Since firms also play a pivotal role in industrialization, so primarily this study deals with firm's KAC and its relationship with

technology. This paper attempts to analyze the process model of KAC by analyzing various studies of KAC at the Korea [Samsung Electronics Company (SEC); hereinafter Samsung] as a case in point. The paper also reviews models and frameworks related to KAC which are proposed in the context of both at individual and organizational levels. The objective of this study is to examine the organizational KAC by analyzing as the case of DRAM technological knowledge and innovation at Samsung. Samsung's rapid technological learning and emerging as the first innovative company of South Korea (hereinafter Korea) in a very short time raises several research questions. (1) Korea was a latecomer and many international firms in advanced countries were leading electronics industry, what are the factors that contributed to Korea's knowledge creation? (2) As a late comer in industry, how does Korea absorbed knowledge so expeditiously? (3) Korea has emerged as one of the leader in electronics industry, especially in the semiconductor, LCD and mobile phone, what are the technological learning strategies that Korea has developed to led to its success? (4) Can other firms in developing countries imitate the knowledge absorptive capacity model of Korea? This paper chooses both descriptive and exploratory research design which leads the study to conclusive research design. The paper utilizes a qualitative content analysis approach along with historical case-based analysis of the KAC, DRAM and available materials of technological learning capability in a late-comer economy, Korea. While studying the complicated dynamics of KAC, no single methodology is proficient. Since it was difficult to collect a large sample with enough information covering all the development stages of KAC model, therefore data is gathered from existing literature and databases such company data, empirical studies, reports, cases, archives and statistics as to obtain measures on a number of firm-level indicators of proactive KAC to validate the proposed model. Multiple tools were used to see dynamics of the KAC clearly and deeply. The paper briefly reviews theories and concepts related to KAC. It then analyzes Samsung as a case in point to illustrate how electronics firms in Korea initiated their technological capabilities which made Korea as one of the leading countries in electronics industry of the world. Since, current literature is progressing; it is believed that this paper will also make a timely contribution to the existing literature on KAC at firm's level.

The rest of the paper is organized as follows. Section 2 highlights Korea's development process and Korea electronics and semiconductor industry. Section 3 deals conceptual

background of KAC and frameworks. Section 4 presents various models of technological learning process in Korea. Section 5 explains the methodology, sample, data collection and analysis used in this study. Section 6 proposes the research model and the case of Korea (Samsung) applied to the proposed model. Section 7 concludes our work, limitations and future research agenda.

2. BACKGROUND

During the last four decades, Korea one of the world's innovation powerhouses has been referred as an ideal example of the world's fastest growing economies. Few economies in the world have matched the Korea's phenomenal economic development in term of industrialization and technological progress (Kim 1997). Despite a natural resource-poor country, Korea still achieved a remarkable economic growth performance as shown in Table 1. The Korean economy grew at an average annual rate of almost 9 percent, raising GDP per capita from US$ 79 in 1960 to US$ 20,045 in 2007. Korea has also achieved phenomenal growth in its export volume, from a mere US$ 33 million in 1960 to US$ 371 billion in 2007. Korea largely relies upon exports to fuel the growth of its economy. It's most important exports are finished products such electronics, semiconductors, LCD panel, mobile phone, computers related, television, motor vehicle, steel, ships and petrochemicals while imports include machinery, oil, steel, transport equipment, organic chemicals and plastics

Table 1: Major Korean Economic Indicators

	1960	1970	1980	1990	2000	2007
Population (1000)	25,012	32,241	38,124	42,869	47,008	48,456
GDP (US$, Billion)	2.0	8.1	63.8	263.7	511,8	969.9
Gross Rate of GDP (%)	1.2	8.8	-1.5	9.2	8.5	5.0
GDP per capital (US$)	79	254	1,645	6,147	10,841	20,045
Trade Balance (US$, Million)	-311	-1,149	-4,787	-4,828	11,786	14,643
Exports (US$, Million)	33	835	17,505	65,016	172,268	371,489
Imports (US$, Million)	344	1,984	22,292	69,844	160,481	356,846

Source: The Statistics Korea

In the early of sixties, Korea among the newly industrializing economies was typically deprived from natural resources, underdeveloped agrarian and one of the poorest countries. Also experiencing misfortunes like Japanese colonial occupation and the Korean War, Korea

suffered from all the difficulties, a poor country faces. Soon, it evolved itself from technologically backward and poor country to relatively modern industrialized economy within a short period of one generation. The development stage of Korea is sequential comprised on decades. In the sixties Korea strategically opted to focus on the development of import-substitution and export-oriented light and labor intensive industries, such as textiles, clothing, toys, plywood and wigs. During the seventies, the Korea again strategically promoted heavy and chemical industries such as steel, shipbuilding, machinery, petrochemicals, construction services and consumer electronics. The government also adopted a series of economic development plans to facilitate and promote these industries. By the mid-eighties, high-tech industries such as computers, memory chips, electronic switching systems, automobiles, and turn key industrial plants has begun to dominate and promote Korea's exports. During nineties and two thousand twenties, Korea focuses on technology, learning, innovation and high value added capital goods industries and small and medium enterprises (SMEs).

Table 2: Top Ten Export Commodities, 1960-2007

Rank	1960	1970	1980	1990	2000	2007
1	Iron ore	Textiles	Apparel	Apparel	Semiconductors	Semiconductors
2	Tungsten ore	Plywood	Electronics	Semiconductors	Computers	Automobiles
3	Raw Silk	Wig	Iron and steel	Shoes	Automobiles	Telecommunications equipment
4	Anthracite	Iron Ore	Shoes	Ships	Petroleum products	Ships
5	Cuttlefish	Electronics	Ships	Video equipment	Telecommunications equipment	Petroleum products
6	Live Fish	Fruits & Vegetable	Synthetic fiber	Iron and steel	Ships	Flat Panel Displays
7	Natural Graphite	Footwear	Wooden products	Synthetic fiber	Iron and steel	Computers
8	Plywood	Tobacco	Plywood	Computers	Textile fiber	Synthetic fiber
9	Rice	Iron & Steel Prod.	Fish	Audio equipment	Synthetic fiber	Automobiles Parts
10	Bristles	Metal Prod.	Electronics good	Automobiles	Color televisions	Iron and steel

Source: Korea International Trade Association (KITA)

IT industry, biotechnology, environment technology, culture technology, nano-technology and space technology had begun to dominate Korea exports. The government adopted special law on innovation of science and technology (S&T) to promote next generation technologies. Table 2 shows that in the 1960s Korea was engaged mainly in labor-intensive industries. In

the 1980s it was trading in medium-low-tech and low-tech industries and moved gradually toward higher-technology industries such as heavy and chemical industries. Now Korea is mainly focuses on high-tech industries such as semiconductors, telecommunication, flat panel displays and so on.

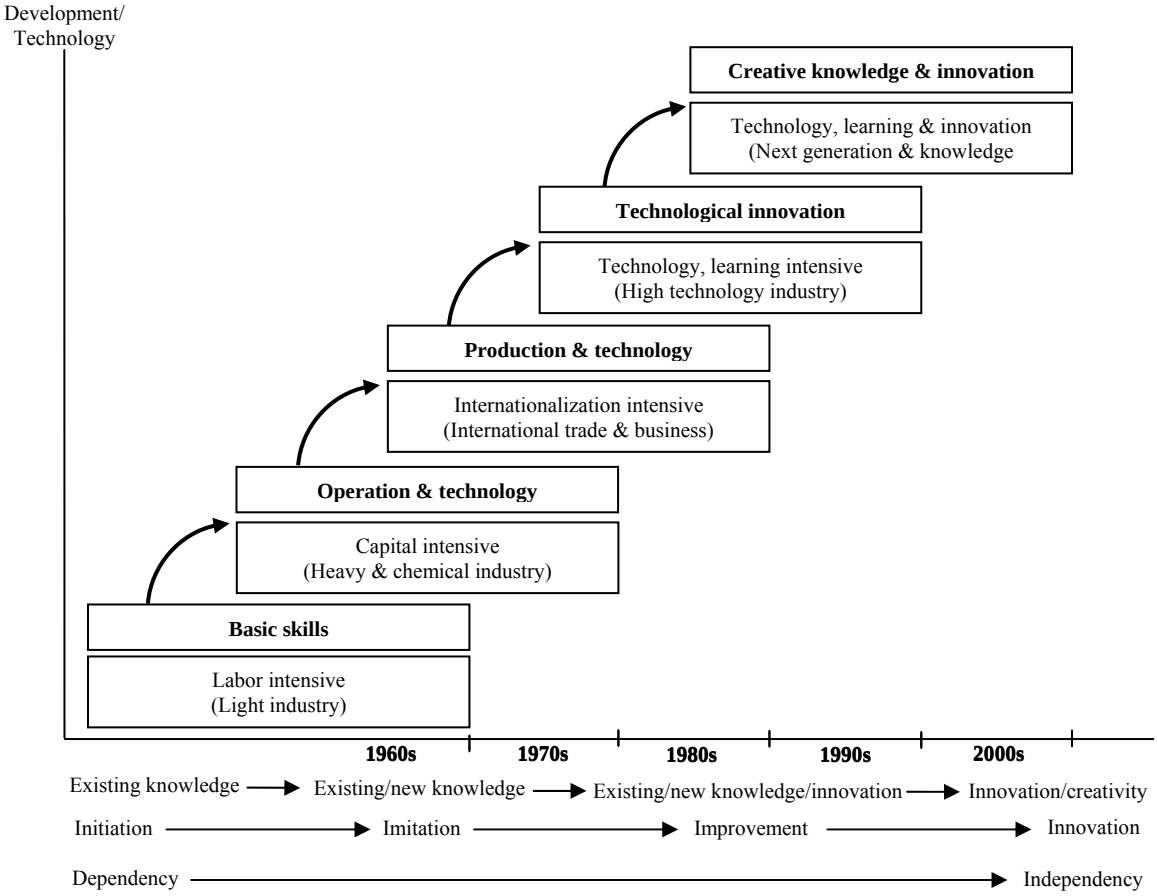


Figure 1: The Development Stage of Korea's Technological Capability

The development stages of Korea's technological capability can be classified into various phases when the process of technological learning is analyzed as shown in Figure 1. Beginning largely dependent on existence knowledge and mature foreign technology, Korean firms moved to innovation and creatively and became independent to generate their own learning and innovation to challenges firms from advanced countries. During the sixties the main focus of technology development was labor intensive (light industry), during the seventies capital intensive (heavy and chemical industry), during the eighties Internationalization intensive (international trade and business), during the nineties

