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Innovation is a hallmark of the consumer electronics industry as firms compete to capture greater shares in a competitive market. The culmination of such innovation recently promoted a trend toward digital convergence within the industry as products from the consumer electronics and computer industries incorporate similar characteristics and capabilities. As such, consumer electronics offers a unique perspective on the role of innovation and national systems of innovation within a technologically motivated industry. National systems of innovation are those systems within a state that promote innovation through educational institutions, technical or scientific institutions, cultural traditions, and government policies. Innovation's link to economic prosperity and the knowledge base associated with innovative behavior confers a highly valuable competitive advantage for nations in an increasingly globalized world. Thus, the incorporation and promotion of national systems of innovation and the trend toward a digital convergence oriented market within the consumer electronics industry could allow American consumer electronics and computer firms the ability to level the balance of power in this heavily Japanese dominated industry. An industry innovation award is used to illustrate differences between Japanese and American firms as well as note the innovative capability of American firms.

NATIONAL SYSTEMS OF INNOVATION IN THE JAPANESE AND AMERICAN CONSUMER ELECTRONICS INDUSTRIES

by

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CHAPTER I

INTRODUCTION

1.1 Problem

A change is occurring within the consumer electronics (CE) industry. Known as digital convergence, this change affords American firms with a strong computer industry background the opportunity to reassert American influence into the heavily Japanese dominated consumer electronics industry. Digital convergence is simply the uniting of the functions associated with the telephone, computer, and television (Yoffie 1997). This research tests the hypothesis that the United States' national system of innovation will enable it to take the lead in pioneering products capitalizing on the possibilities presented by digital convergence. Unique differences, such as firm employment, firm revenue, and product specialty, exist between the national systems of innovation of both countries. Additionally, innovation within Japanese firms is more often characterized as incremental whereas innovation within American firms is characterized as more radical (Goto 1997b). American firms have the ability to utilize innovative experience in the computer industry as well as a traditionally more radical approach to innovation to develop digital convergence products. Complementary industries that produce digital products overlap due to the "blurring" of industrial lines between those industries associated with digital convergence.

Japan's historic path toward industry domination illustrates the possibility for future dramatic geographic realignment of the industry. Japanese consumer electronics firms achieved dominance in the consumer electronics market during the closing decades of the 20th century. As such, Japanese firms generate many breakthroughs in television and other audio and video equipment design and engineering. Technological progress within the consumer electronics industry is an ever-present phenomenon due to persistent innovation and short product cycles. The culmination of such innovation promotes the trend toward digital convergence within the industry as products from the consumer electronics and computer industries incorporate similar characteristics and capabilities. Consequently, the research question addressed in this thesis is how can American firms with strong innovative capability in the computer industry and/or consumer electronics industry successfully penetrate and compete with Japanese firms in the consumer electronics sector?

One potential answer to this question lies in the utilization of a national system of innovation by American firms. National systems of innovation are those systems within a state that promote innovation through educational institutions, technical or scientific institutions, cultural traditions, and government policies (Freeman 1995, 1). Furthermore, the institutions and actors that comprise a national system of innovation are influenced as that system matures (Goto 1997). Innovation's link to economic prosperity and the knowledge base associated with innovative behavior confers a highly valuable competitive advantage for nations in an increasingly globalized world. High-technology activities generate positive externalities that exceed the market value of those activities.

Spillovers of knowledge and diffusion of technology within a country afford that country a greater economic advantage that cannot be easily calculated (Guerrieri and Milana 1995). American and Japanese national systems of innovation and their respective impact within the consumer electronics industry demand thorough examination to provide an overarching understanding of how these systems contribute to innovative behavior and the successful marketing of innovative products. Additionally, the introduction of digital convergence oriented products permits such analysis to naturally extend to the computer industries of each country. The combination of a distinct national system of innovation and the "blurring" of industries between the consumer electronics and computer industries potentially produces a favorable environment for American firms to introduce digital convergence oriented products with market appeal.

1.2 Objective

The trend within the consumer electronics industry toward digital convergence products and the trend's potential to reinvigorate American firms allows for an examination of the role of national systems of innovation within a highly technical and scientific industry wherein R&D is crucial for the market success of a firm. Such an examination is needed to determine the potential for American firms to become successful in an industry largely dominated by Japanese firms for the past three decades. Analyses of 1) the consumer electronics industry's strength in the United States, 2) patent data, 3) innovative firms, and 4) select digital convergence products will further this examination. A determination of American strength within consumer electronics will be used to build a foundation for other analyses in this research. The presence of such a foundation provides evidence of American involvement in an industry thought to be dominated by Japanese firms. Patent data will be used to assess leading countries by the number of U.S. patents granted to those countries. Furthermore, patent data will allow analysis of which companies are being granted patents within the United States. A sample of innovative firms within the industry will be used to illustrate American and Japanese innovative participation. Winners of a prestigious industry award for innovation will be used in this sample. Analysis of a range of digital convergence products will indicate the potential for American firms to be successful within these emerging markets.

Digital convergence's emergence and its ongoing implementation in consumer products necessitate distinguishing the connection between the consumer electronics and computer industries. *American potential to regain some measure of influence in consumer electronics would benefit from such a connection due to American strengths associated with computer related innovations and the country's strong computer industry*. Innovation within both industries will be examined with a focus on digital convergence oriented technologies and how such technologies could benefit American firms. Thus the purpose of this thesis will be to further the understanding of digital convergence within these two complementary industries and to offer a perspective on how the blurring of these industries can benefit American firms with support from a national system of innovation.

1.3 Hypothesis

The focus of this research is the incorporation and promotion of national systems of innovation and a possible trend toward a digital convergence oriented market within the consumer electronics industry that could allow American consumer electronics and computer firms the ability to level the balance of power in this Japanese dominated industry. Both countries have distinct national systems of innovation that influence the creation and application of technology from indigenous firms. How these firms benefit from aspects of their respective national systems of innovation affords researchers an opportunity to analyze the key ingredients that comprise a successfully implemented innovation system. Thus, the hypothesis of this research asserts American firms are highly innovative within the CE industry and have the ability to release technologically advanced digital convergence products. Furthermore, American CE firms are distinctive from their Japanese counterparts due to unique national innovation systems present within each country that have shaped each respective CE industry. This distinctiveness occurs from *differences in revenue generated, employment, and product specialty*.

Revenue and employment analysis allow for a determination of the size of innovative firms while product specialty analysis allows for a determination of specific technology segments attributed to those firms. Differences in these three areas suggest differences in the national systems of innovation attributed to Japan and the United States. Lastly, there is a possibility that one country's innovation system might be better suited to bring innovative digital convergence products to market if differences are found between these specific innovation systems.

CHAPTER II

REVIEW OF LITERATURE

The literature review of this thesis is comprised of four sections. The opening section examines the importance of innovation within an industry. Subsequently, an overview of national systems of innovation follows. The innovation systems of both the United States and Japan are reviewed and a comparison chart is provided. The last two sections cover aspects of the consumer electronics industry. Section three examines innovation within the consumer electronics industry while section four examines the emerging digital convergence trend within the industry.

2.1 Innovation within Industry

The economic prosperity of nations and regions benefits greatly from innovation (Feldman and Florida 1994; Feldman 2003). Innovation can be process and/or product innovation. Process innovation is the incorporation of new methods into production while product innovation is the creation of new products or services (Feldman 2003). Most consumers are far more aware of the benefits of product innovation due to the marketing of products that results from the application of such innovation. Process innovation boosts a firm's ability to increase productivity, product quality, or better facilitate the application of a new technology through the utilization of innovative process methods. One example is encouraging increased interaction between product engineers and production managers to boost the flow of knowledge between multiple divisions within a firm. Furthermore, innovation can be either revolutionary (radical) or evolutionary (incremental) in nature (Goto 1997b; Feldman 2003). A revolutionary product has the ability to create a new market category due to the dramatic application of a new technology whereas an evolutionary product improves on current technology by bettering the application of previous product generations.

2.1.1 Measures of Innovation

Measures of innovation can include the inputs and outputs associated with innovative behavior. An example of an input to innovation would be research and development funding or university/ firm interaction whereas an output example would be the patents that result from innovative efforts. Patents will be used in this research. Knowledge spillovers and increased intellectual breakthroughs can often be attributed to the presence of “star scientists” (Feldman 2003). Although not fully utilized in this research, star scientists are an input to innovation because they contribute to important scientific and technological advancements through the publication and application of those specific advancements in an industry. Their presence denotes the possibility for innovative achievements in a geographic location. Japanese entrepreneurs/scientists such as Ibuka Masaru and Matsushita Konosuke, both discussed later, played a crucial role in the development of the consumer electronics industry in Japan.

Patents play a crucial role in the understanding of innovation (Metcalfe 1995). Patents can be described as “the institutional device whereby market economies seek to cope with the peculiarities of knowledge production” (Metcalfe 1995, 26-27). Furthermore, patents are important instruments of technology policy. Without such instruments there would be little incentive to innovate due to the inability to protect knowledge creation. Patent statistics allow for close examination of who is pursuing innovative activity and where they are pursuing it. Freeman (1987) notes that patent statistics within the United States changed dramatically between 1975 and 1985. In 1975, Japan accounted for 8.9 percent of patents issued in the United States while accounting for 17.9 percent in 1985. Patents issued to US companies decreased from 64.9 percent in 1975 to 55.5 percent in 1985 (Freeman 1987, 21). This time period coincides with Japanese penetration into America's consumer electronics and automobile markets. Patent data can further be partitioned by individual companies to illustrate who is pursuing innovative activity where. The United States Patent and Trademark Office maintains nationality and firm specific data associated with each patent application and grant. Patent citation also adds to the wealth of data analyzable through patent references.

2.1.2 The Innovative Environment

The innovative environment also plays a crucial role in the study of innovative behavior. Such an environment includes both the soft and hard infrastructure of a region often associated with industrial agglomerations. A connection exists between innovation and the technological infrastructure of a region. This infrastructure allows for the mobilization "of sources of knowledge, networks of firms that provide expertise and technical knowledge, concentrations of research and development (R&D) that enhance opportunities for innovation by providing knowledge of new scientific discoveries and applications, and business services with expertise in product positioning and the intricacies of new product commercialization" (Feldman and Florida 1994, 1). Thus, innovation has an inherent spatial nature that impacts a regions respective innovative processes and capabilities. A spatial characteristic associated with innovation is noteworthy due to the idea that geographical proximity through agglomeration offers firms specific benefits (Markusen 1996; Porter 2003; Feldman 2003; Wood and Parr 2005). Benefits of agglomeration include increased face to face contact, knowledge spillovers, and scale economies. Proximity affords firms the ability to gain access to information that is not easily codified over long distances. As a result, firms are near the action when they spatially congregate and innovation benefits due to a unique combination of competition and cooperation.

2.1.3 Innovative Differences between the US and Japan

Differences exist in the methods associated with innovation and product creation in Japan and the United States. The United States is characterized as focusing on more **radical** innovation while Japan is characterized as focusing on more **incremental** innovation (Goto 1997b). The impact of continuous small improvements can be as drastic and technologically important as more dramatic breakthroughs. The organization structure of Japanese R&D management is also geared toward the **quick** development and introduction of new products. This organizational structure is reflected in the rotation of Japanese R&D personnel within firms, close intra firm relationships between production and R&D divisions, and a nexus between intra and inter firm interaction and R&D (Goto 1997b).

Japan's rise to innovative excellence occurred following the Second World War with such companies as Sony, Matsushita, and other soon to be electronics giants creating household items like radios and appliances. According to Freeman (1995),

> At first, in the 1950s and 1960s, the Japanese success was often simply attributed to copying, imitating, and importing foreign technology and the statistics of the so called 'technological balance of payments' were often used to support this view… It soon became evident, however, as Japanese products and processes began to outperform American and European products and processes in more and more industries, that this explanation was no longer adequate… The Japanese performance could now be explained more in the terms of R&D *intensity*, especially as Japanese R&D was highly concentrated in the fastest growing civil industries, such as electronics. Patent statistics showed that the leading Japanese electronics firms outstripped American and European firms in these industries (11).

Japan became a world leader in innovation through increased R&D effort and a desire to produce quality goods with mass market appeal. Japanese firms successfully entered and gained solid footholds in multiple industries that were American mainstays. Japan would no longer be seen as a country that produced cheap, low quality goods. According to Block (2008), a Developmental Bureaucratic State (**DBS**) emerged in Japan following the Second World War. The role of this DBS was to allow Japanese firms to mature and eventually challenge foreign competitors through the use of incentives and subsidies to better facilitate indigenous firm entry into a potentially risky market. This allowed Japan to strengthen its 'national absorptive capacity' through focused inward technology flow and investment in strategic industries (Mowery and Oxley 1995).

Japan and California experienced a concurrent rise as technologically advanced economies with tremendous "competitive advantage." Competitive advantage denotes the relative success of a production system within an institutional context while comparative advantage denotes greater efficiency in the production of a good (Ettlinger 1991, 392). The technological innovation within California's Silicon Valley is an important reason for California's economic success. Feldman and Florida found that California was the most innovative state in the areas of computers, measuring equipment, communications equipment, electronic industrial machinery, and electronic equipment in 1982 (Feldman and Florida 1994).

A primary reason for the technological rise of both California and Japan was the presence of leading individuals within both a competitive and cooperative business environment. Cooperation within a competitive environment (co-pete) can occur with the formation of cooperative agreements between universities, governments, or firms as a means for securing outside sources of funding and knowledge (Ettlinger 1991). This scenario is particularly true in Japan. Individuals such as Matsushita Konosuke, Morita Akio, Ibuka Masaru, and Sasaki Tadashi became leaders in Japan's burgeoning consumer electronics industry as they contributed to the economic prosperity of companies like Matsushita, Sony, and Sharp. The entrepreneurial spirit of these men and the co-pete environment within Japan were responsible for the rise of a technologically advanced economy in Japan as well as an increase in Japan's competitive advantage.

2.1.4 Innovation within Consumer Electronics

A hallmark of consumer electronics, innovation fuels the industry's short product cycles and technological progresses. Consumer electronics industries are very reliant on R&D employing a greater percentage of scientists and engineers than other industries

(CEA 2005). A highly skilled workforce is needed to fulfill the R&D, production, and marketing agendas of firms (IBIS World 2008). Firms allocate large percentages of their yearly budgets to R&D in order to create innovative products and ultimately bring those products to market. Sony is a great example of a CE firm that focuses on innovation and the respective R&D associated with that innovation. Sony's 2007 financial statement notes that the firm allocated 7.1 percent of its net sales and operating revenue to R&D expenses (Sony 2007, 48). Innovation and continued technological development in the consumer electronics industry has been a long established philosophy for Sony. Characterization of the firm as a "corporate guinea pig" demonstrates the firm's leading position within the CE industry (Luh 2003).

Established in 1946, Sony ascended from a shop in war devastated Tokyo to become a corporate giant that reigns over hugely popular consumer electronics, gaming, and computer divisions while also owning movie and music studios. Sony's *Founding Prospectus*, composed by cofounder Ibuka Masaru in 1946, cites the importance of innovation within the firm. The *Prospectus* promotes an ideal, dynamic workspace for engineers to better perfect their skills and thus be innovative. The *Prospectus* additionally promises that Sony will bring high-technology products to the household by rapidly commercializing technological advancements from universities and other institutions (Ibuka 1946).

Innovation is also an important barrier for entry into the consumer electronics industry. The high cost associated with R&D, short product cycles, and the need for skilled labor to create innovative products limits the access of newer and smaller firms into an industry dominated by larger firms. However, this research will show that even smaller firms have an important place within the CE industry. Many larger firms are creating technological alliances in an attempt to offset the high cost of continued R&D within the industry (IBIS World 2008). These alliances afford firms access to technology that might be too costly or unavailable to individual R&D departments. Such alliances and co operations can be beneficial to an economy. They can help increase R&D expenditures, reduce the costs and times associated with research projects, or facilitate more efficient allocation of R&D resources (Goto 1997a). Lastly, innovation is not solely associated with technology and new products but also creative marketing within consumer electronics (IBIS World 2008). Firms such as Apple and Google have launched innovative marketing campaigns to promote their products. Apple's IPod has used creative marketing in combination with innovative technology to acquire a large share of the portable music player market (Caryl 2008).

2.2 *National Systems of Innovation*

National systems of innovation are those systems within a state that promote innovation within that state (Lundvall 1985, 2000; Lundvall and Maskell 2003; Freeman 1987, 1995; Porter 1990; Groenewegen and van der Steen, 2006). Such systems include "national education systems, industrial relations, technical and scientific institutions, government policies, [and] cultural traditions" (Freeman 1995, 1). Furthermore, innovations are not only generated by these organizations and actors but by their complex patterns of interaction (Saviotti 1997). National innovation systems promote learning and knowledge within a nation, and "there has always been a strand of thought that has emphasized learning as a potential source of comparative advantage" (Fagerberg 1995, 244). The ultimate goal of any national system of innovation is to promote and foster innovative activity through the interaction of institutions and firms. Much of the research concerning national systems of innovation focuses on their continued importance in the globalizing world. Competitive advantage is created and maintained due to differences between locations (Porter 1990). In addition, "the concept of innovation systems conveys the idea that innovations do not originate as isolated, discrete phenomena, but are generated by means of the interaction of a number of entities or actors/agents" (Saviotti 1997, 180). Globalization only has the appearance of decreasing the importance of the nation. In reality, the importance of the nation only increases with globalization because it is with the skill and knowledge created within a nation that that nation can maintain its competitive advantage in an increasingly globalized world (Lundvall and Maskell 2003).

Thus a paradox exists with respect to national systems of innovation and globalization. Globalization reinforces the need for such systems within a nation to promote innovation and "compels firms and governments alike to focus on the remaining localized (immobile) capabilities" not available to all firms (Lundvall and Maskell 2003, 364). Most R&D activities are still domestically based and benefit from national systems of innovation even though multinational corporations (MNCs) are increasingly establishing R&D activities overseas. Additionally, the domestic platform remains an important element with respect to ownership and control (Freeman 1995). Therefore, American firms will largely remain American, Japanese firms will remain Japanese, and EU firms will remain EU because of continued reliance on home nations for innovative and knowledge resources supplied through national system of innovation. While firms might initiate R&D activities outside the home nation those activities most often focus on local design modifications (Freeman 1995).

2.2.1 National Systems of Innovation Models

According to Groenewegen and van der Steen (2006), there are two models concerning the theoretical contributions of national systems of innovation within a nation. The first model illustrates how policy makers have interpreted the theoretical contributions of national systems of innovation in association with the New Institutional Economy (NIE) perspective. The NIE perspective utilizes specific benchmark innovation indicators believed to measure innovative activity and performance within a country, the Benchmark National Innovation Systems Model, to better design institutions that facilitate innovation. This Benchmark Model for innovation systems focuses on the major institutions, organizations, and interactions between public and private actors in an attempt to identify specific policy recommendations associated with innovative behavior (Groenewegen and van der Steen 2006). The second model is the Layered Institutional Model that differentiates between layers of institutions so as to better understand the interconnectedness of any national innovation system and specific innovative activity within a country. This model is comprised of five layers: (from highest to lowest) informal institutions (culture and values) and technology, formal institutions (the role of the state and political system), formal institutions (laws and policies), institutional arrangements (contracts and networks), and individual actors (routines and learning capability). The higher layers can constrain the lower layers while the lower layers can influence the higher layers (Groenewegen and van der Steen 2006).

2.2.2 National Systems of Innovation in the US and Japan

Over the last 30 years, market fundamentalism dominated politics in the United States through self-regulation within the market to solve economic and social issues (Block 2008). This practice is best described by Adam Smith's "invisible hand" guiding the economy with minimum government involvement. One area in which the role of market fundamentalism has not been dominant is in the encouragement and facilitating of new and better technologies and innovation. As mentioned above, innovative ability creates a comparative advantage among nations. Many governments, including the United States, notice the need to foster this ability in order to stay ahead in an increasingly competitive world economy. The United States has a broad technology base with both firms and universities involved in extensive research efforts, but this technology base does not always hold true for more specific product and process innovations. Therefore, it is impossible for the United States to maintain an innovative lead in every industry (Simons and Walls 2008).

According to Block (2008), a Developmental Network State (DNS) emerged in the United States vastly different from the Developmental Bureaucratic State (DBS) that emerged in Japan following the Second World War. A DBS is designed to allow domestic firms to close a technology gap through the use of government initiatives to prompt firms to enter a market they otherwise would not. A primary objective of a DNS is to assist firms in the "development of new process and product innovations that currently do not exist" by increasing the productivity of the scientific and technical knowledge base through a set of government actions that include brokering, facilitating, or resource targeting (Block 2008, 171-172). The American DNS is largely hidden from public view and highly decentralized. Examples of government initiatives within a DNS are the National Aeronautics and Space Agency (NASA) and the Atomic Energy Commission, both of which contributed to new technological and scientific breakthroughs within the United States.

American philosophy associated with innovation has often been to allow innovation to flourish on its own (Simon and Walls 2008). According to Simon and Wells (2008), there are a number of cornerstones associated with American innovation. First, incentives for innovation within the United States have largely been centered on monetary returns with the potential for others to profit from an individual's innovation restricted through the use of patents. Patents must not be granted too easily because a large number of patents protecting trifling advancements could limit technological progress. Firms can often bypass patent rights by incorporating modified versions of a technology. American corporations also have access to a corporate R&D tax credit for a percentage of their R&D expenses. Second, federal funding is available for R&D activities accounting for 27.7 percent of the total funding for R&D activities in 2006 (Simon and Walls 2008, 2). Agencies that provide funding include the Department of Defense and the National Science Foundation. Third, the United States has a strong mix of entrepreneurial (smaller sized firms and start-ups) and large firms. Larger firms have the resources and capabilities for extensive product and process innovation while also bringing these innovations to a market whereas smaller firms have proven they can provide new and capable technologies that larger firms might overlook. Lastly, the United States provides innovators with an institutional and social infrastructure that accepts and promotes innovative behavior such as an extensive university system and acceptance of immigration. Such a social infrastructure creates a culture that values extensive R&D efforts as well as ongoing innovation.

National systems of innovation arose within East Asian economies after the Second World War (Freeman 1987; Mowery and Oxley 1995). A key ingredient to the success of these economies was inward technology flow and a reduction in the 'technology gap' associated with the application of that technology flow. The Japanese and East Asian economies were able to exploit foreign technology through inward technology flow while also instituting national policies to promote absorptive capacity within their respective economies (Mowery and Oxley 1995). The ultimate goal for inward technology flow is a transition to the manufacture of more sophisticated products by a highly skilled and innovative workforce. Methods for inward technology flow include joint ventures and alliances, foreign investment, import of advanced goods, and licensing. A "critical contribution of national innovation systems is to supply the human capital needed to exploit opportunities created by links with foreign sources of technology" (Mowery and Oxley 1995, 88). The regional proximity of firms also contributes to inward technology flow by attracting foreign firms. Ultimately, a country's innovation system evolves as its economy matures.