technology and learning intensive (high technology industry), and since 2000 technology, learning and innovation (next generation technologies and knowledge economy). Korea also focused on basic skills during the sixties, operation and technology during the seventies, production and technology during the eighties, technological innovation, creativity knowledge and innovation since 2000. Table 3 summarizes the literatures on the process development of Korea. In section 4 some of these studies are discussed in detail.

Table 3: Stage Models of Korea Technological Innovation

	Stage model of Korea technological innovation process
Kim (1980)	implementation → assimilation → improvement
Lee et al. (1988)	initiation → internalization → generation
Kim (1997)	duplicative imitation → creative Imitation → innovation
Kim (1999)	mature technology intermediate technology → emerging technology
Lee & Lim (2001)	path-creating → path-skipping → path-following
Lee & Kim (2001)	initiation → propagation → integration → networking
Kim & Lee (2002)	embryonic → infant → growth → turnaround
Choi (2010)	collective learning → collective recombination → collective creativity
Jang (2010)	institutional building → technology catching-up → S&T leadership
Song (2011)	technological acquisition → technological catch-up → technological creation
Chung and Ahn (2011)	capacity building → industrialization → structural transformation → advanced knowledge economy
Chung (2011)	promoting technology learning → developing R&D capability → advanced S&T innovation system
Cho and Lee (2003)	Globally & vertically cooperative → transitional or discordant → reciprocally strategic

2.1 Korean Electronics and Semiconductor Industry

Once opted for catching-up with advanced countries like US, Europe and Japan, Korea has now emerged as global leader in the electronics industry of the world relying on its own technology and knowledge capabilities. The electronics industry of the advanced economy, Korea has made significant contributions in the electronics industry of the world. The Korean electronics industry has also accounted for the lion's share of economic growth in the country. The electronic industry of Korea (LG, Samsung, Daewoo and Hyundai) started its remarkable rapid expansion and development during 1960s with the production of black and white TV sets, stereos and radio communication equipment through the international transfer of

production technology (Kim, 1980). In the early stage, few important factors have greatly affected the Korea development initiation. The government sanctioned imports of consumer's electronic products as a means of "import substitution" as the national industrial policy and pursued an export-oriented industrialization strategy (Kim, 1997), it created opportunities for local companies to develop their KAC process. This creative crisis construction has proven to be a great source of KAC development for Korean electronics companies. The exemplary government support, the establishment of *chaebols,* and development of human resources (HRD) and entering of multinational firms and their refusal to provide and share knowledge with local small firms have also significantly contributed to the electronics industry of Korea. During the 1970s, Korean companies have achieved remarkable achievement and rapid development in terms of process and production, speed and time, size and capacity, technological capability, financial performance and have had a great impact on the electronics market of the world (Lee et al, 2004). Korea also became a highly competitive in the semiconductors and still has remarkable achievements in the industry. Korea's semiconductor industry was started in 1965, when the U.S Kommy Semiconductor Company established a joint venture to assemble discrete devices. While many multinational firms such as Toshiba, Fairchild, Motorola, Signetics, AMI and Control Data had began during the mid-1960s to assemble discrete devices such as transistors and integrated circuits. Table 4 shows the foreign investment in Korea's semiconductor business since 1965 to 1973.

In beginning semiconductor industry was depended on foreign investment and technology in Korea while capitalizing on indigenous cheap labor (Cho and Lee, 2003). The turning point in the Korea's semiconductor industry was, when Ki-Dong Kang, a Ph.D. and an engineer worked for Motorola established Hankook[1] Semiconductor the first local firm in 1974. Soon this firm faced financial constraints and Samsung acquired it. Ki-Dong Kang was proofed a great source of tacit knowledge for Korean engineers who got the initial experience in semiconductor production and design (Kim,1997). The enormous investment of the four largest conglomerates (termed as *chaebol*) in Korea – Samsung, Hyundai, LG and Daewoo greatly contributed to the semiconductor industry.

[1] In Korean language Korean name for Korea, simply, Korea Semiconductor

Table 4: Foreign Investment in Korea's Semiconductor Business 1965 – 1973.

Year	Domestic company name	Foreign investment company (nationality)	Volume of investment ($1,000)	Share (%)
1965	Kommy Semiconductor	Kommy (America)	76	25
1966	Semico	Fairchild (America)	2,145	100
	Korea Signetics	Signetics (America)	1,679	100
	Korea Micro	KMI (America)	224	49
1967	Motorola	Motorola (America)	7,544	100
1968	Imac	Komy Cer Co. (America)	432	100
1969	MinSung	Hahn-American (America)	145	35
	Korea Toshiba	Toshiba (Japan)	1,400	70
	Samsung Sanyo	Sanyo and Smitomo (Japan)	1,500	50
1970	TaeHan Micro	AMI (America)	2,264	100
	Korea Electrovoice	Electrovoice (America)	50	50
	Korea Varadyne	Varadyne (America)	294	49
	Korea IC	Tesco (America)	700	50
	Toko	Toko (Japan)	390	100
1971	KTK	Toko (Japan)	n/a*	n/a*
1972	Korea Rohm	Rohm (Japan)	n/a*	95
	Tokyo Silicon	Sanyo (Japan)	1,624	100
1973	Korea SanKen	Sanken (Japan)	700	100

*n/a: not available.
Source: Bae (1997) in Korean cited by Cho and Lee (2003)

These conglomerates also played a pivotal role in the leading position of Korea in the semiconductor industry. Table 5 shows the exponential growth in production and exports of Korea's semiconductor industry. In 1970 total production was US$ 32 million which had been up to US$ 5.1 billion in 1990 and US$ 14.8 billion in 1994. Similarly In 1970 total export was US$ 32 million which had been up to US$ 4.5 billion in 1990 and US$ 11.7 billion in 1994. Table 6 also shows the development process of semiconductor industry in Korea, as in 1960s it was totally depended up foreign firms but in 1990, it became totally independent in development of both DRAM design and production. Table 6 also shows the rapid Korea's catching-up process in the semiconductor industry. Korean firms absorbed knowledge demonstrating advanced technological capabilities that surpass even those of the US and Japan. Following parts further explain this development process.

Table 5: Semiconductor Industry Production and Exports (in million of US)

Production	*1966*	*1970*	*1975*	*1980*	*1985*	*1990*	*1994*
Production	0.002	32	231	424	1,155	5,104	14,800
Exports	0.002	32	178	415	1,062	4,541	11,720
Events	Multinationals firms entered assembly operations in Korea (1965)	Firms began to fabricate wafers & produce LSIs (1975)		*Chaebols* entered VLSI production under foreign license (1984)		Became independent in DRAM design & production (1988)	

Source: Kim (1997b)

Table 6: Gap between Advanced Countries and Korea in the Semiconductor Industry

Development Time	*64K DRAM*	*256K DRAM*	*IM DRAM*	*4M DRAM*	*16M DRAM*	*64M DRAM*	*256M DRAM*
Pioneer in the US & Japan	1979	1982	1985	Late 1987	Early 1990	Late 1992	Mid-1995
Pioneer in Korea	1983	1984	1986	Early 1988	Mid-1990	Late 1992	Early 1995
Gap	4 years	2 years	I year	6 months	3 months	Same	Ahead of the US & Japan

Source: Kim (1997b)

Semiconductor industry in Korea has achieved a tremendous market share not only in domestic but also in the global market as shown in the Table 7.

In its early stages of development, Korea had no proper technical skills and technologies. Many US and Japanese companies refused to transfer technology to Korean firms, since it was dependent on foreign technologies. Korean firms's initial strategy was imitation, acquisition, assimilation, transformation and exploitation of products and processes from the US and Japanese companies. At that time, it was unclear and could not be anticipated that a firms mostly relaying on imported foreign technology and knowledge, having inferior products, with low and cheap prices, and poor quality and design would become world's leading companies in the electronics market. It was also not predictable that it would become a "challenge to compete with" those companies which once denied to share knowledge and provide technology to it.