Similar to Britain during the industrial revolution and the United States and Germany in the late nineteenth century, Japan was able to create and exploit a technology gap following the Second World War. Importantly, technology gaps are not only created with technological and scientific activities within a country but through better organization of production, investment, marketing, and facilitating entrepreneurship driven innovation (Freeman 1987). These important institutional changes and research initiatives play a crucial role in how a country exploits and builds upon technology and innovation, while also creating a favorable environment that encourages innovation. Therefore, Japan's current technological standing in the world is not only associated with its position as a leading innovator and technologically motivated society but also by the social and institutional foundations that foster such technology and innovation.

Japan's national system of innovation was apparent before the First World War. It was largely associated with the involvement of Japan's strong central government in the country's economy, the value of education and training within the country, the country's ability to import and improve technology, and cooperation between the Japanese government and industry (Freeman 1987). Post Second World War initiatives in Japan also contributed to the country's national system of innovation and its current technological presence in the world. The Ministry of Economy, Trade, and Industry (METI), formally the Ministry of International Trade and Industry (MITI), plays a crucial role in innovation and technology in Japan through the promotion of advanced technology with wide market appeal. Furthermore, METI works with R&D personnel and university scientists to determine and stay informed about technology trends. Japan's comprehensive education and training system continues to remain important within the country by facilitating the flow of information and instilling ideals of quality and innovative behavior in Japan's workforce. Finally, Japan created a model of competition that remains an integral aspect of the country's national system of innovation because it encourages long-term research and investment goals as well as promoting "technological change, high quality, and product differentiation" (Freeman 1987, 51). This model of competition counters the desire for short-term profits that have the potential to negatively impact long-term research and investment objectives.

The United States is seen as following a "mission-oriented" policy due to the efforts associated with military, energy, and space innovation, whereas Japan is seen as having a "diffusion-oriented" policy allowing for knowledge transfer between military and civilian innovative initiatives (Malecki 2005, 1180-1181). These orientations demonstrate a difference in each country's ability to transfer technology. According to Malecki (2005), the United States' mission-oriented stance facilitates "trickle-down" diffusion. America's focus toward military technology can hinder the diffusion of such technology into commercial applications. On the other hand, Japan's diffusion-oriented stance facilitates "trickle-up" diffusion allowing military applications of commercial technology. This distinction is important because commercial technology is more often geared to efficiency and profitability. Figure 2.1 offers a brief comparison of the Japanese and American national systems of innovation.

Figure 2.1: Aspects of the Japanese and American National Systems of Innovation

	Japan	**United States**
Innovation Type	**Incremental**: Characterized by continuous improvements to both products and processes, **"diffusion-oriented."** Innovation benefits from a link between the R&D, production, and marketing of a product. Short product cycles are therefore common.	**Radical**: Characterized by a pursuit of breakthrough type technologies, **"mission-oriented."** The creation of the Advanced Research Projects Array (ARPA) for "beyond the horizon" technology is an example. Broad technology base.
Innovative Firm Sizes and Firm Interaction	**Large Firms Dominate**: Government practices have historically favored large firms and made entry into specific industries difficult for smaller firms. The Keiretsu system is important. Firms involved in co-operative interactions yet highly competitive. Historical connections important.	**Small to Medium Firms Dominate**: These firms are often responsible for the introduction of exotic and innovative ideas. Hire many university graduates. Larger firms have more extensive resources. Influenced by co-operative behavior of firms. "Winner takes all" approach still important.
Government Involvement	**High**: Government ministries such as METI have historically influenced the direction and pace of technological progress. Government involvement is highly visible and centralized. Private R&D spending still dominates.	**Medium to High**: Government involvement in defense related R&D is high. Involvement in nondefense R&D is more decentralized and fragmented across different economic sectors. Coordination is limited and.
Patent System	**Promotes Technological Diffusion**: Characterized by patent laws and practices that allow for quicker diffusion of innovative results for economic success.	**Limits Technological Diffusion**: Characterized by more strict patent laws and practices that protect innovative results. Inventor rights are important.
Worker Mobility	**Intra Firm Movements:** Workers often stay and move within firms for much of their employment lifetime. A seniority wage system discourages movement between firms.	**Inter Firm Movements**: Compared to their Japanese counterparts, American workers move between firms more often.
Technology Diffusion	**"Trickle-up"**: Transfer between military and civilian activities. Idea of "spin-on" with off the shelf technologies for military applications. Mechanisms for technology transfer.	**"Trickle-down"**: Limited spillovers from military technology into commercial applications. Process of innovation geared toward the "mission" not commercial opportunities.
Education	**Important**: A strong university system with high academic standards. Industry desire for human resources influences education system. Cooperation with industry for specific and practical problems with commercial appeal.	**Important**: A strong university system supports a wide array of technological and scientific research agendas. Cooperation between the private and public sectors is important for both the pursuit and funding of R&D at the university level.

Sources: Goto 1997a; Goto 1997b; Freeman 1987; Malecki 2005

2.3 *A Geographic Shift in the Consumer Electronics Industry*

According to the Japan Electronics and Information Technology Industries Association (JEITA), the strengths of the Japanese consumer electronics industry are innovation and R&D (Sangani 2006). Thus, the rise of Japanese firms in the consumer electronics industry is an important aspect in understanding the current state of innovation and innovation policy within the industry. American firms such as RCA long served as technology and market leaders in the industry. RCA's collapse decimated America's technological learning base in consumer electronics and brought an end to the dominance of the American consumer electronics industry as a whole (Chandler Jr. 2001). RCA's failures allowed for near total Japanese dominance within the industry. Why and how did this power shift occur? Simply put, Japanese firms were able to capitalize on market demands and conquer the global market due to key government and management decisions. Japan offered Japanese entrepreneurs a competitive and cooperative business environment (co-pete) to better foster new ideas and create marketable products. Japanese firms became dominant in the industry because they were more diverse and produced more products than American firms. They entered industries similar to consumer electronics in order to extend their comparative advantage. "Japan's Big Four - Matsushita, Sanyo, Sony, and Sharp - had become full-line producers" using "their integrated learning base to commercialize products of new technologies and to enhance existing ones" (Chandler Jr. 2001, 79). Production and innovation within the semiconductor industry in Japan also surpassed that of American firms. Japanese firms have never strictly been semiconductor firms like many of their smaller American counterparts but rather large, highly integrated electronics firms that provide the necessary semiconductors for their respective technologically oriented products (Freeman 1987). As a result, these firms constitute the primary reasons for Japan's current dominance in the consumer electronics market.

During this time period, the Cold War was still a primary concern within the United States. Defense spending and R&D related activities took precedence over other endeavors. Due to this concern, many of the more talented American engineers and scientists were highly sought after for defense reasons, ultimately limiting their ability to contribute to the advancement of consumer goods like electronics. Japanese engineers and scientists were able to place their efforts in the design and manufacturing of goods specifically intended for consumer consumption (Johnston 1999). As such, Japanese firms became leading suppliers for consumer electronics goods in the United States.

American firms are highly competitive in areas such as components and software. Furthermore, American manufacturers "focus on the production of high-end consumer electronics as well as the design and marketing of products manufactured elsewhere" (CEA 2005, 2). The high cost of production in the United States forces firms that produce goods there to increase the price of those goods. Therefore, consumer electronics firms that produce goods in the United States often focus on higher end products that are considered exoteric to the common consumer. This allows these firms to place a premium on the purchasing price for their respective products. A local example of an American consumer electronics firm that produces high end products in North Carolina is Cary Audio Design based in Apex, North Carolina. Ultimately, much of the production of goods from American firms is either manufactured abroad by those firms or outsourced to foreign manufactures due to labor costs in the U.S. (IBIS World 2008).

2.3.1 HDTV as an Example of Technology Policy

In the late 1980s and early 1990s, high-definition television (HDTV) contributed to heated debates about the future of the consumer electronics industry. The creation of an HDTV standard and the respective technological innovation associated with the inception of HDTV initiated discussion as to whether HDTV should be a strategic industry in the United States (Beltz 1991). Strategic industries are supported by governments through various policies in hopes of promoting spillovers into other industries. This is a strong example of a national system of innovation at work. The argument against such policies focuses on the difficulties in measuring technological spillovers between industries and firms. Furthermore, many skeptics still question the specific role government should play in the market. A strong motivation for strategic industries would be to promote greater profits in those particular industries (Beltz 1991).

HDTV is a widely adopted technology in today's society, but the battle to create an HDTV standard was both lengthy and challenging. Potential profits and royalties from patents associated with the adoption of an HDTV standard divided the consumer electronics industry into multiple camps (Kaminsky 1988). Firms from Japan, Europe, and the United States desired to promote their own version of HDTV in the belief that whoever succeeded could control the consumer electronics industry for many years to come. At the time, it seemed HDTV would become another bitter war between firms similar to the VCR and Beta technology standardization war in the late 1970s and early 1980s (Beltz 1991).

Advocates for HDTV believe it to be representative of a new era in consumer electronics due to the technological promises associated with the technology. The components associated with the manufacture and design of HDTVs are also associated with the manufacture and design of computers. Thus, the consumer electronics industry and computer industry could benefit from cross industry innovations and opportunity. The potential benefits of HDTV are not just confined to these two industries but could possibly extend to medicine, telecommunications, and education (Beltz 1991). This concept clearly supports the current trend toward digital convergence between the consumer electronics and computer industries. Furthermore, advocates for the promotion of a HDTV industrial policy in the United States believe that such policy would strengthen technological spillovers in the "electronics food chain." According to these advocates, flexible manufacturing techniques associated with short-product cycles in the production of consumer electronics would benefit other industries' attempts to respond to changing markets more rapidly. While HDTV would account for a relatively small portion of the overall economy, it would have strong upstream connections to the production of semiconductors and other electric component manufacturers (Beltz 1991).

Opponents for a strategic policy supporting HDTV question the demand, standards, and technological linkages associated with HDTV. Of particular importance to skeptics in the debate is the degree of convergence between HDTV and computers. The "timing and degree of market convergence will also be influenced by factors such as consumer preference for a multipurpose set that has interactive capabilities, compatible video standards for televisions and computers, and the general regulatory framework- all of which are not yet known" (Beltz 1991, 72). A final criticism against a HDTV strategic industry policy is the over exaggeration associated with foreign competition to create a HDTV standard. Opponents believe that all parties involved experience severe technological hurdles in their research and development. Furthermore, the idea that the race to create HDTV is a national race is erroneous. International networks exist between firms and these firms often participate in co-development and co-production activities (Beltz 1991). With this type of connection between firms, the implementation of any HDTV standard would benefit firms from more than one country.

2.3.2 The Importance of the Computer Industry

The United States led in the computer industry for many years. Much of the United State's dominance is attributable to IBM and its extensive research since its inception. Other firms contributed to the US presence in the industry such as- Dell, Gateway, Hewlett Packard, Apple and Microsoft. Japanese firms are also active in the computer industry and are largely represented by Fujitsu, Nippon Electric Company (NEC), Toshiba, and Hitachi. These Japanese firms control a large segment of the industry and are major foreign competitors to American firms. Differences exist between American and Japanese firms within the industry. Most importantly, Japanese firms are diversified beyond electronics and entered the computer industry by relying on their experiences with other electronic products such as appliances, semiconductors, and light and heavy electrical equipment (Alfred Chandler Jr. 2001). Many of these Japanese firms have secured their position in Japan as industry leaders and are much older than any American competitor, excluding IBM.

American firms still have a very important advantage over Japanese rivals: commercialization of the micro processor in the 1980s. This advantage allows for American firms to dominate the personal computer sector. Clusters such as California's Silicon Valley allow for hotbeds of innovation to further promote American dominance within the industry. Thus, Japanese firms remain challengers within the computer industry and are not the dominant firms in world markets like their consumer electronics counterparts (Chandler Jr. 2001).

2.4 Digital Convergence within Industry

Japanese firms have experience in both the consumer electronics and computer industries, while most American firms that are leaders in the computer industry lack consumer electronics experience. Japan entered the computer industry through other electronics industries, such as consumer electronics. The supporting nexus that emerged between industries exemplifies a noteworthy competitive strength for Japan's core companies. The co-evolution of the consumer electronics and computer industries benefits both industries within Japan by reinforcing their respective technical and functional capabilities (Chandler Jr. 2001). Proximity is crucial for this co evolution because the supporting nexus of the consumer electronics industry is available to Japanese firms entering the computer industry. This allows firms within each industry to produce products outside their respective industry. Furthermore, the "growth of this unique concentration of electronic knowledge and organizational capabilities necessary to commercialize new products and processes and to improve existing ones helped propel the swift expansion of Japan’s five core computer companies (all headquartered in Tokyo) and four electronics companies into overseas markets” (Chandler Jr. 2001, 235). Success in overseas markets brought further expansion of the nexus supporting both industries. This nexus is an example of digital convergence between industries. According to Chandler Jr. (2001), American firms lack this nexus.

Digital convergence is the overlap of complementary industries that produce digital products, creating opportunities for consumer electronics, computer, and communications firms to capture new and emerging markets. Figure 2.2 illustrates the many industries associated with digital convergence as well as a number of firms within those industries. A firm is not restricted to any one industry. Firms such as Sony and Samsung often have multiple divisions or subsidiaries that participate in different industries. Sony has a consumer electronics division, and Sony Pictures Entertainment owns Columbia Pictures. According to Yoffie (1997, 5), “in its simplest form, convergence means the uniting of functions of the computer, the telephone, and the television set.”

Digital convergence is an extension of technological convergence and can largely be attributed to the falling cost of computer power and bandwidth. An important driver for convergence is the increasing number of creative combinations of content and technology that has led to a wide array of new products (Yoffie 1997). Technological convergence is nothing new within the consumer electronics industry. A historical example includes the advent of extensive rail systems that relied heavily on the technological contribution of the steam engine. Ultimately, any technological convergence between industries heavily impacts the firms that make up those industries (Greenstein and Khanna 1997).

Figure 2.2: Industries Associated with Digital Convergence

Digital Convergence*			
Computers	**Consumer Electronics**	**Communications**	**Content and Software**
Hewlett-Packard	Sony	Verizon	Microsoft
Dell	Matsushita	Sprint	Universal
NEC	Toshiba	DoCoMo	Columbia Pictures
Fujitsu	Samsung	AT&T	Warner Brothers
Apple	LG	Time Warner	Fox
IBM	Sharp	BellSouth	Viacom
Intel	Philips	Quest	Disney

*A firm can be in more than one industry: Sony produces computers, TVs, DVD players, and owns Columbia Pictures.

Source: By Author

The Consumer Electronics Association (CEA) proclaims that the computer revolutionized the way we work while the television revolutionized the way we relax. Together they revolutionized the way we stay informed (CEA 2009). Attempts to integrate the abilities of the computer and television have occurred for many years. Current televisions, most notably Samsung and Panasonic models, offer viewers the ability to access weather, news, and other applications although these models are more often step up models in a manufacturer's product line. A natural problem with the convergence of the computer with the television is integrating the "two-foot" (computer) and "ten-foot" (television) experiences (CEA 2009). A computer is often a single person experience, while television serves multiple people, hence the "two-foot" and "ten-foot" distinctions. Televisions today have the capability to integrate with home networks to access audio or video files on an individual's computer or harness the many multimedia possibilities of the internet. A *Business Week* article quoted a Philips vice-president stating, "Convergence is finally happening… digitization is creating products that can't be categorized as tech or consumer electronics" (Baker et al. 2004, 68).

Digital Convergence provides the "Big Bang" of electronics with the hope of fostering a new era of innovation (Baker et al. 2004). The prominent industries involved in this collision are noted in Figure 2.1. The very nature of convergence dictates that these different firms need help in creating convergence oriented technology as they venture out from their own industry. Chips that once graced only computers are increasingly being incorporated into other electronics devices, allowing these new devices the computing power to accomplish many new and diverse tasks. As such, chip manufactures stand to benefit from supplying the growing demand for their products. *Business Week* quoted Intel Chief Executive Craig Barrett, "As technology converges, our opportunities expand… this is where we're putting all our resources" (Baker et al 2004, 68). This Big Bang of convergence will be extreme. Questions will arise regarding industry direction and consumer demand, and it will be innovative firms that answer these questions as they bring technology to market. Firms will venture into new territory and compete with other firms that they previously did not. Newcomers and up-starts stand to benefit also as "they have the chance to sprint ahead on the strength of one breakthrough idea" (Baker et al. 2004, 68).

Firms have responded to emerging digital convergence opportunities for a number of years. Yoffie (1997) specifically mentions the efforts of NEC and Apple as each firm recognized the potential associated with digital convergence opportunities. NEC's "Computers and Communications" slogan from 1977 highlighted technological convergence within multiple industries, proclaiming:

> As digital technology finds its rightful place in communications, communications technology will inevitably converge with computer functions, and communications networks will become capable of more effective transmission of information. With distributed processing systems linking a group of processing units, the computer will become highly systemized and inseparable from communications (Yoffie 1997, 4).

Apple chairman, John Sculley, believed that computer, telecommunications, consumer electronics, media, and office equipment were all separate and distinct industries in the 1990s, but firms would quickly move to take advantage of emerging digital technologies as the computer became a more central aspect within people's lives (Yoffie 1997). Technologies mature at different rates so digital convergence time frames are uncertain. What is certain is that the "mass acceptance of convergence requires content as well as infrastructure" (Yoffie 1997, 5). With content come many other questions, such as who has ownership of what? The digital rights associated with content is a sticky subject that continues to be debated as the different layers of industry struggle to maintain control of creative content (Baker et al. 2004).

The consumer electronics and computer industries are not the only industries experiencing digital convergence. Another modern example of digital convergence includes the growing relationship between phone, cable, and internet firms in the ever expanding communications industry. Importantly, “the convergence of technology may provide an opportunity for a new product, but it never guarantees a market. The object of competition in these markets is thus not to produce a better mouse trap, but to find out before your rivals whether customers are trying to trap mice” (Gomes-Casseres and Leonard-Barton 2001, 364). Consequently, as digital convergence overtakes the market that market becomes populated with an increasing number of competitors that were formally not competitors. These competitors must rely on innovation to bring viable technology to the market while also successfully attracting consumers to that product. Thus, there is a need to determine the elements for successful entry and survival if a digital convergence oriented market materializes. Figure 2.3 is comprised of ideas from a 2004 *Business Week* article and illustrates the digital convergence trend.

Figure 2.3: The Impact of Digital Convergence

Elements Promoting Digital Convergence
Increased Bandwidth: High-speed lines are now being used by one-third of U.S. households, with higher percentages in parts of Asia. Some 14 million broadband users run wireless networks at home. This is the vital plumbing for delivering music and video there.
Digital Television: Massive investments in Asia should drive down prices of flat computerized TVs by 50% within two years. These will become the essential furniture of the networked home. And users will want ever more bandwidth to fill the high-definition screens.
Content Subscription: New offerings such as Rhapsody's music service, Comcast's Video on Demand, and Disney's MovieBeam deliver music and movies via the Web. Content collections sit on the network, and subscribers click for music and programming.
Smart Phones Proliferate: Cell phones should be in the hands of nearly 2 billion people by 2007, up from 1.3 billion today. The coming gizmos will connect to the Web for e-mail, music, and video clips from anywhere, anytime.
Potential Results of Digital Convergence
Networks: Entertainment and business move onto high-speed networks, within homes, offices, and throughout the mobile world. Most wires disappear.
Programming: Myriad Web sites compete with TV networks, and legions of individuals beam their own video up to the Web and become programming publishers.
The Fading of Time: TV and radio schedules virtually disappear as programming-on-demand takes over everything except major sports and news events.
Video Communication: As phones merge with computers, video calls finally take off. Far-flung teams work on shared documents in virtual meetings, igniting off shoring and telecommuting.
Five Companies Associated with Digital Convergence
Samsung: Shaping up as the titan of hardware, the Korean company is a power in TVs, phones, and components such as flat screens and chips. **Danger**: Lacks entertainment programming to sell with its machines, which would distance it from hardware price wars and Chinese manufacturers.
Microsoft: Sees Windows linking a plethora of new music, phone, and video services. Banking on Xbox and media PCs for the living room. **Danger**: Couch potatoes may resist linking entertainment systems to software known for complexity, crashes, and viruses.

IBM: Is betting that untangling converging technologies will be big business for its services group. Big Blue also is creating new chips with Sony for video games. **Danger**: Up-and-coming Chinese chip foundries eventually may succeed in undercutting IBM on price to power next-generation game machines.
Intel: Is spending $2 billion to build chips for the full gamut of coming machines, from smart phones and flat-panel TVs to handheld video players. **Danger**: The chip giant is battling on enemy turf. Texas Instruments has more savvy in communications, while IBM and Sony are tops in games.
Comcast: Plans to equip its 21 million subscriber homes for Web phone service within 18 months, and its Video on Demand could shake up the industry. **Danger**: Its cable connections are slow by global standards. And consumers could bypass cable, to download programming directly from studios and artists.
What is Needed for Digital Convergence to Succeed
Simplicity: Manufacturers must make networking a house and setting up mobile services as simple as plugging in a TV. If they fail, the promise of the technology will remain locked inside the box -- and only geeks will buy it.
Standards: The industry must settle on a strong standard for digital-rights protection. Without it, studios and publishers will withhold music and programming. Other technical standards should allow all the pieces to work together, preferably from a single remote.
Other Platforms: Startups and individuals will drive growth with an explosion of new services, applications, and programming -- but only if they can develop on a free and open software platform not ruled by any one group or company.

Source: Baker et al. 2004, 68

CHAPTER III

RESEARCH DESIGN

3.1 Review of Research Hypothesis

The focus of this research is the incorporation and promotion of national systems of innovation and a possible trend toward a digital convergence oriented market within the CE industry that potentially allows American CE and computer firms the ability to level the balance of power in this Japanese dominated industry. The trend within the consumer electronics industry toward digital convergence products and their potential to reinvigorate American firms allows for an examination of national systems of innovation within a highly technical and scientific industry wherein R&D is crucial for the market success of a firm. Both countries have distinct national systems of innovation that influence the creation and application of technology from indigenous firms. Thus, the hypothesis of this research asserts American firms are highly innovative within the CE industry and have the ability to release technologically advanced digital convergence products. Furthermore, American CE firms are distinctive from their Japanese counterparts due to unique national innovation systems present within each country that have shaped the CE industry. Differences between American and Japanese innovative firms suggest differences in the innovation systems of these countries.

Analysis of patent data, as well as innovation awards accredited to CE firms will demonstrate the innovative activity and capability of the consumer electronics industry in both the United States and Japan. This analysis will also highlight differences in firm size and product specialty between American and Japanese CE firms. Patent data was collected from the United States Department of Commerce's Patent and Trademark Office. The data includes country and individual firm patent statistics. Innovation award data was obtained from the Consumer Electronics Association's Consumer Electronics Show (CES) Innovations and Engineering Awards program. This data indicates the innovative capability of the United States and Japan.