Table 7: Global DRAM Production Share by Company (in percentage)

	2006	*2007*	*2008*	*2009*	*2010*
Samsung (Korea)	25	24	26	30	41
Hynix (Korea)	15	19	19	21	21
Micron (USA)	8	10	9	12	9
Qimonda (Germany)	10	7	5	0	0
Elpida (Japan)	7	7	10	13	16
Winbond (Taiwan)	3	3	3	1	1
Nanya (Taiwan)	3	2	2	2	4
Powerchip (Taiwan)	10	10	8	6	3
ProMos (Taiwan)	7	6	6	2	2
SMIC (China)	4	3	0	0	0
Inotera (Taiwan)	7	9	8	6	8
Rexchip (Taiwan)	0	0	6	7	5

Samsung achieved the second largest position in the memory chips business after Japan and the third largest position in semiconductors after Japan and the US (Kim, 1997). Samsung was initially famous for producing inferior products low quality with design. It was exporting cheap, original equipment manufacturer (OEM) products in the early 1990s (Chang, 2008). Most of its product development strategy was based on imitating its rivals in Japan and the US. Samsung is now gathering cutting-edge technologies and core competences and striving to re-emerge as a world class e-company leading the digital convergence revolutions. It is becoming a product innovative company by converging, diversifying and integrating its products, technologies and business into a network. Samsung's quick response to any kind of environmental change, all parts of management process such as administration management, customer management, supply change management and R&D management is integrated by information technology (IT) process (SEC, 2010).

3. KNOWLEDGE ABSORPTIVE CAPACITY (KAC): CONCEPTUAL FRAMWORKS

3.1 Definition of knowledge absorptive capacity

The concept of knowledge absorptive capacity (KAC) was coined by Cohen and Levinthal (1989, 1990, 1994). Cohen and Levinthal (1989: 569) introduce the term absorptive capacity which refers to *a firm's ability to identify, assimilate, and exploit knowledge from the*

environment-what we call a firm's 'learning' or 'absorptive' capacity. Keeping in view, the exploitation of external knowledge is crucial to innovative capabilities, "*absorptive capacity represents an important part of a firm's ability to create new knowledge*" (1989: 570). In their later study Cohen and Levinthal (1990) revise the original definition of KAC, putting forward a new insight and employ research on individual's cognitive aspects, problem solving and learning capabilities underlying the learning process. They redefine KAC as *a firm's ability to recognize the value of new external knowledge, assimilate it, and apply it to commercial ends* (Cohen and Levinthal, 1990: 128). Again Cohen and Levinthal (1994: 227) adjust the definition of KAC as *a capability which is not only enables a firm to exploit new extramural knowledge, but to predict more accurately the nature of future technological advances.* In essence Cohen and Levinthal (1989, 1990, 1994) provide an evolving definition of KAC construct. Although, original definition of KAC is limited to three main dimensions of knowledge or a three-stage learning process that is, recognition, assimilation and application but several review studies have expended conceptualization of original KAC construct (e.g., Dyer and Singh, 1998; Jansen et al., 2005; Lane and Lubatkin, 1998; Lane et al., 2006; Van den Bosch et al., 1999; Todorova and Durisin, 2007; Zahra and George, 2002). It is also true that literatures on KAC expended vastly but very few studies (Dyer and Singh, 1998; Lane and Lubatkin, 1998, Lane et al., 2006; Zahra and George, 2002) have revised or expended Cohen and Levinthal's definition.

The first study to re-conceptualize the original KAC construct, Lane and Lubatkin (1998) propose *relative absorptive capacity*. The unit of analysis mainly differentiates the two constructs. Cohen and Levinthal (1989, 1990, 1994) view KAC as a firm-level construct which absorbs knowledge from a sector while Lane and Lubatkin (1998) view KAC as interorganizational-level construct which absorb knowledge from other organizations. Lane and Lubatkin (1998) define relative absorptive capacity as *the ability of a firm (student or receiver) to value, assimilate, and apply new knowledge obtain from another firm (teacher or sender).* They conclude that R&D activities explain about four percent of variance in interorganizational learning while similarity in organizational structures, learning process and system greatly explain an organization's KAC from the other organization.

Linking KAC with organizational learning, Kim (1995; 1998) defines it as *learning capability skills that enable a firm to assimilate, use, adapt and change existing knowledge*

(for imitation) and problem-solving skills that enable a firm to develop new product and processes to create new knowledge (for innovation) while acquiring, adapting and internalizing managerial know-how.

Based on more analyzed reviews, Lane et al. (2006) define KAC as *a firm's ability to utilize externally held knowledge through three sequential processes: (1) recognizing and understanding potentially valuable new knowledge outside the firm through exploratory learning, (2) assimilating valuable new knowledge through transformative learning, and (3) using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning*.

This study employs the re-conceptualization proposed by Zahra and George (2002) which distinguish four dimensions of KAC into two subsets i.e., potential KAC (knowledge acquisition and knowledge assimilation) and realized KAC (knowledge transformation and knowledge exploitation). Zahra and George (2002) define KAC as *a set organization organizational routines and processes by which firms acquire, assimilate, transform and exploit knowledge to produce a dynamic organizational capability.* KAC depends on knowledge source, prior related knowledge and experience of a firm which are referred as antecedents of KAC (Cohen and Levinthal, 1989, 1990; Zahra and George, 2002). Key moderators of KAC include regimes of appropriablity, activation triggers, power relationship and social integration mechanisms, and it influences competitive advantages of a firm such as strategic flexibility, innovation and performance (Cohen and Levinthal, 1989, 1990; Todorova and Durisin, 2007; Zahra and George, 2002).

3.2 Dimensions of knowledge absorptive capacity

Based on theoretical backgrounds and empirical studies, researchers define KAC as a multidimensional construct (Camisón and Forés, 2010; Cohen and Levinthal 1990; Jiménez-Barrionuevo et al., 2010; Lane and Lubatkin, 1998; Todorova and Durisin, 2007; Zahra and George, 2002) and come up with different dimensions. These dimensions are also referred as components, stages, phases, processes or sequence but more or less these dimensions as collectively give common understanding of KAC construct. The original study, Cohen and Levinthal (1990) propose three dimensions of the construct that is recognition the value of

new knowledge, assimilate it and apply it to commercial ends. Based on Cohen and Levinthal (1990), Michael (1997) decomposes KAC into three major elements: external knowledge acquisition, knowledge dissemination within the firm, and the technical competence that resides in the firm. Lane and Lubatkin, 1998 establish the same three dimensions of Cohen and Levinthal's (1990). Subsequently, Lane et al. (2001) segment KAC into three dimensions that is understand new knowledge, assimilate new knowledge and apply the assimilated knowledge. Again Lane et al. (2006) and Lichtenthaler (2009) refer these three dimensions as exploratory, transformative and exploitative learning. Based on Cohen and Levinthal's (1990) model, Zahra and George (2002) propose KAC construct into four dimensions and combine them into two subsets as knowledge acquisition and assimilation (potential KAC) and knowledge transformation and exploitation (realized KAC). Zahra and George's model is strongly criticized by Todorova and Durisin (2007) and they re-visit Cohen and Levinthal's model and again suggest KAC into four dimensions such as knowledge recognition, acquisition, assimilation or transformation and exploitation. Table 8 summaries distinct dimensions that compose a firm's KAC.

4. MODELS OF TECHNOLOGICAL LEARNING PROCESS IN KOREA

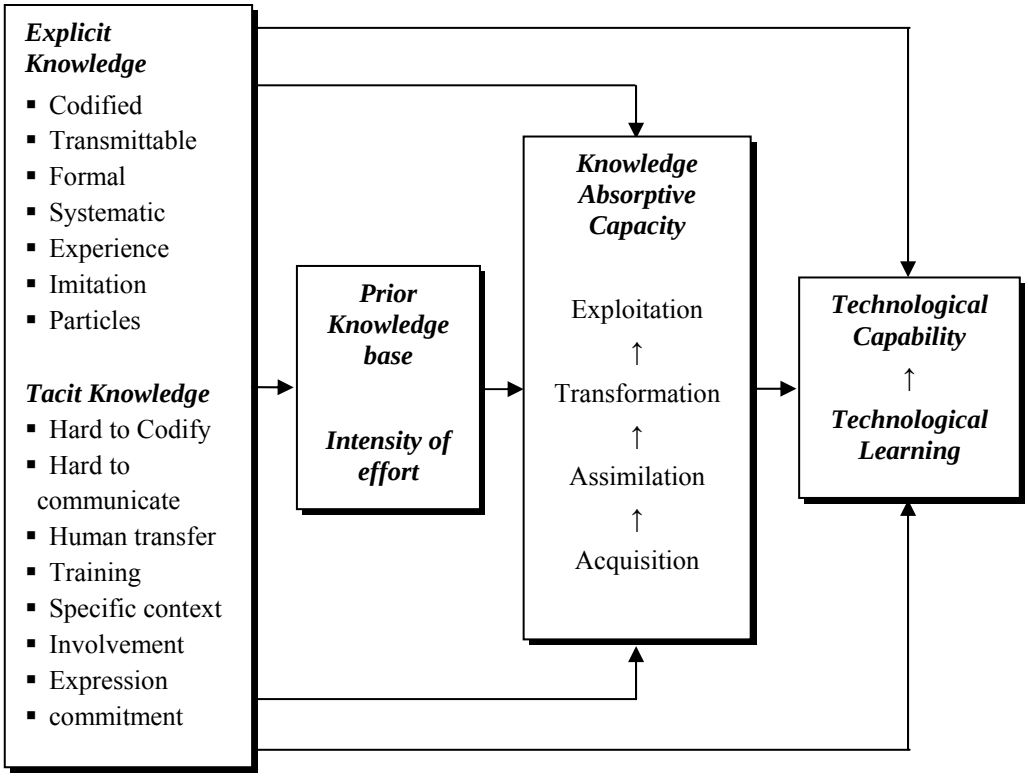
Based on empirically studies and theoretical backgrounds, many researchers have proposed different models and frameworks to analyze Korea learning process (Chung and Ahn, 2011; Chung, 2011; Cho and Lee, 2003; Choi, 2010; Jang, 2011; Kim, 1980, 1997; Kim and Lee, 2002; Lee et al., 2004; Lee and Lim, 2001; Lee and Kim, 2001; Song, 2011). In Korea, knowledge management (Choi and Lee, 2002; Lee and Kim, 2001; Lee and Choi, 2003), technology, learning and innovation (Kim, 1997), are widely studied but very few studies have captured KAC's multi-dimensional nature with few exceptional (Kim, 1995, 1997, 1997b, 2001). As shown in Table 3 typical stage models which have explained the development process of Korea's technology, learning and innovation.

Table 8: Dimensions of KAC related to the study

Illustrative Studies	Knowledge absorptive capacity			
	Dimension I	**Dimension II**	**Dimension III**	**Dimension IV**
Polanyi (1966)	explicit knowledge	tacit knowledge		
Cohen and Levinthal (1990)	Recognition the value	Assimilate	Apply	
Huber (1991)	acquisition	information distribution	Information interpretation	organizational memory
Nonaka (1994)	socialization	Articulation	combination	internalization
Lei et al. (1996)	information transfer	experimentations	organization's routines	
Lane and Lubatkin (1998)	Recognition the value	Assimilate	Commercialize	
Michael (1997)	Acquisition	Dissemination	Technical competence	
Lane et al. (2001)	Understand new knowledge	Assimilate new knowledge	Apply the assimilated knowledge	
Hitt et al. (2000)	explicit & tacit knowledge	experimentations	organization's routines	
Mathews (2002)	Preparation	seeding	propagation	sustainability
Zahra and George (2002); Camisón and Forés (2010); Jiménez-Barrionuevo et al. (2010); Flatten et al. (2011)	Potential KAC		Realized KAC	
	Acquisition	Assimilation	Transformation	Acquisition
Lane et al. (2006)	Exploratory learning: Recognize and understand new external knowledge	Transformative learning: Assimilate valuable external knowledge	Exploitative learning: Apply assimilated external knowledge	
Todorova and Durisin (2007)	Potential KAC		Realized KAC	
	Recognize	Acquire	Assimilate or Transform	Recognize
Lichtenthaler (2009)	Exploratory learning: Recognize and Assimilate	Transformative learning: Maintain and Reactivate	Exploitative learning: Transmute and Apply	

In this study only few frameworks of KAC that relate to the key theme of this study will be discussed. Kim (1998) views KAC as firm's learning capability that develops problem-solving skills. The same study also identified four-phase learning processes, i.e preparation, acquisition, assimilation, and improvement. Learning capability related to assimilate knowledge (for imitation) while problem-solving skills relates to create new knowledge (for

innovation; Kim, 1998). KAC has two important components; prior knowledge base and intensity of effort. Prior knowledge base refers to firm's learning capabilities that accumulate existing knowledge to make sense of, assimilate, evaluate and utilize outside knowledge (Cohen and Levinthal, 1990; Kim, 1998). The intensity of effort refers to firm's problem solving skills that only exposure to relevant external knowledge it not enough and an effort is made to internalize it (Kim, 1998). Stage I and stage II of the proposed framework can correspond to the prior knowledge while stage III and stage IV to intensity of effort. Zehra and George (2002) explained KAC as a set of firm's processes and practices, by which it acquires, assimilates, transforms, and exploit external knowledge to produce dynamics capabilities to obtain competitive advantage which leads to superior performance. Lei et al. (1996) propose a model that firm's dynamic core competences are based on organizational learning and organizational learning is a function of a firm's KAC (Kim, 1998). Lei et al., (1996) concerns that firm's learning is based on three aspects. The first relates to the integration into systemic meta-learning of universal and tacit knowledge through information transfer.



Source: Huber (1991); Kim (1998). Complied by the authors.

Figure 2: The Process of KAC

Second, firms engage in continuous improvement and redefinition of heuristics through experimentation. Finally on the basis of dynamic routines, firms develop their specific skills and capabilities. These three factors are related to the stage II, III and IV respectively of the proposed model. Hitt et al., (2000) suggests that three elements are required for the firm's technological learning. 1) to obtain explicit and tacit technological knowledge from both external and internal sources, 2) to engage firms in experimentations that results in continues improvement and innovation and finally 3) to assimilate technological knowledge throughout the firms by organization practices. Prior knowledge accumulates both explicit and tacit knowledge; intensity of effort makes this accumulated knowledge to solve firm's problems and contributes to firm's KAC. KAC contributes to the firm's effective technological learning and the process of technological learning expedites firm's technological capability as shown in Figure 1**.** Lee and Lim (2001) propose new trend in learning process of Korea which is distinct from previous models of Kim (1980; 1997). It attempts to explore the process of technological capability learning by means of catching-up and come up with three different patterns of catching-up, i.e, path-creating, path-skipping and path-following. Soon, Kim and Lee (2002) examine to explore the patterns of technological learning in Korean firms. It provides in-depth case analyses evidence to show how the Korean Electronic Parts Industry evolved from subcontractor group to 1) production focus group, 2) market focus and finally 3) innovator group. Song et al. (2004 in Korean citied by Choi, 2010) classifies that Korea is entering into post catching-up stage and at the firm level, there are three patterns in this new trend: deepening of accumulated technologies, architectural innovation through recombination of existing knowledge and science-based technological innovation. Lee et al. (2008 in Korean citied by Choi, 2010) emphasize the need for three capabilities: the capability to manage core competencies, the capability to integrate internal and external knowledge sources, and the capability to pursue innovation policy and strategy. Choi (2010) revisits Korean innovation model and emphasizes in search of new framework on Korean technological innovation activities in Korea. Korean firms by means of KAC, have to challenge new dimensions of uniqueness such as creative technological ideas, distinctive technological capabilities, and unique innovation systems (Choi, 2010). Choi (2010) also classifies learning process in Korea into three phases: path-following, path-revealing and path-creating. These valuable studies show how Korea's KAC was developed through various frameworks. A recent issue

2(4)(2011) of *STI Policy Review* carry a number of excellent articles to overview Korean science, technology and innovation (STI) and how Korea absorbed knowledge capacity in various industries. Although all these valuable studies give a good concept of KAC at firm's level but they do not reflect new trends in KAC. This study emphasizes the need for a dynamic framework. A model proposes a continuous process to generate KAC which contributes organizational learning to achieve competitive advantage that yields superior performance.

5. METHOD

5.1. Methodology and sample

Recently various analytical methodologies are applied to carry out qualitative research such as content analysis methodology (Ceci and Iubatti, 2011; Lee and Kim, 2001), case study (Yin, 2009) and object-oriented and subject-oriented approaches (Fagerberg et al, 2012). Keeping in view the objective of this study, multi-methodology approach is applied. This study employed qualitative content analysis as an explanation method in case study research (Kohlbacher, 2005; Yin, 2009). The analytical method of the study is content analysis methodology for the fifteen cases related to Korea (Samsung) with secondary data to exam the data to ensure the objective, systematic and qualitative techniques of the content of communication (Berelson, 1952, 1971; Kerlinger, 1974; Kohlbacher, 2005). Content analysis approach is a methodology used in social sciences (Ceci and Iubatti, 2011; Julien, 1996; Lee and Kim, 2001; Rooi and Snyman, 2006) research for measuring or observing variables of interest in a systematic, objective and qualitative manner on the basis of textual analysis (letters, diaries, interviews, speeches and books). Usually it is applied to available materials such as documents, reports, articles, cases, newspapers, archives, and minutes of meetings. It is also applied to materials that are produced for particular research problems. It was not convenient to observe the sample of interest directly and also was difficult to collect data through scaling techniques or interviewing the respondents. Therefore, for such situations, content analysis approach is more suitable to be applied in which the researchers take the communications that people have produced and ask questions of the communication (Kerlinger, 1974). The "subject-oriented" approach refers to either to use the knowledge of

experienced scholars within the field to elicit their subjective view of the evolution of the field or to approach the scholars within the field more directly and ask them about their views (Fagerberg et al, 2012). Thus the "subject-oriented" approach is also considered suitable to assist the methodology of the study. At the same time, due to the extent of the control the authors have over the actual behavioral events and the focus of contemporary events, case study is also considered to be more appropriate methodology for this study (Yin, 2009) to understand the major issues surrounding the KAC, organizational learning and technological innovation at Korea. Therefore, in-depth case analysis is carried out to facilitate the content analysis methodology.