Digital convergence's emergence and its ongoing implementation in consumer products necessitate distinguishing the connection between the consumer electronics and computer industries. The CEA defines the industries within the consumer electronics sector. All data associated with the CEA came from the CEA website. These industries include an assortment of electronic device industries, but the primary concern for this research will be those industries associated with audio and video product manufacturing, computer product manufacturing, and content creation, in order to establish a digital convergence connection between these industries. American potential to regain some measure of influence in consumer electronics would benefit from such a connection due to American strengths associated with computer related innovations and the country's strong computer industry. Innovation within these industries will be examined with a focus on digital convergence oriented technologies and how such technologies could benefit American firms. Thus this research will further the understanding of digital convergence within these complementary industries and offer a perspective on how the blurring of these industries is influenced by national systems of innovation.

3.2 Study Area

The United States and Japan were chosen for this research due to their historical presence in the consumer electronics industry and long standing innovative legacies. Due to reasons mentioned above, the United States' leadership within the industry faded allowing Japan to flourish. The consumer electronics industry still remains an important industry within the United States. Many of the leading consumer electronics firms in the world such as Sony, Toshiba, and Matsushita (Panasonic) are Japanese. These firms are important players in the introduction and diffusion of innovative ideas and products within the industry and market. Products from these firms are common sights within most American households. Is your television made by Sony, Toshiba, or Panasonic? What about your stereo system or alarm clock?

Japanese firms rose to power in large part due to the fall of the consumer electronics industry within the United States. This research predominantly focuses on the United States and its ability to regain some measure of influence within consumer electronics through success in an emerging digital convergence market. Statistics to support an American presence within consumer electronics will demonstrate a still strong and thriving industry within the United States. Leading consumer electronics firms within the United States include Harmon International and Bose, but computer firms within the United States such as IBM, HP, Dell, Microsoft and Apple also have the ability to capitalize on recent digital convergence trends.

3.3 The CEA and Industries in the Consumer Electronics Sector

Many firms and associations make up what is known as the consumer electronics industry. The CEA promotes the combined goals and agendas for the industry, maintains statistics, and frequently analyzes important trends within the industry. The CEA also tracks the economy and its impact on CE related issues. It is an international association with members from many different countries. Members, most often firms within the industry, can access the statistics and studies maintained and initiated by the CEA. The CEA claims more than 2,200 members from multiple countries. These members comprise manufacturers, retailers, custom installers, and even firms such as Yahoo. Nonmembers have limited access to data collected by the CEA but some data is released for public access. The CEA holds a yearly trade show, the Consumer Electronics Show (CES), for firms to demonstrate and showcase new products and technologies. These products are often the pinnacle of technology in their respective product categories. The best of these products receive awards for innovation.

3.3.1 The CE Sector

The CEA defines the CE sector to include all electronics manufacturing and content industries composing 23 total industries (14 manufacturing industries and 9 content industries). Table 3.1 lists the industries within the CE sector as well as their corresponding NAICS code. The North American Industry Classification System (NAICS) distinguishes specific industries within the United States. Three manufacturing industries were adjusted to include only CE related manufacturing. For the purpose of this research these combined industries constitute the CE sector. Analysis of the consumer electronics sector in the United States demonstrates the sector's health and weaknesses within the economy. Data from CEA reports as well as the IBIS World industry database are used. CEA reports were acquired from the CEA website while the IBIS World industry database was accessed through the University of North Carolina Greensboro.

3.3.2 Content and Software Creation

American firms are also instrumental in software and content development associated with the consumer electronics industry. Table 3.1 lists the industries associated with consumer electronics content creation. An industrial agglomeration and creative powerhouse within the content industry, Hollywood, feeds much of our need for the content used in electronic devices (Scott 2005). Hollywood is therefore able to shape and influence the film and television industries over much of the world. The creation of content is an important aspect of this analysis due to the need for audio, video, and other software content for use with electronic devices. Content and software are at the heart of the digital convergence trend due to the many electronic ways in which consumers are now able to view, listen, or interact with available content. Software and content creation will be assessed within the United States. Industry reports for content creation come from the IBIS World industry database. Box office data come from The Motion Picture Association of America (MPAA) and Box Office Mojo websites. The MPAA is a powerful association within the film industry that not only supplies continuously updated box office calculations but industry reports used to assess a multitude of industry related phenomenon.

Table 3.1: CEA Defined Consumer Electronics Industries

Manufacturing of Electronics	**NAICS**
1. Audio and video manufacturing	3343
2. Electronic computer manufacturing	334111
3. Doll, toy, and game manufacturing (portion)	11993
4. Watch, clock, and other measuring and control devices	334518-9
5. Telephone apparatus manufacturing	33421
6. Photographic and photocopying equipment manufacturing (portion)	333315
7. Other computer peripheral equipment manufacturing	334119
8. Electro medical apparatus manufacturing	334510
9. Computer storage device manufacturing	334112
10. Broadcast and wireless communications equipment	33422
11. Office machinery manufacturing	333313
12. Search detection and navigation instruments	34511
13. All other electrical component manufacturing	334412-19
14. Magnetic and optical recording media manufacturing	334613
Content for Electronics	**NAICS**
1. Telecommunications	5133
2. Cable network and subscription broadcasts	5132
3. Radio and television broadcasts	5131
4. Motion picture and video industries	5121
5. Software publishers	5112
6. Video tape and disc rental	53223
7. Information services	5141
8. Sound recording industries	5122
9. Data processing services	5141

Source: Consumer Electronics Association (CEA) 2008, 5

3.4 Patent Analysis

Patents are crucial instruments within innovation policy, so their analysis is important for understanding innovation within firms. Patent data was obtained from the Department of Commerce's Patent and Trademark Office. The accessed data is divided by year for all years from 1963 to 2007 and includes patents granted to all industries. The years before 1994 are aggregated with patents granted noted separately for each successive year through 1994 to 2007. Patents granted by county illustrate the differences between the United States, Japan, and all other countries. Individual firm patent data allows for further analysis by illustrating which firms are granted patents.

3.5 CES Innovations Design and Engineering Awards Program

Each year, the CES honors the best products from a range of product categories with an innovation award to mark an important achievement in the CE industry. According to the CES (2009), "the Innovations Design and Engineering Awards program recognizes the most innovative consumer electronics (CE) products in the industry's hottest product categories. Innovation has become a hallmark for the best designed products in consumer technology." As such, these yearly awards offer a sampling of innovative firms within the CE industry. Data for these awards was collected from the CES website for the years 2003 through 2008. 2009 award winners were not yet chosen as of this writing. No data was available for those years before 2003.

Product categories expanded each year so a greater number of awards were issued each successive year. There were 34 award categories for 2008 while only 22 existed in 2003. Table 3.2 lists the award categories for 2008. The analysis illustrates which firms are innovative in particular product categories. The nationalities of firms are recognized along with individual firm revenue, number of employees, and product specialty. Product specialty will dictate a firm's primary market segment as consumer electronics, computers, or software. A firm's nationality, revenue, and number of employees will be determined by utilizing firm websites, the Market Line database, and the ReferenceUSA database. Both databases were accessed through the University of North Carolina Greensboro. Analysis focused on year 2007 data. When 2007 data was unavailable a firm's most recent data was used. Firm nationality, revenue, and employment further the analysis of innovative breakthroughs within the CE industry.

Table 3.2: CES Innovations Design and Engineering Awards Categories for 2008

Audio Accessories	High Performance Audio	Personal Electronics
Audio Components	Home Applications	Portable Media Players
Computer Accessories	Home Networking	Portable Media Accessories
Computer Hardware	Home Theater Speakers	Portable Power
Computer Peripherals	Home Theater Accessories	Telephones
Digital Imaging	In-Vehicle Audio	Video Accessories
Eco-Design and Sustainable Technology	In-Vehicle Accessories	Video Components
Electronic Gaming	In-Vehicle Control/ OEM Integration	Video Displays
Enabling Technologies	In-Vehicle Navigation/ Telematics/ ITS	Wireless Handsets
Furniture	In-Vehicle Video	Wireless Handsets Accessories
Headphones	Integrated Home Systems	
Healthcare	Multi-Room Audio/Video	

Source: cesweb.org

3.6 Digital Convergence

Analysis of the digital convergence trend concludes this analysis accessing individual product categories of the CES Innovations Awards. The research focuses on video related categories associated with digital convergence possibilities. These possibilities are assessed along with each firm's position within the industry. Digital convergence in its simplest form is "the uniting of functions of the computer, the telephone, and the television set" (Yoffie 1997, 5). Modern digital televisions and HDTVs are very much digital convergence devices due to their processing and content display capabilities which allow them to become the digital centerpiece of the home (Baker et al 2004).

Consequently, video related devices offer an excellent area of analysis for determining digital convergence possibilities. Luckily, the CES has specific award categories associated with video related devices; although, the names of these award categories evolved over time. An example would be the Video (2003), Video Components (2005), and Video Displays (2007) category. A category for Mobile Video was also introduced during this time period. Therefore, categories will be chosen by the researcher based on their relevance to video related technology. Award categories will include actual video displays and components that are designed to integrate with those displays. Each award category used will be noted and its relevance justified based on the researcher's experience. The results demonstrate the degree of American involvement in award winning video related digital convergence innovation. Mention of award nominees for each category supplements this analysis. This allows for an expanded view of those firms associated with video related innovative activity.

Weaknesses are present within this analysis. The CEA is an industry association that promotes the industry. Therefore, any data and/or statistics released by the CEA are subject to a degree of bias in favor of the industry. Using an industry innovation award also limits the overall sample of firms to those firms that won an award. Firms that do not receive an award are in no way lacking innovative capability. As such, many other firms could possibly be capable of the innovation associated with consumer electronics and/or digital convergence.

CHAPTER IV

FINDINGS

The purpose of this research is to further the understanding of digital convergence and to offer a perspective on how the blurring of the CE and computer industries can benefit American firms influenced by an American national system of innovation. This will be tested by distinguishing differences between American and Japanese national systems of innovation. Analysis of patent data, firm size, and product specialty will illustrate these differences. The presence of differences suggests one country's innovation system might be more capable at bringing innovative digital convergence products to the CE market. This chapter begins with an analysis of the health of the CE industry within the United States.

4.1 The Consumer Electronics Industry within the United States

This section demonstrates the overall importance of the consumer electronics industry within the United States. Economic activity associated with the consumer electronics industry directly contributed $585 billion to the gross domestic product and 4.4 million jobs in the United States in 2008. Furthermore, the Consumer Electronics Association (CEA) calculates that the CE industry contributed $1.3 trillion in 2008 to the gross domestic product of the United States through a combination of direct, indirect, and induced effects (CEA 2008, 2-3). Indirect effects include the purchase and use of inputs (products and services) from other industrial sectors. Induced effects include the economic contribution associated with employees within the CE sector as they support local and national economies. Thus, the direct contribution of the CE industry to the US GDP is 4.1 percent of the national economy while the indirect and induced effects contribution to the US GDP is 10.4 percent of the national economy. Leading states within the CE industry include California with over $450 billion, Texas with over $230 billion, and New York with over $190 billion in CE related economic activity (CEA 2008, 3).

The CEA defines the CE sector to include all electronics manufacturing and content industries composing 23 total industries (14 manufacturing industries and 9 content industries). Figure 3.1 lists the industries within the CE sector. In 2004, manufacturing industries accounted for 11 percent of goods and services sold while content industries accounted 89 percent. This equates to $33 billion for manufacturing industries and $269 billion for content industries (CEA 2008, 4). Audio and video manufacturing is one example of the many manufacturing segments within the CE sector. Table 4.1 shows industry values for audio and video manufacturing in the United States. Revenue decreased $2,379 million between 2004 and 2008, along with a decrease in the number of establishments and number of enterprises in audio and video manufacturing. The number of establishments in 2008 was 469, while the number of enterprises was 456. Exports increased each year from 2004 to 2008. Imports increased each year from 2004 to 2007 but decreased in 2008 with the general economic turndown.

Table 4.1: Inflation Adjusted Prices for NAICS 3343 (Audio and Video Manufacturing)*

	2004	**2005**	**2006**	**2007**	**2008**	
Industry Revenue	11,187	10,261	9,633	9,141	8,808	US $Mil
Industry Gross Product	3,484	3,174	3,293	3,107	2,976	US $Mil
Number of Establishments	546	514	499	484	469	Units
Number of Enterprises	530	500	485	470	456	Units
Employment	20,304	19,242	18,169	17,624	16,853	Units
Exports	6,429	7,103.3.3	7,937	8,176.2	8,339.7	US $Mil
Imports	39,294	42,151	46,778	46,781.3	45,845.6	US $Mil
Total Wages	877.8	874	839	814	781	US $Mil
Domestic Demand	44,052	45,309	48,474	47,747	46,314	US $Mil

Source: IBIS World Industry Report; *Within the United States

It is prudent to include content industries as an important segment of the consumer electronics sector due to the overwhelming contribution these industries provide to the consumer electronics market. This segment of the CE sector is an important aspect of digital convergence. Table 3.2 (p.45) shows content industries include movie, television, music, and software creation. Table 4.2 (p.54) illustrates the worldwide distribution of box office revenue from 2001 to 2007. While motion picture production is only one of the many content creation industries in the CE sector, it offers a good example of U.S involvement in content creation. Domestic box office revenue grew by 18.5 percent from 2001 to 2007, while international results increased 98.8 percent during the same time period. The domestic percentage of worldwide box office results decreased from 48.5 percent in 2001 to 36.8 percent in 2007 due to astounding international growth. The top 20 grossing films in the United States in 2007 originated from only seven different studios. Each grossed over $100 million with the top four grossing over $4 million each. Disney led all studios with five of the top 20 films. Fox had four while Paramount, Universal, and Warner Brothers had three each. Sony and New Line each produced one film in the top 20 (MPAA 2007, 6).

This is important because countries such as India and China release many of their own domestic films. India produces more films annually than Hollywood. In 2000, the American film industry accounted for 87.5 percent of the market in Australia, 81.9 percent in Germany, 75.3 percent in the United Kingdom, 64.8 percent in Japan, and 58.3 percent in France while only producing 460 films that year (Scott 2005). Hollywood has proven successful over the years and will likely remain successful in the foreseeable future. Hollywood's investment in infrastructure, creative abilities, and general strength as an industrial agglomeration reinforces its durability (Scott 2005). Table 4.3 shows the top ten studios by percentage of 2007 box office revenue for the United States. Paramount, owned by Viacom, led all studios with 15.5 percent. Table 4.3 also shows each studio's controlling nationality. Universal is owned by GE (80 percent) and Vivendi (20 percent). All of these studios are influenced by the Hollywood agglomeration.

Table 4.2: Worldwide Box Office in US $ Billions

Year	Domestic	International	Total	Domestic %
2001	8.1	8.6	16.7	48.5
2002	9.3	10.5	19.8	47
2003	9.2	10.9	20.1	45.8
2004	9.2	15.7	24.9	36.9
2005	8.8	14.3	23.1	38.1
2006	9.1	16.3	25.5	35.7
2007	9.6	17.1	26.1	36.8

Source: Motion Picture Association of America (MPAA) 2007

Table 4.3: Major Studio Share of 2007 Domestic Box Office

Studio (nationality)	2007 Share ($9.6 Billion)
Paramount (US)	15.5%
Warner Brothers (US)	14.7%
Buena Vista (US)	14.0%
Sony/ Columbia (Japan)	12.9%
Universal (US/France)	11.4%
20th Century Fox (US)	10.5%
New Line (US)	5.0%
Lionsgate (Canada)	3.8%
MGM/ UA (US)	3.8%
Fox Searchlight (US)	1.4%

Source: Boxofficemojo.com

4.2 Patents within the United States

The following analysis demonstrates a difference between Japan and the United States with respect to patenting innovative ideas. Table 4.4 shows the number of patents granted by country in the United States from 1963 to 2007. The United States led all countries in patents granted during these years with 2,460,775 (55 percent) out of 4,222,954 total patents. Japan was the second leading country with 692,181 (16 percent). Germany was the third leading country with 304,161 (7 percent). All data for 1963 through 1993 is aggregated. Between these years, the United States accounted for 1,386,175 (63 percent) patents out of 2,198,193 granted. Japan accounted for 269,116 (12 percent) of all patents. Therefore, the United States' percentage of all patents fell between 1963 and 2007 as other countries obtained greater percentages of patents. The United States experienced a gradual decline in the percentage of patents granted to its firms from 1994 to 2007. The total number of patents granted each year to American firms actually increased during this same period from 56,066 to 79,527 (70 percent). A maximum of 89,823 patents occurred in 2006 before the decline in 2007. This difference between percentage and number of patents occurs because the cumulative number of patents from all countries increased during the 1994-2007 time period.

Japan's percentage of patents granted in the United States increased between 1963 and 2007. Table 4.4 shows that Japan's percentage of all patents granted were consistent between the years of 1994-2007. The specific years Japan's percentage increased are not noted due to the limitation of aggregated data for all pre 1994 years. Japanese growth in the electronics and automobiles industries during the 1970s to the present is a likely cause for Japan's increased percentage of patents granted. Japan's total number of patents also increased each year. In 1994, Japan accounted for only 22,384 patents granted but received 33,354 in 2007 (a 67 percent increase). Japan's maximum year was 2006 with 36,807 patents granted. Japan's total number of patents increased 67 percent from 1994-2007, while the United States increased 70 percent during the same time period. Thus, when comparing the United States and Japan there are many similarities. Specific firm patent data are examined in order to uncover distinctions between the two countries.

Table 4.5 (page 61) shows the leading firms granted patent from 1998 to 2007 as well as each firm's 2007 revenue. Each of the top 15 firms is heavily involved in technological breakthroughs as evidenced by Table 4.5. Many of the firms in the table are also important within the consumer electronics and/or computer industries. Six of the 15 firms are American, and eight are Japanese. The remaining firm is South Korean (Samsung). These firms are a proverbial who's who of electronics and technology. IBM, Samsung, Sony, Intel, and Panasonic are featured. The total number of patents granted for American firms is 84,479 and the total number for Japanese firms is 110,691. The leading American firms in Table 4.5 account for 10 percent of all patents granted to American firms during this time period (839,983 patents). The Japanese firms account for 33 percent of all Japanese firms during this time period (332,677 patents). This suggests that the bulk of America's innovative ability is accounted for by a larger number of firms that are comparatively granted fewer patents than their Japanese counterparts.

Table 4.4: Patents Granted within the US for All Industries

Year	US	US % of Total	Japan	Japan % of Total	All Countries
Pre 1994	1386175	63	269116	12	2198193
1994	56066	55	22384	22	101676
1995	55739	55	21764	21	101419
1996	61104	56	23053	21	109645
1997	61708	55	23179	21	111984
1998	80289	54	30840	21	147518
1999	83905	55	31104	20	153485
2000	85068	54	31295	20	157494
2001	87600	53	33223	20	166035
2002	86971	52	34850	21	167331
2003	87892	52	35515	21	169022
2004	84271	51	35348	22	164291
2005	74637	52	30341	21	143806
2006	89823	52	36807	21	173772
2007	79527	51	33354	21	157283
Total	**2,460,775**	**58**	**692,181**	**16**	**4,222,954**

*Patents granted by date of patent grant

Source: US Patent and Trademark Office, Department of Commerce

Figure 4.5: Patent Grants to Firms from 1998-2007.*

Firm	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**Total**	Revenue**
1. **IBM** (US)	2,657	2,757	2,886	3,411	3,288	3,414	3,248	2,941	3,621	3,125	**31,348**	104,286
2. **Canon** (Japan)	1,919	1,793	1,890	1,877	1,891	1,992	1,805	1,829	2,367	1,983	**19,346**	38,091.4
3. **Samsung** (S.K.)	1,305	1,542	1,437	1,446	1,328	1,313	1,604	1,641	2,451	2,723	**16,790**	106,308.4
4. **Matsushita** (Japan)	1,034	1,052	1,137	1,440	1,544	1,774	1,934	1,688	2,229	1,910	**15,742**	79,625.2
5. **Micron Tech** (US)	581	934	1,304	1,643	1,834	1,707	1,760	1,561	1,610	1,476	**14,410**	5,688
6. **Sony** (Japan)	1,316	1,417	1,385	1,363	1,434	1,311	1,305	1,135	1,771	1,454	**13,891**	63,500
7. **Hitachi** (Japan)	1,094	1,008	1,036	1,272	1,600	1,892	1,513	1,271	1,732	1,381	**13,799**	87,772
8. **NEC** (Japan)	1,627	1,843	2,020	1,953	1,821	1,181	813	661	728	600	**13,247**	43,921.1
9. **Toshiba** (Japan)	1,170	1,200	1,232	1,149	1,130	1,184	1,311	1,258	1,672	1,519	**12,825**	60,916
10. **Intel** (US)	701	733	795	809	1,077	1,592	1,601	1,549	1,959	1,864	**12,680**	35,382
11. **Fujitsu** (Japan)	1,189	1,192	1,146	1,166	1,211	1,302	1,296	1,154	1,487	1,293	**12,436**	46,805
12. **GE** (US)	729	699	787	1,107	1,416	1,139	976	904	1,051	911	**9,719**	172,738
13. **Mitsubishi** (Japan)	1,080	1,054	1,010	1,184	1,373	1,242	781	621	610	459	**9,405**	43,100
14. **HP Dev Comp** (US)	0	0	0	0	0	1,292	1,775	1,790	2,099	1,466	**8,422**	91,658
15. **Motorola** (US)	1,406	1,192	1,196	778	712	610	563	456	576	411	**7,900**	42,879

*Patents by year of grant **Expressed in US millions

Sources: US Patent and Trademark Office and Market Line

International Business Machines (IBM) leads all other firms with 31,348 patents during this time period. The next firm listed has over 10,000 fewer patents. IBM also leads all firms between 1963 and 2007, but the firm only has the third highest 2007 revenue ($104,286 million) behind Samsung ($106,308.4) and General Electric ($172,738 million). Samsung has the third most patents during this time period with 16,790. Although General Electric is the leading firm by revenue out of the top 15 patent receiving firms, it is only the 12th in patents grated with 9,719. Canon is the leading Japanese firm and second only to IBM in patents granted with 19,346. Micron Technology is noticeable due to its relatively low 2007 revenue ($5,688 million) and high number of patents granted (14,410) compared to other firms. All other firms have revenues over $30,000 million with many having revenues over $70,000 million. Micron Technology is an American firm that specializes in computer related components.

Distinctions also occur between these firms when comparing the specialties of each. Although all are heavily involved in technology oriented innovation, some of the firms are more invested in computers and others consumer electronics. The leading American firms are industry leaders within computers, while the majority of the Japanese firms are leaders within consumer electronics. Micron Technology has already been discussed. IBM, Intel, and Hewlett-Packard are mostly known for the production of computer related devices or components. Motorola is largely known for production of wireless communications devices but the firms is also involved in the manufacture of chips for electronic devices. General Electric is involved in a wide assortment of manufacturing including aviation and consumer electronic goods. The firm even owns a majority share of NBC Universal. Canon is heavily involved in the cameras and camcorders. NEC and Fujitsu are known for computers as well as consumer electronics devices. Both firms recently withdrew from the manufacture of plasma HDTVs. Matsushita, Sony, Hitachi, Toshiba, and Mitsubishi are known for consumer electronics as well as other electronics related industries. Samsung, the lone Korean firm, is known for consumer electronics but has many other divisions associated with a diverse array of other industries.