Fifteen cases related to Korea were used as materials for the content analysis. To meet the objectivity of this study, these cases were selected carefully and special attention was paid to the aim of the study and the cases related to DRAM because this study analyzes the DRAM industry. Other materials were collected from the existing literature and databases such company data, annual reports, company website, other related websites, articles, reports, archives and statistics as to obtain measures on a number of firm-level indicators of proactive KAC to validate the proposed model.

5.2. Data collection and analysis

This study used a qualitative research approach as analytical method; therefore available materials were used. The methodology of the study basically relies upon a synthesis of the existing literature on the KAC and a re-analysis of this literature in accordance with the analytical framework presented in section 6. Two possible ways to analyze the materials of content analysis are manifest and latent contents (Babbie, 1992). Analysis deals with the visible materials, overt components or surface content is referred as manifest content. While, analysis deals with underlying, implicit meaning of the content is referred as latent content. This study employed latent content analysis because the cases collected for this study were written for various objectives and purposes by different authors and the focus areas were not the same. In content analysis, objectivity is ensured by the analysis carried out according to explicit rules and procedures that enable other researchers to obtain the same results from the same materials used (Nachmias and Nachmias, 1987). This study acknowledged expertise of eight experts as evaluators for the reliability of the validation. It also acknowledged the

reviews and comments from scholars regarding the materials and methodology used in this study. Such approach is well accepted in previous research (Cho and Lee, 2003) All the evaluators have satisfactory research background and knowledge of the study. Two experts belong to Samsung whose inputs increase the level of reliability of the study, while the other six experts have enough understand of research and theoretical background of study.

6. PROPOSED MODEL

Based on Zahra and George (2002) and Kim (1980, 1997) a four-stage theoretical model of KAC is proposed in this section. This model shows how most, if not all, firms in late-comers initiate, implement, assimilate, improve and develop KAC at firm's level. This hypothetical framework consists of four development stages. 1) knowledge initiation, 2) knowledge imitation, 3) knowledge improvement and finally 4) knowledge innovation, creating a higher knowledge base for the knowledge initiation of another cycle of KAC as shown in Figure 3. The spirals in Figure 3 show complete process of the model. These spirals may measure the level of KAC at firm or country level. For example at firm's level, Spiral 1 may show the process of KAC for 64K DRAM. The completion of Spiral 1 created a higher explicit and tacit knowledge base for the knowledge initiation stage of 264K DRAM. Similarly, at country level Spiral 1 may show technological learning process of American automobiles industry when it started to imitate British technology (steam engine). Spiral 2 shows the KAC process of Japan when it started to imitate the US technology (e.g., automobiles) and Spiral 3 shows KAC process of Korea when it started to imitate Japanese and the US technologies (e.g., automobiles). Both in developed and developing countries, sources of many firms' innovations are existing knowledge which comes from the outside. Large multinational firms are also a major source of KAC for DCs. Many times, the emergences of multinational firms in a local market of DCs also create opportunities for developing KAC in the local firms.

In developing countries many firms *initiate* their KAC by borrowing the idea of *knowledge imitation* (implementation of new knowledge), *knowledge improvement* (assimilation of new knowledge) and *knowledge innovation* (application and commercialization of new knowledge) from external environment (especially firms in

advanced countries). The first stage proposed in the model is *knowledge initiation* which is also starting stage.

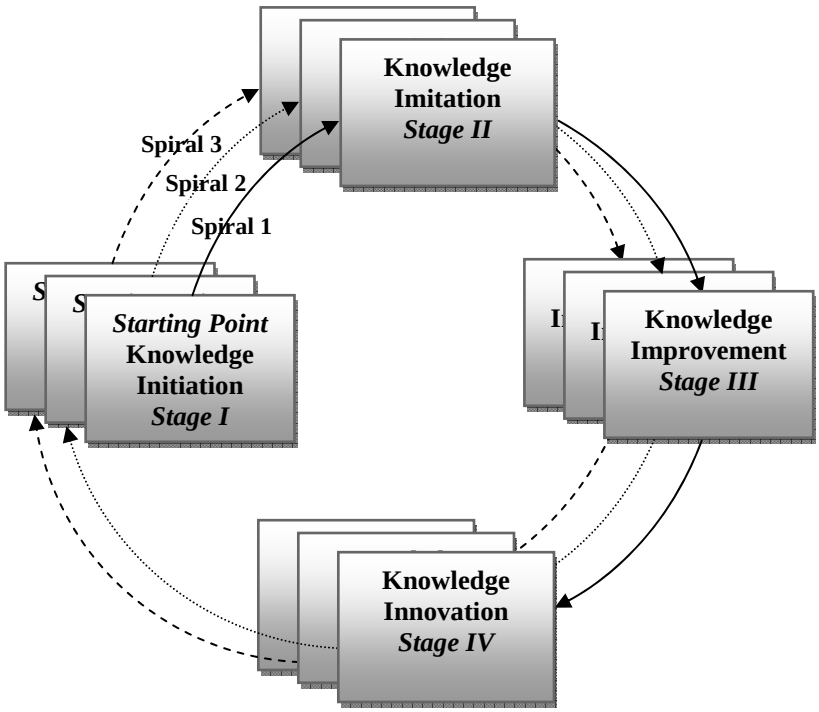


Figure 3: Proposed Research Model

It refers to the firm's capability to search, discover, identify and initiate external knowledge. During this stage, three elements can influence KAC i.e intensity, speed and direction (Zahra and George, 2002). In case of Korea, many multinational firms entered into Korean market and they were reluctant to provide or share their knowledge with local Korean firms. It was the developmental initiation of KAC for local small firms. The refusal of large firms galvanized local small firms having lack of knowledge and technical know-how to initiate KAC at their own resources. Samsung initiated KAC for DRAM technology in Stage this stage. The second stage is *knowledge imitation*. In the early age of many firms in developing countries have no detailed idea of what kind of knowledge they need. They are not only lacking in ability to identify the appropriate knowledge but also the exact implication of what knowledge is necessary to solve their problems (Mason, 1974). They are also lacking ability in the selection of appropriate technological knowledge to be acquired for the driving sector, in the selection of appropriate technological knowledge to be developed for the evolving

sector and emerging technological knowledge to be developed for the leading sector (Salimuddin, 2004). This stage makes firm able to analyze, process, interpret and understand the knowledge and information acquired from external environment (Kim, 1998; Zahra and George, 2002). Although it is knowledge imitating stage but still "wisdom of imitating" is very essential in this stage. Many Korean firms absorbed KM from the advanced countries like the US, Europe and Japanese firms by mean of acquisition and imitation. Similarly, in its early stage of knowledge development, Japan assimilated knowledge from the US and Europe. To a certain extent, the US also went through a similar pattern. The third stage is knowledge improvement. After successfully identifying and importing appropriate TK, firms do not simply imitate knowledge but gradually improve the knowledge by instituting a proper adaption strategy. Since most of the absorbed knowledge could not fulfill the requirements of receiving firms in developing countries, so KAC needed to be modified according to available resources and the local environment in which the modified knowledge will be operated. This stage makes firm's capability to improve, develop and refine the processes and practices that facilitate integrating existing knowledge, the newly acquired knowledge and assimilated knowledge (Zahra and George, 2002). Zahra and George (2002) also calls it transformation phase. Sometimes the receiving firms make attempts to make the KAC more advanced. They also make efforts using their own resources and capabilities to be less reliant on the outside knowledge. Knowledge improvement involves adapting the existing knowledge to the needs of indigenous markets suitable for indigenous resource endowments and climate change and adapting a technology delivery system and organizational structure suitable to indigenous social, cultural and political environments. Samsung did not simply imitate absorbed DRAM technological knowledge, but actively adapted and improved the knowledge in Stage III. Finally the fourth stage is *knowledge innovation*. In this stage, the firms are fully capable and now generate their own knowledge for innovation by using their own knowledge management, KAC, learning capabilities and R&D. During this stage, firm applies and exploits knowledge. Zahra and George (2002) refer it as exploitation phase. During this stage, firm also becomes capable to refine, broaden, and leverage existing competencies and knowledge or create new competency and knowledge by integrating imitated and improved knowledge (Zahra and George, 2002). The recipient firms in developing economies become competent to innovate without any assistance from firms in advanced countries once they

borrowed knowledge. Many firms in newly industrialized countries for instance, Samsung, LG and Hyundai in Korea have successfully entered into this stage. As a result, those firms' once imitated knowledge become innovative and lead companies to generate their own knowledge and innovations. These new emerging firms are now becoming a "challenge" for established firms in advanced countries from which they once borrowed knowledge. Similarly, other poor and less capable firms would follow the same pattern and would imitate those firms which once relied on imitation themselves. In Stage IV, Samsung was fully capable to develop its own DRAM technological knowledge and was not relying on imported knowledge. Therefore, the following relationships are proposed:

1) Stage 1: Knowledge initiation will have positive impact on knowledge imitation.
2) Stage 2: Knowledge imitation will have a positive impact on knowledge improvement.
3) Stage 3: Knowledge improvement will have a positive impact on knowledge innovation.
4) Stage 4: Knowledge innovation will have a positive impact on knowledge initiation.