4.3 CES Innovations and Engineering Awards

Table 4.6 shows results from CES Innovations and Engineering Awards winners from 2003 to 2008. Eight firms out of a total of 181 were not included in country of origin results due to these companies lacking websites or not being found in the industry databases used. Their lack of inclusion in origin results prohibited revenue and employment analysis. Possibilities for the lack of data for these eight firms might include any number of them being absorbed by another firm (typically a merger and acquisition of a successful smaller firm by an established larger firm), change of name, or simply a halt of business. The data includes many firms that have not been in existence long. Examples of these firms include Kaleidescape (2001) and Niveus Media Inc (2002). Both firms entered the CE industry within the last 10 years and proceeded to become CES Innovations Award winners shortly after establishment, Kaleidescape in 2005 and Niveus Media in 2005 and 2008. Furthermore, revenue and employment data were not available for every award winning firm.

Table 4.6: CES Innovations and Engineering Awards by Country

	United States	Japan	Other
Total Awards Won (181)*	115	18	40
Total Number of Firms (128)*	88	9	23
Average Revenue of Firms**	6,415.737	39,188.19	19,600.78
Median Revenue of Firms**	200	36,382.75	3,114.75
Average Number of Employees***	14,977.41	121,077.9	33,443.85
Median Number of Employees***	473	109,900	7,431
Notable Firms	HP, Dell, Intel, and Motorola	Panasonics, Sony, and Toshiba	Samsung, LG, and Philips

*8 firms had no data for origin **In US $ Millions: 37 US, 1 Japan, and 11 others lacked Revenue data *** 37 US, 1 Japan, and 10 others lacked Employee data

Source: cesweb.org

The private ownership of firms is a primary reason for the lack of data from many of those firms. The number of firms lacking data is noted in Table 4.6 for each calculation. Thus, only available firm data was used for those calculations. Firms that won multiple awards were calculated once for revenue and employment values. Comparisons are made between countries later in this section.

4.3.1 American Firms

As seen in Table 4.6, the United States accounts for 115 awards won by firms between 2003 and 2008. These 115 awards are divided among 88 different firms with some firms winning multiple awards. Notable firms include Hewlett-Packard with four awards, Dell with three awards, and Motorola with five awards. These firms also lead all American firms with 2007 revenues of $104,286 million, $57,420 million, and $36,622 million respectfully. Employment numbers are equally high at each firm as compared to other American award winners, with HP having 172,000 employees in 2007, Dell having 90500, and Motorola having 66,000.

The average revenue for award winning American firms is $6,415.74 million while the median revenue is only $200 million. The difference between the mean value and median value is $6215.74 million. This disparity can be attributed to the data distribution being positively skewed. A mean value greater than median value accounts for this skew and indicates the majority of firms have values less than the average. This impacts the distribution of the data. Analysis of the data shows that 36 of the 51 American firms used to calculate revenue values had less than $1,000 million in revenue and 22 of the 51 had less than $100 million in revenue with one having recorded no revenue for 2007. The larger firms like HP, Dell, Intel, and Motorola have more than $30,000 million in revenue and are not representative of the majority of American firms in the data. They also account for the skewed nature of the data.

The average employment for award winning American firms is 14,977 and the median is 473. Like revenue, employment data distribution is positively skewed with the mean value greater than the median value. The disparity between the mean value and median value is 14,504. Therefore, the majority of firms have far fewer employees than the average number suggests. A median value of 473 indicates that half of the firms have less than 473 employees. Of the American firms used for employment calculations, 34 of the 51 employed 1000 workers or less. Six firms had greater than 50,000 employees with two greater than 150,000. These high employment firms are not representative of the majority of the data and account for the skew. The maximum value was Hewlett-Packard with 172,000 employees in 2007, and the minimum value was Integral Technologies with 5 employees in 2007.

4.3.2 Japanese Firms

Japanese firms accounts for 18 of the 181 CES Innovations and Engineering Awards between 2003 and 2008 (Table 4.6). Those 18 awards are attributed to only 9 firms with firms such as Sony receiving four, Panasonic four, and Toshiba two awards each. Average revenue for these nine firms is $39,188.19 million. Median revenue is $36,382.75 million. These revenue values are very similar with only a $2805.44 million difference. Although the mean is greater than the median this difference does not drastically influence the distribution of the data because four of eight firms are below the average. Notable firms with high revenue values include Panasonic ($79,625.2 million), Sony ($70,355.8 million), and Toshiba ($60,916 million). These are the only firms with more than $60,000 million in revenue for Japanese CES Innovations Award winners. Firms below the mean and median revenue values include Sharp with $25,960.5 million, Sanyo with $18,300 million, and Alpine with $2,213.2 million.

Average employment for Japanese award winning firms is 121,077.9 and median employment is 109,900. The difference between these values is 11,177.9. The mean is greater than the median which results in positively skewed distribution; although, four of eight firms have values below the average. This skew is due to one firm having more than 130,000 employees compared to any other firm. This difference alone is greater than the total number of employees at four of the Japanese firms. Four firms have employment values greater than 160,000 of the nine firms used for the calculations. These include Panasonic (328,700), Toshiba (191,000), Fujitsu (167,374), and Sony (163,000). The firm with the least number of employees is Alpine with only 13,403.

4.3.3 Firms from Other Countries

Japan and the United States are the focus of this research but the influence of firms from other countries must also be analyzed. Countries besides Japan and the United States to win CEA innovation awards include such countries as South Korea, United Kingdom, Netherlands, Germany, Taiwan, and Canada. Of these countries, South Korea with the industry giants of Samsung and LG and the Netherlands with Philips are very influential within consumer electronics. Samsung is a global titan with corporate divisions leading multiple industries. The data used within this analysis only pertains to Samsungs electronics division.

A total of 40 CES Innovation awards are credited to countries other than Japan and the United States (Table 4.6). These 40 awards are divided among 23 different firms, with Samsung accounting for seven and Philips accounting for eight. These two firms received the most CES Innovation Awards between 2003 and 2008. The average revenue for firms not Japanese or American is $19,600.78 million. The median revenue for these firms is $3,114.75 million. Half of all firms have revenue below $3,114.75 million. The mean is greater than the median; therefore, the data distribution is positively skewed. This is largely due to Samsung's $106,388.4 million revenue for 2007. LG ($57,700 million) and Philips ($36,726.2 million) are also high revenue firms. Only one firm, Leadtek Research Inc. ($188.5 million), has revenue of less than $200 million.

The average number of employees for firms from other countries is 33,443.85; the median number of employees is 7,431. Again, the mean is greater than the median. Data distribution is therefore positively skewed. The difference between the mean and median is 26,012.85. Ten of the 13 firms have below average employment values. The three firms above the average are Samsung (150,000), Philips (123,801), and LG (80,283). The next closest firm is China's TCL- Thomson Consumer Electronics with 29,749. The firm with the least number of employees is Germany's NAVIGON with 400 workers.

4.3.4 Comparisons between Countries

The CES Innovations and Engineering Awards data from 2003 to 2008 indicates the United States leads all countries in awards received and number of firms that received awards. As already indicated (Table 4.6), the United States accounts for 115 innovation awards given to 88 different firms. Japan accounts for 18 awards given to nine different firms. South Korea accounts for 14 awards given to six different firms. The Netherlands accounts for six awards given to only one firm. The greater number of awards for American firms could be attributed to the Consumer Electronics Association's choice of venue for its Consumer Electronics Show (CES). The show is held every January in Las

Vegas, Nevada. As such, the location choice could limit the number of firms from foreign countries.

Both average revenue and average employment indicate that American firms are generally smaller than Japanese competition. American firms average $6,415.74 million in revenue compared to the $39,188.19 million in revenue for Japanese firms. American firms also average fewer employees than Japanese firms with 14,977 compared to 121,077. The difference in firm size is even more drastic when median values for revenue and employment are compared. American firms have a median revenue value of $200 million whereas Japanese firms have a median revenue value of $36,382.75 million. The difference between these two values is $36,182.75 million. This specifies that half of all award winning American firms are below $200 million in revenue and half of all award winning Japanese firms have less than $36,382.75 million in revenue. Median employment values indicate that half of these American firms have fewer than 473 employees whereas half of these Japanese firms have less than 109,900 employees. The difference between these two values is 109,427. The American values for revenue and employment are also lower than the other category representing all award winning firms from countries other than Japan and the United States

4.4 Digital Convergence and CES Innovations Awards

The following section demonstrates the relevance of digital convergence within the consumer electronics industry and the role of American firms in promoting innovation associated with digital convergence. This research focuses on video related digital convergence possibilities from the CES Innovations Awards utilized in the previous analysis. Such an analysis is relevant due to the emerging role of the television as the center of a digital home. Computers, audio/video devices, and other electronic equipment have the potential to be used in conjunction with digital televisions.

The award categories are divided into two parts. The first part focuses on display devices that won awards. The firms associated with each device are noted and their respective position in the industry analyzed. The second part focuses on award winning video components that have the capability or were designed to utilize the display functions of a digital television. The categories for this aspect of the analysis are diverse and require justification for their subsequent use. Many of the categories contain products that potentially can be used with a television. These firms and their place in the industry are also noted.

4.4.1 Display Devices

There were only three award winners for video display devices from 2003. Two different display technologies are covered with these awards. Both Toshiba and Philips received awards for LCoS (Liquid Crystal on Silicon) rear-projection HDTVs. Sharp received an award for a DLP (Digital Light Projection) projector. DLP is a technology created by Texas Instruments, and companies that use it must license the technology. American firms won no awards for video display devices during 2003. Toshiba and Sharp are Japanese owned while Philips is Dutch owned.

In 2004, only one winner was in the category for video related devices, but that winner is not a display device. Video display devices won awards in two other categories. Samsung received an award in the Accessories category for a DLP rear-projection digital television while Philips received an award in the Electronic Gaming category for a LCD (Liquid Crystal Display) television. Tight Systems received an award in the Online/Internet category for a portable multimedia player with home media integration capabilities. Again, no American firms received awards for display devices that year. The categories with display devices do show the fluid nature of the CEA's selection process for each category. Video display devices are not relegated to only the Video category but can receive awards in other categories if they demonstrate capabilities beyond being a television. This is the essence of digital convergence.

Three video display devices received awards in 2005. LG received an award for a computer display in the Computer Components category, TCL- Thomson Consumer Electronics received an award in the Digital Displays category for a DLP rear-projection television, and Toshiba received an award in the Mobile/Vehicle Electronics Audio/Video category for a portable DVD player. No American firms received awards during that year for display devices.

Five video display devices received awards in 2006. LG and eMagin received awards in the Digital Display category. LG received an award for a wireless plasma television, and eMagin received an award for an OLED (Organic Light Emitting Diode) headset designed to simulate a 3D viewing experience. Philips received an award in the Home Theater category for a complete home theater system integrating all the needed audio/video components with a digital display. Samsung received an award for a portable media player with audio and video capabilities. Finally, Icon-TV received an award in the Vehicle Video Electronics category for a vehicle installed HDTV and computer device.

There were three award winners from 2007 with video display devices. Hewlett-Packard received an award in the Video Display category for a LCD set. According to its award description, the HP LCD demonstrates "a breakthrough in digital convergence" (CEA 2009). The second award was received by New Media Life, Inc. in the Portable Electronics: Audio/Video category for a portable VOD (Video on Demand) device. 2007 witnessed an American computer powerhouse capture an innovation award within a video display category by using computer knowledge to integrate expanded capabilities into a display device. The second award winner also demonstrated unique digital convergence innovative capability by integrating mobile video functions with VOD and HDTV content. Directed Electronics received an award in the Mobile Video category for a portable DVD and MP3 player.