6.1 A process model of KAC: The Case of Samsung's Electronics

The electronics industry of the advanced economy, Korea has been passed through the process model of KAC. Entering of foreign companies into the electronics industry of Korea and when they refused to transfer their knowledge and technology to local firms originally initiated the developmental growth in the electronics industry of Korea. Considering the case of Samsung, when the multinational companies refused to share their knowledge and technology with it, it actually initiated Samsung's technological innovation and KAC. Samsung developed its technological capability by means of reverse engineering and transfer of technology. It implemented, accumulated and innovated imported technology as shown in Figure 4. The four developmental stages of KAC at Samsung are discussed below.

6.1.1. Stage I: Knowledge initiation

In *Stage I*, in the mid of 1960s, many multinational firms from the US and Japan entered into Korean markets as shown in Table 4. They were reluctant to provide knowledge and information to the local firms. It was the developmental start of KAC for local small firms

including Samsung. Multinational firms such as Toshiba, Motorola, Fairchild, Signetics, Control Data and AMI (Kim, 1997) initiated assembling discrete devices. Their early production line was simple. All components were imported in the form of "packaged" from the parent firms and were assembled in a simple form. The denial of these firms created new self-development opportunities for the local firms. As a result, a Korean-American scientist with a doctorate degree and experience at Motorola established the first local semiconductor firm. Samsung had already realized its fortune in the semiconductors business. In spite of facing huge challenges due to its limitations in technology, lack of technical skills and poor quality, Samsung acquired the necessary prior knowledge base related to semiconductors and ventured into its business. The tacit knowledge was also transferred to Samsung engineers (Kim, 2001). Initially, it acquired knowledge related to DRAM technology from Micron Technology, a US semiconductors firm. Table 9 shows that Samsung originally imported technologies from other foreign firms in developed countries. Succinctly, the following relationships are proposed:

Proposition 1a: Entering of multinational firms positively contributes in the knowledge initiation into local market.

Proposition 1b: Refusal of multinational firms to transfer knowledge to local firms positively contributes in the creation of KAC into local firms.

Proposition 1c: Acquisition of existing knowledge from multinational firms positively contributes in the knowledge initiation into local market.

Proposition 1d: The emergence of multinational firms in local market creates opportunities for KAC in local firms.

6.1.2. Stage II: Knowledge imitation

In *Stage II* of KAC model, the multinational firms had already created opportunities for Samsung to establish new businesses. Samsung initiated its developmental progress by implementation of imported foreign technologies. Its progression was established through transfer of technology. Since it was the initial stage, Samsung faced many challenges regarding technology, source of technological change, technical know-how, capability of skilled human resources, research and development (R&D) and absorptive capacity (Cohen and Levinthal, 1990). Samsung's initial strategy was imitation. (Kim, 1997) calls it

"Duplicative Imitation", implementation of foreign technology through reverse engineering. Samsung had acquired eight years experience in producing transistors and integrated circuit production through transfer of technology and reverse engineering. After that, it was ready to enter in the VLSI (very large scale integrated) semiconductor business. A task force was formed to spend six months in collecting all explicit and tacit knowledge regarding VLSI.

They also conducted a market analysis. The team then spent one month in the US and met experts in the industry and in the market. They concluded by identifying the potential technology suppliers. Many multinational firms refused to transfer technologies and share

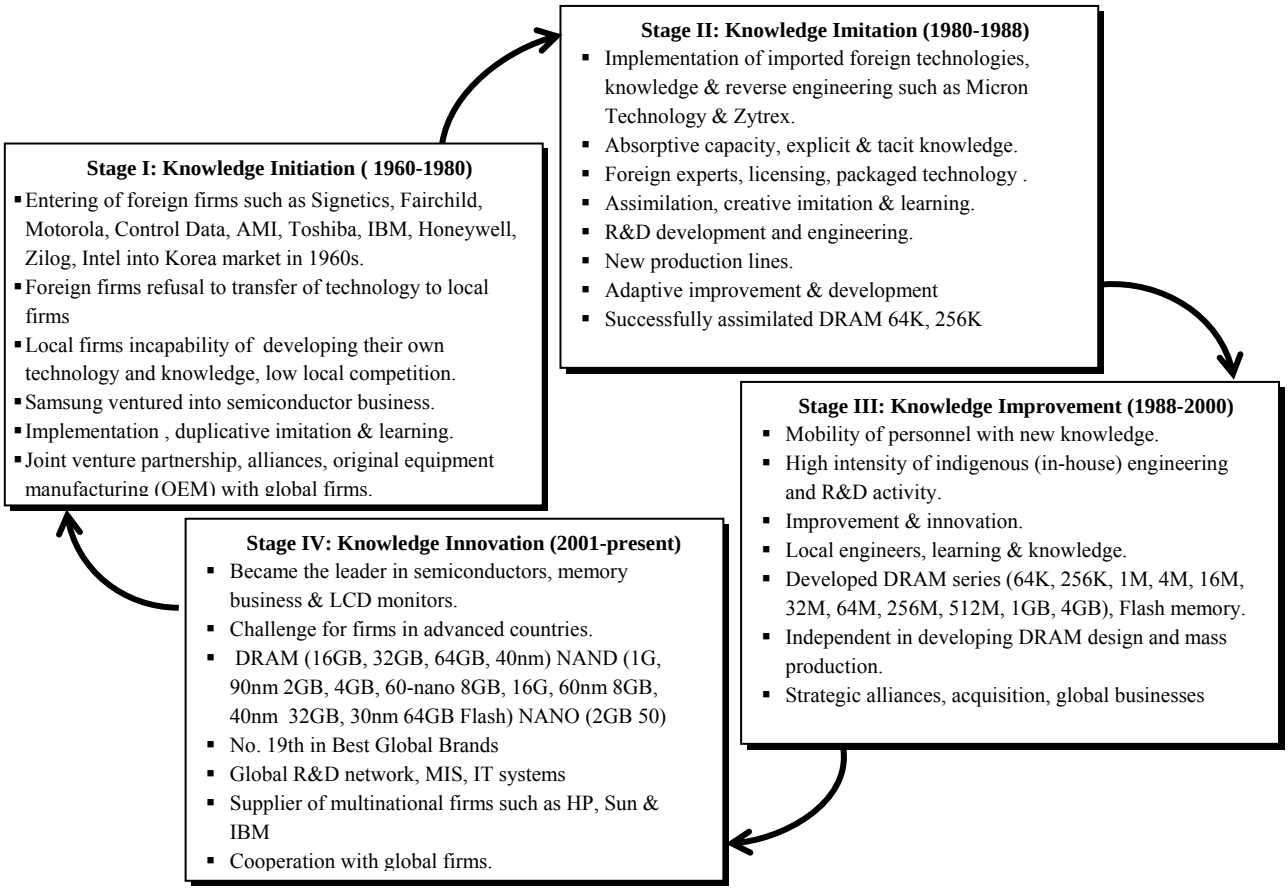


Figure 4: KAC Model of Samsung's Technological Capability

their knowledge to Samsung. The prior knowledge base in Stage I had made Samsung capable to identify and acquire the sources of external technologies and explicit and tacit knowledge (Kim, 2001). It succeeded in acquiring many technologies from foreign firms. For instance, it succeeded to acquire 64K DRAM technology from Micron Technology (USA) and process technology from Sharp (Japan; see Table 9). In the beginning, Samsung imported the

"packaged technology" and only assembled 64K DRAM chips. Having experience in LSI chips, it faced no problem in assembling 64K DRAM chips. In 1983, it succeeded to develop its technological capability in 64K DRAM. The next challenge it faced was the "process development" for 64K DRAM. Therefore, the following relationships are proposed:

Proposition 2a: Transfer of knowledge from abroad positively contributes to the knowledge imitation stage.

Proposition 2b: Succeeding in acquiring existing and new knowledge from abroad positively contributes to the knowledge imitation.

Proposition 2c: Transfer of knowledge from abroad positively contributes to KAC in local firms.

Table 9: Technology originally imported from other firms

Technology	*Technology Imported from*	*Country*
Color TV	Matsushita	Japan
Microwave	Ampherex	USA
64K SRAM	Sharp	Japan
256K ROM	Sharp	Japan
64K RAM & 256K DDRAM	Micron Technology	USA
High-speed MOS process	Zytrex	USA
8-bit microprocessor	Zilog	USA
32-bit microprocessor	Intergraph	USA
16K EEPROM	Exel Micro	USA
telecom ICs	ITT	USA
Process Technology (DRAM)	Sharp	Japan

6.1.3. Stage III: Knowledge improvement

In *Stage III*, Samsung increased its technological learning by KAC. Samsung accumulated its existing knowledge base and intensity of effort by assimilating 64K DRAM technology and developed its technological capability. It had already successfully implemented DRAM technology imported from Micron Technology and diffused it in Korea. Samsung organized two task force teams, one based in the US and another in Korea. These teams were lead by highly experienced Korean-American scientists, who had had doctorate degrees with experience and expertise at international established firms in the US. These teams also included highly-trained researchers and engineering personnel from both the US and Korea. They were paid handsome salary packages. The Korean engineers also participated in training

and research in the US. These teams exchanged their research. The mobility of local experienced technical personnel at Samsung who also played a pivotal role in the diffusion of DRAM technology. These personnel were also trained by technology suppliers. As a result of these task force teams, Samsung engineers brought tacit knowledge and developed the capability to assimilate the imported technologies of 64K DRAM in a very short time. The teams then started for their next challenge which was to develop "production process" for the mass production of 64K DRAM. The teams again gathered all explicit and tacit knowledge regarding mass-production plants and they succeeded to imported Sharp's process technology for 64K DRAM mass production. In the middle of 1984, Samsung started the mass production of 64K DRAM. Samsung become the third country after the US and Japan to introduce DRAM chips (Kim, 1997a).

The mass production of 64K DRAM had developed a platform to produce the 256K DRAM. Samsung had adopted a "dual strategy" approach for the development of the 256K DRAM. Again two teams were formed for the development of the 256K DRAM, one in the US and other in Korea, but they were assigned different tasks. They analyzed all the explicit and tacit knowledge about the 256K DRAM. This time, they again contacted Micron Technology, but only for circuit design. The development the 64K DRAM provided them enough experience for developing the process technology for the 256K DRAM. In October 1984, the Korean team succeeded in achieving its assigned task and developed the 256K DRAM while the US based team developed it in early 1985 and its mass production was also started at the same time. Accumulating the explicit and implicit knowledge, licenses from the foreign firms, establishing two R&D centers in the US and Korea at the same, mobility of engineers, strong collaboration between the two centers, management strategies such as "crisis construction mode" (Kim, 1997b) and government support immensely contributed to Samsung becoming the world's largest producer of DRAM technologies. Samsung's technological capabilities then increased expeditiously. Soon it developed 1M, 4M, 16M, 64M and 256M DRAM successfully. The gap between Korea and advanced countries (the US and Japan) in developing the 64K DRAM was 4 years. This gap was reduced to 2 years in case of developing the 256K DRAM while Korea was ahead of Japan and the US in developing the 256M DRAM (see Table 6; Kim, 1997). Samsung had moved on to "Creative Imitation"

(Kim, 1997) by not fully relying on foreign technological capabilities. In short, the following relationships are proposed:

Proposition 3a: Adaptive technological innovation strategy positively contributes to the knowledge improvement stage.

Proposition 3b: The successfully implementation of new knowledge positively contributes to KAC in local firms.

6.1.4. Stage IV: Knowledge innovation

Increasing its technological capability by KAC and accumulated explicit and tacit knowledge, Samsung is now leading the global market in high-tech electronics and e-digital media. Beginning with imitation strategy through transfer of technology and reverse engineering, Samsung has moved on to improvement strategy, accumulating and adapting imported technology. Finally, Samsung emerged as the first innovative company of Korea which has been recognized globally. The international firms which refused to transfer technology and knowledge to Samsung are now facing big challenges from it. Samsung is now generating technology innovation by using its own technological capabilities and to challenging firms in advanced countries in the global market. Samsung is now relying less on imported technologies and external knowledge. It has developed 1M, 4M, 16M, 64M and 256M DRAM using totally their own technological innovation capabilities and resources. Table 10 shows a glimpse on historical development of DRAM technology at Samsung (Choi 2010; SECb). It has been investing tremendously in its global R&D network, having six centers in Korea and eighteen centers in North America, Europe and Asia. Therefore, the following relationships are proposed:

Proposition 4a: Indigenous knowledge creation positively contributes to the knowledge innovation stage.

Proposition 4b: Effectively application and commercialization of new knowledge positively contributes to the knowledge innovation.

Proposition 4c: KAC positively contributes to the knowledge innovation.

Table 10: History of DRAM technology development

Year	***1983***	***1884***	***1986***	***1988***	***1990***
Progress	64K DRAM	256K DRAM	1M DRAM, 1M SDRAM	4M DRAM	16M NAND Flash
Year	***1992***	***1995***	***1996***	***1997***	***1999***
Progress	256M DRAM	32M	1GB	64M	256MB NAND
Year	***2000***	***2001***	***2002***	***2003***	***2004***
Progress	516MB NAND	1G NAND	90nm 2GB NAND	4GB NAND	60-nano 8GB NAND Flash
Year	***2005***	***2006***	***2007***	***2008***	***2009***
Progress	16G NAND	60nm 8GB, 40nm 32GB	30nm 64GB NAND Flash	2GB 50 NANO	40nm DRAM

7. DISCUSSION AND CONCLUSION

Since KAC is a new development agenda for developing countries, this paper explored how the electronics and semiconductor industry in Korea developed through technological innovation capabilities by means of firm's KAC. Using the case of Samsung, this paper shows that electronics firms in Korea have developed their KAC through a process model of KAC as shown in Figure 3 and Figure 4. Today most innovations are limited to developed countries. Developing economies or late-comers are still dependent on technologies and knowledge developed in developed world. The experience of Japan, Korea, and China suggests that developing economies have also strong potential for innovation and technology capabilities. Since technological learning in many developing economies is in a transition stage, they can learn from the experiences of the aforementioned countries. For developing economies – late-comers, several lessons can be derived from the Korean's KAC process. For Korea which started technological learning and KAC process on a very poor knowledge base, absorbing knowledge capability from external source (especially from advanced countries) has been an indispensable means to compensate the deficiencies of the indigenous technological and learning capability. The process model of KAC (see Figure 3) how most of the firms in developing economies initiate, imitate, improve and develop (innovate) knowledge acquired from external sources or advanced countries. As a latecomer, Korea (Samsung) focused on quick initiation, imitation, improvement and innovation of technological capability and

learning which leaded to the development of its KAC. In the beginning it relied on borrowed knowledge and learning, aggressively invested on time, focused on technologies with clear trajectories (Chang, 2008), followed the path of catching-up with already existing forerunners. While strong internal infrastructure, R&D capability, successful integration of process, production and personnel innovation, success in DRAM development, product portfolio and solution, production efficiency and diversification, cost effectiveness and speed are the early competitive advantages which makes it succeeded in the industry. Realizing the sense of a "digital convergence" and becoming digital e-company, Samsung is approaching three strategic innovation strategies i.e., creativity, talent and partnership management. No doubt that many factors influenced Samsung's performance but it is safe to say that technological advancements and quick learning, knowledge and creativity are the most significant. From the very beginning Samsung recognized that for global competition it has to development technological knowledge by means of KAC. Technology and knowledge have close relationship and both have contributed to the great success of Samsung. It is also believed that technology is a form of knowledge and to examine knowledge development, we need to understand technological change (Garud and Nayyar, 1994; Bettis and Hitt, 1995; Hitt et al., 2000) that is what Samsung did. For Samsung now the challenge is how it can compete with emerging Chinese companies such as Haier in China and succeeds globally and what are the key features that are critical to sustainability in the electronics industry and to maintain a global leader position? The novelty and valued added of this study results from its proposed process model of KAC (see Figure 4) and propositions. A potential side effect of this study relying upon and integrating established theory and concepts is that, individually, some of the ideas may not appear new. However, it is believe that, taken as a whole, this study offers novel insight into how firm is developed through technological innovation capabilities by means of its KAC.

Finally, this study has the following limitations arising from the case study using qualitative content analysis. The proposed model has been validated by qualitative latent content analysis. Therefore, the model also needs empirical research for generalizibility in different industries and different countries which have similar developmental structures as Korea. It will provide useful implications not only for policy makers and managers but also for those developing countries which attempt to follow the same pattern of KAC process.

Firms in developing countries and other latecomers or followers have lessons from Samsung's experience. The latecomers or followers having limited resources and lack of knowledge, technological capabilities can learn how to catch-up by initiation, imitation, improvement and innovation. Second, also latent content analysis approach is more valid but less reliable. Finally, this study used available materials produced for different purposes and were written by different authors which leads to the possibility of sample biasness. Future research of the authors will also focus to design a study and identify those internal and external factors (variables of organizational structure and components of organizational environment) that affect KAC, technological learning and capability at firm's level in developing contexts. Further on the basis of empirical data to develop hypotheses, show relationships among those identified factors and which factors can affect significantly the model (see Figure 4) at different stages and finally draw implications for research, managers and policy makers.

REFERENCES

Babbie, E. (1992). *The practice of social research*, (6th ed.). Belmont, California: Wadsworth Publishing Company.

Bae, Y.H. (1997) Technological innovation and development of technological capabilities in the Korean semiconductor industry (in Korean). In: Keun, Lee (ed.). *Technological Capability and Competitiveness of the Korean Industries*. Seoul: Kyungmoon Press.

Berelson, B. (1971), "*Content Analysis in Communication Research",* Glencoe, Ill.

Berelson, B. (1952). "Content Analysis in Communication Research". Free Press, Glencoe, IL.

Bettis, R.A. and Hitt, M.A. (1995). "The new competitive landscape", *Strategic Management Journal*, 16 (Special Issue): 7–19.

Camisón, C., and Forés, B. (2010). Knowledge absorptive capacity: new insights for its conceptualization and measurement. *Journal of Business Research*, 63(7): 707-715.

Ceci, F. and Iubatti, D. (2011), "Personal relationships and innovation diffusion in SME networks: A content analysis approach. *Research Policy*, doi:10.1016/j.respol.2011.10.003

Cho, H and Lee, K. (2003). The developmental path of networking capability of catch-up players in Korea's semiconductor industry. *R&D Management,* 33(4): 411-423.

Choi, Y. (2010). Korean Innovation Model, Revisited. *STI Policy Review,* 1(1): 93-109.