2008 featured three awards received by video display devices. LG received an award for a plasma television in the Video Display category. Prism received an award in the Eco-Design and Sustainable Technology category for a LED-based projector. LED offers greater energy efficiency for display technologies and will probably be integrated in many more products in the coming years. Finally, Dell received an award in the Computer Peripherals categories for a large computer display with high-definition capability.

4.4.2 Video Components

The following products will primarily feature video related functions. Some products and their respective category were not used because the primary function of the device was not video related. Cameras and camcorders were not used. Computers will be noted because of their growing role in digital convergence applications. Computers and HDTVs often feature standardized connections so they can be used in conjunction with one another. Other products used for this section include multimedia servers, DVD systems, digital video recorders, and video processors. All are primarily intended to be used with a television. Without a television, their functions would be of little or no use. Their digital convergence capabilities exist due to the use of powerful processing chips, electronic programming guides, and digital storage.

In 2003, only two awards meet the above criteria. Philips received an award in the Audio category for an integrated music and video speaker system. EchoStar received an award in the Satellite Systems category for its DISH Network DVR with interactive television functions. Dish is one of the major satellite television providers in the United States, and they feature a multitude of digital content, as well as HDTV programming and movies.

The year 2004 had four awards meeting these criteria. As noted previously, 2004 featured a product that won an award in the Video category that was not a display device. That product was Belkin's multipurpose SpeedPad. The SpeedPad is a keyboard, mouse, and remote control hybrid allowing speedy use with multimedia applications. MTI received an award in the Digital Imaging category for a video switcher. Direct TV received an award in the Retail Resources category for a DVR with integrated TIVO service. Hewlett-Packard received an award in the Accessories category for a portable tablet computer.

Five awards were received by video components in 2005. Niveus Media received an award in the Home Data Networking category for an audio/video server designed to integrate into a home network. Sony received an award in the Home Theater category for a HDTV tuner with DVR capabilities. Akimbo Systems received an award in the Online/Internet category for a multimedia player with video on demand service through the internet. Silicon Optix received an award in the Software/Embedded Technologies category for a video processing chip with advanced video processing functions. Finally, Kaleidescape received an award in the Video Components category with an advanced whole-house video distribution system.

Four devices in 2006 met the above criteria. Polk Audio received an award in the Audio category for an all-in-one speaker system with integrated DVD player. Ace Computers received an award in the Integrated Home Systems category for a media server with integrated multimedia and computing functions. LeadTek Research received an award for a multimedia set-top box providing a combination of internet provided television functions, video streaming, and DVD playback. Scientific-Atlanta received an award in the Video Components category for a DVR.

Four awards were received by video related components in 2007. Dell received an award in the Computer Hardware for a multimedia computer designed to integrate computing and entertainment functions. Sony received an award in the Electronic

Gaming category for the Playstation 3 which incorporates multimedia and gaming functions in one device. Intel received an award in the Enabling Technologies category for a microprocessor. Ubicod received an award in the Home Networking category for a multipurpose set-top box with internet capability.

Three video components were featured in 2008. Dell received an award in the Computer Hardware category for a notebook computer. Sling Media received an award in the Multi-Room Audio/Video category for a set-top box with the capability to deliver a broad range of content television. SE2 Lads received an innovation award in the Integrated Home category for a very unique digital convergence device. SE2 Labs' ITC One (Integrated Theater Console) combines the capabilities of a media center, game console, DVD player, video processor, power amp, audio processor, and power conditioning. The ITC one also comes with the option to add a display and/or speakers to fulfill the complete home entertainment experience.

4.4.3 Digital Convergence and the Firms Involved

The firms above demonstrated an ability to create innovative products with digital convergence capabilities in video. The displays and components that won the awards noted above are not the only products available to the consumer. Many other firms create products that meet digital convergence criteria. These products are not always video related. Media servers used for video are often just as capable of dealing with audio or internet related content. Furthermore, as the above overview has demonstrated there are many firms and countries involved in these products. Within each of these countries, national systems of innovation impact how these firms perform innovative product and process development.

Firm size differed between the United States and Japan. The above analysis of digital convergence products illustrates a further difference. American firms won awards for digital video devices while claiming a multitude of awards for video components. Dell, Hewlett-Packard, and eMagin are all American firms that won CEA innovation awards for display products. Of the three, Hewlett-Packard was the only firm to receive an award for a true television. eMagin's award was for a 3D headset solution and Dell's was for a large computer monitor. Other American firms demonstrated capability in categories associated with mobile video displays designed for automobile use. American firms were influential in video components. Multimedia servers integrating computing and multimedia features are widespread among American firms. Kaleidescape is such a firm. Products from Kaleidescape are often extremely expensive but the firm recorded a sales growth of 747 percent between 2004 and 2007 (EngadgetHD 2008). Niveus Media, Sling Media, and Vudu were all nominated in the Video Components category in 2008. Each firm specializes in media center type products designed to deliver video content to televisions. Computers were also dominated by American firms.

Japan received very few awards for digital video devices. Toshiba and Sharp were the only major Japanese firms with awards in this category. Each firm's award came in 2003. Japanese firms were nominated for many display device awards. Panasonic, Hitachi, and Pioneer were all nominated in the Video Displays category for 2008. South Korean and Dutch firms captured most of the video display CES

Innovations Awards due to the presence of LG, Samsung, and Philips. Japanese firms did have a strong presence in display components due in large part to the efforts of Sony. Sony received an award for the Playstation 3. The Sony Playstation 3 is very much a digital convergence product, and the product obviously has a wide adoption rate for Sony. Sony also received an award for a high-definition receiver with DVR capabilities.

These results might be surprising due to the propensity to assume Japanese domination in the consumer electronics industry. As overview of 2008 nominees for video display devices illustrates, Japanese firms are indeed highly innovative in video related products and winning a CES award does not prohibit a firm from being successful in a product category. Table 4.7 shows North American LCD and plasma shipments in 2007. Sony shipped 12.8 percent of all LCD televisions in quarter four of 2007. Sharp shipped 8.4 percent of all LCD televisions that same quarter. Panasonic and Hitachi demonstrate similar success in plasma television shipments; although, Panasonic was able to ship nearly 40 percent of all plasma televisions in quarter 4 2007. Vizio, an American firm, demonstrates that the United States has the capability to succeed in video displays by shipping nearly 11 percent of all LCDs in quarters three and four in 2007. Ultimately, all firms must be aware of the growing South Korean threat in consumer electronics. Both Samsung and LG have strong television innovative capability. The combination of CES Innovations Awards received and strong television shipment percentages make Korean firms very influential in the industry.

Table 4.7: LCD and Plasma North American Shipments: 3rd and 4th Quarter 2007

LCD	**Q3 2007**	**Q4 2007**
1. Sony	9.7%	12.8%
2. Samsung	10.7%	12.3%
3. Vizio	10.9%	10.7%
4. Sharp	11.3%	8.4%
5. Polaroid	7.6%	8.1%
Other	49.7%	47.7%
Plasma	**Q3 2007**	**Q4 2007**
1. Panasonic	29.4%	38.5%
2. Samsung	19.4%	20.4%
3. LG	13.4%	13.7%
4. Hitachi	9.5%	8.7%
5. Philips	7.2%	6.0%
Other	21.1%	12.7%

Source: Widescreen Review 2008

CHAPTER V

CONCLUSION

The consumer electronics industry greatly influences how people live, work, and play. Innovation within the industry affords consumers access to technologies with the power to make work and every day activities more efficient and productive. Innovation also allows consumers to utilize technology for a greater enjoyment of life. More importantly, innovation drives industry and sets specific firms a-part from others in terms of profitability and productivity.

Japan rightly receives much credit for dominating the consumer electronics industry. Japanese firms are highly recognizable within the industry and account for many popular brands often associated with quality and innovative progress. This research illustrates that consumer electronics is also an important industry within the United States and that American firms also offer innovative and quality products. American brands are also hugely popular in certain product categories such as audio and computers. American firms have also proven to be successful in bringing innovative and award winning technology to the CE market.

Innovative behavior confers a highly valuable competitive advantage for nations in an increasingly globalized world. Globalization tendencies might appear to diminish the importance of the nation, but such is not the case. The importance of the nation only increases with globalization because it is with the skill and knowledge created within a nation that that nation can maintain its competitive advantage. Therefore, it is important to study a nation's ability to foster innovative behavior largely found in that nation's national system of innovation. The consumer electronics industry and the current trend associated with digital convergence oriented products offer a platform whereby the United States' national system of innovation can be analyzed. The observation that American firms focus on more radical innovation seems to hold true for consumer electronics. American firms accounted for a greater percentage of CES Innovation Awards received than any other country. Given that the CES Innovation Award is only awarded to the most innovative products in the most up-to-the-minute product categories it is no surprise that America's more radical approach warranted a greater number of awards.

The analysis highlights the existence of differences between innovative American and Japanese firms within the CE sector. While Japan maintains a strong hold on the consumer electronics industry, digital convergence allows American computer firms and consumer electronics firms an opportunity to reassert American influence into consumer electronics. According to the founder of Kaleidescape Michael Malcolm, "The center of gravity is shifting a little closer toward Silicon Valley than Tokyo. At Kaleidescape, our software and hardware engineers all came out of the computer industry. We had to learn audio and video… but I think it is a lot easier to make that transition than to go in the other direction" (Yarm 2007, 58). Firms such as Apple and Microsoft have already demonstrated this ability with successful products like the iPod and Xbox 360.

Kaleidescape and Vizio have also experienced success. Proven innovative American firms are smaller than their Japanese counterparts in both revenue and employment. The comparison is not even close. Japanese firms that won the Consumer Electronics Show Innovations and Engineering Award averaged far more revenue and employment than American firms. Comparison of median values for these firms only exacerbated these differences. Innovative American firms with consumer electronics related industries are thus more likely to be smaller. Furthermore, patent data illustrates that leading Japanese firms account for a greater percentage of total patents granted to all Japanese firms within the United States. European firms also proved to be unique. Data also show that both the United States and Japan need to be aware of the growing threat from South Korean firms that have shown innovative capability in consumer electronics. Table 4.7 illustrates Samsung's influence in both LCD and plasma TV. Samsung and LG have also received a number of CES Innovations Awards.

There are weaknesses within this research due to its limited scope. Each aspect of the United States' and Japan's national innovation systems could not be fully analyzed. This research is limited to only the study of industry health, patent grants, firm size, and innovative capability within the CE sector. A more in depth study will be needed to analyze the many other aspects of the innovation systems within these countries. Furthermore, this research utilizes an industry award to measure innovative capability. Those firms that fail to receive this award are in no way lacking innovative capability. Consequently, many other firms could possibly be capable of the innovation associated with consumer electronics and/or digital convergence. Finally, many products within the

CE industry utilize components from a multitude of firms. Each of those components is the result of its own extensive R&D. This research attributes the credit of an innovation award to the firm associated with the final product and not those firms with components in that product.

Future research opportunities that exist within this study include more extensive analysis of the Japanese national system of innovation's influence on Japanese consumer electronics firms and the spatial tendencies for innovative behavior of these firms within Japan. Furthermore, future research could analyze the increasing role of cooperation in the form of joint ventures or other forms of shared R&D endeavors between firms within consumer electronics and computers. How do these endeavors benefit each company and will such endeavors continue to occur in the future? Lastly, how might the rise of China and/or South Korea influence the consumer electronics industry? Thus, many questions need to be answered to better determine the continued impact of digital convergence and national innovation systems within specific countries and industries.

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