Cohen, W. M., and Levinthal, D. A (1989). Innovation and learning: The two faces of R&D. *Economic Journal*, 99: 569–596.

Cohen, W. M., and Levinthal, D. A (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35: 128–152.

Cohen, W.M, and Levinthal, D (1994). Fortune favors the prepared firm. *Management Science*, 40: 227–251.

Chang, S. (2008). Sony vs. Samsung: the inside story of the electronics giants' battle for global supremacy. Hoboken. NJ: John Wiley and Sons.

Chung, S.C, and Ahn, H. (2011). From Capacity-building to Innovating: The Role of International Linkages in Korean Science and Technology Development. *STI Policy Review,* 2(4): 39-54.

Chung, S.C. (2011), *Innovation, Competitiveness, and Growth: Korean Experiences*, Annual World Bank Conference on Development Economics 2010, Global.

Davenport, T.H., and Prusak, L. (1998). *Working knowledge: How organizations manage what they* know. Harvard Business School Press, Boston, MA.

Drucker, P. (1968). *The age of Discontinuity: Guidelines to our Changing Society*, New York: Harper and Row.

Drucker, P. (1993). *Post-capitalist society,* Oxford, Butterworth-Heinemann

Dyer, J. H., and Singh, H. 1998. The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, 23: 660–679.

Fabrizio, K. (2009). Absorptive capacity and the search for innovation. *Research Policy*, 38: 255-267.

Fagerberg, J., Landström, H., and Martin, B.R. (2012). Exploring the emerging knowledge base of "the knowledge society". *Research Policy*, 41(7): 1121-1131.

Garud, R., and Nayyar, P.R. (1994). Transformative capacity: continual structuring by intertemporal technology transfer. *Strategic Management Journal*, 15: 365–385.

Gebauer, H., Worch, H., and Truffer, B. (2012). Absorptive capacity, learning processes and combinative capabilities as determinants of strategic innovation. *European Management Journal, 30*(1): 57-73.

Hitt M.A, Ireland R.D, and Lee, H. (2000). Technological learning, knowledge management, firm growth and performance. *Journal of Engineering and Technology Management* 17: 231–246.

Huber, G. P. (1991). Organizational Learning: The Contributing Processes and the Literature. *Organization Science,* 2(1): 88-115.

Jang, Y. (2011). Evolution of Korean STI Policies. *STI Policy Review,* 1(1): 01-08.

Jiménez-Barrionuevo, M.M., García-Morales, V. J., Molina, M. L (2010). Validation of an instrument to measure absorptive capacity. *Technovation*, 31(5-6): 190-202.

Jansen, J., Van den Bosch, F., and Volberda, H. (2005). Managing potential and realized absorptive capacity: How do organizational antecedents matter? *Academy of Management Journal*, 48(6): 999-1015.

Julien, H. (1996), "A content analysis of the recent information needs and uses literature", *Library and Information Science Research*, 18: 53-65.

Kerlinger, F. N. (1974). Foundations of behavioral research, (2nd ed.). New York: Holt, Rinehart and Winston, Inc.

Kim, L. (1980). Stages of development of industrial technology in a LDC: A Model," *Research Policy,* 9(3): 254-277.

Kim, L. (1995). Absorptive Capacity and Industrial Growth: A Conceptual Framework and Korea's Experience. In B.H. Koo and H.P. Dwight (Eds.), *Social Capacity and Long-Term Economic Growth*: 266-287. New York: St. Martin's

Kim, L. (1998). Crisis Construction and Organizational Learning: Capability Building in Catching-up at Hyundai Motor, *Organization Science*, 9(4): 506-521.

Kim, L. (1997). *Imitation to Innovation: The dynamics of Korea's technological learning*. Cambridge, MA: Harvard Business School Press.

Kim, L. (1997b). The Dynamics of Samsung's technological learning in semiconductors. *California Management Review*, 39(3): 86-100.

Kim, L. (2001). *Absorptive Capacity*, *Co-opetition*, and *Knowledge Creation.* In I, Nonaka and T, Nishiguchi (Eds), Knowledge Emergence: Social, Technical, and Evolutionary Dimensions of Knowledge Creation: 270-285. New York : Oxford University Press.

Kim, Y., Lee, B. (2002). Patterns of technological learning among the strategic groups in the Korean electronics parts industry. *Research Policy*, 31 (4), 543–567.

Kogut, B., and Zander, U. (1992). Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. *Organization Science*, 3(3): 383-397.

Kohlbacher, F. (2005). The Use of Qualitative Content Analysis in Case Study Research. *Forum: Qualitative Social Research*, 7(1), Art. 21, http://nbn-resolving.de/urn:nbn:de:0114-fqs0601211.

Lane, P. J. and M. Lubatkin (1998). Relative absorptive capacity and interorganizational learning, *Strategic Management Journal*, 19(5), 461–477.

Lane, P.J., Salk, J.E.. and Lyles, M.A. (2001). Absorptive capacity, learning, and performance in international joint ventures**.** *Strategic Management Journal,* 22**(**12**):** 1139–1161

Lane, P. J., Koka, B. R. and S. Pathak (2006). The reification of absorptive capacity: a critical review and rejuvenation of the construct, *Academy of Management Review*, 31(4), 833–863.

Lee, J. and Kim, Y. (2001). A stage model of organizational knowledge management: A latent content analysis. *Expert Systems with Applications*, 20, 299–311.

Lee, S., Lee, M., and Pecht, M. (2004) . *Korea's Electronics Industry*. Washington, D.C: University of Maryland, Calce EPSC Press.

Lee K, and Lim, C. (2001). Technological Regimes, Catching-up and Leapfrogging: Findings from the Korean Industries. *Research Policy*, 30 (3): 459-483.

Lei, D., Hitt, M.A., Bettis, R., 1996. Dynamic core competencies through meta-learning and strategic context. *Journal of Management,* 22, 549–569.

Lichtenthaler, U. (2009). Absorptive capacity, environmental turbulence, and the complementarity of organizational learning processes. *Academy of Management Journal*, 52(4):822-846.

March, J.G., and Simon, H.A. (1958). *Organizations*, John Wiley & Sons.

March, J.G. (1991). Exploration and exploitation in organizational learning, *Organization Science*, 2(1): 71-87.

Mason, R. H. (1974). The Selection of Technology: A Continuing Dilemma. *Columbia Journal of World Business*, 9(2): 29-34.

Mathews, J.A. (2002). Combinative capabilities and organizational learning in latecomer firms the case of the Korean semiconductor industry, *Asia Pacific Journal of Management*, 19: 467-488.

Murovec, N., and Prodan, I. (2009). Absorptive capacity, its determinants, and influence on innovation output: Cross-cultural validation of the structural model. *Technovation*, 29: 859–872.

Nachmias, D. and Nachmias, C. (1987). "Research methods in the social science", (3rd ed.). New York: St. Martin's Press.

Nelson, R.R., and Winter, S.G. (1982). *An evolutionary theory of economic change*. Harvard University Press, Cambridge, MA.

Nonaka, I. (1991). *The knowledge creating company*. Harvard Business Review, 69: 96–104.

Nonaka, I and Takeuchi, H. (1995). *The knowledge creating company*, New York: Oxford University Press.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science,* 5(1): 14–37.

Ozawa T (1974). *Japan's Technological Challenge to the West 1950-1974: Motivation and Accomplishment*. MIT Press, Cambridge, MA.

Polanyi, M. (1966). *The Tacit Dimension,* London: Routledge and Kegan Paul

Rooi., H. and Snyman, R. (2006). A content analysis of literature regarding knowledge management opportunities for librarians. New Information Perspectives Vol. 58 No. 3, 2006: pp. 261-271.

Salimuddin, M. (2004). Technology Management-Issues and Strategy for Developing Countries. Presented in ICQI'S 8th Int'l Convention on Quality Improvement, in Lahore Aug 21-22, 2004.

SEC; Samsung Electronics Co. Ltd. (Producer). (2010) Vision and Strategy (video show). (On-line) Available http://www.samsung.com/us/aboutsamsung/ir/newsMain.do, accessed on June 17, 2010

SECb; Samsung Electronics Co. Ltd. (2010) About Us-History Retrieved Aug 2, 2010 from http://www.samsung.com.

Song, S. (2011). Growth and Technological Development of the Korean Shipbuilding Industry. *STI Policy Review,* 2(4): 55-64

Teece, D.J., Pisano, G., and Shuen, A. (1997), Dynamic capabilities and strategic management. *Strategic Management Journal*, 18:509–533.

Todorova, G. and B. Durisin (2007). Absorptive capacity: valuing a reconceptualization,*The Academy of Management Review*, 32(3), 774–786.

Utterback J.M. (1994). *Mastering the Dynamics Innovation,* Cambridge, MA: Harvard Business School Press.

Van den Bosch, F. A. J., Volberda, H. W., and De Boer, M. (1999). Coevolution of firm absorptive capacity and knowledge environment: Organizational forms and combinative capabilities. *Organization Science*, 10: 551–568.

Yin, R. (2009). *Case Study Research: Design and Methods,* Sage Publication Inc.

Zahra, S., and George, G (2002). Absorptive Capacity: A Review, Reconceptualization and Extension. *Academy of Management Review,* 27(2):185-203.