Defying Value-Shift:

How incumbents regain values in the industry with new technologies

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Abstract

Historically, incumbent assembly firms with unquestionable strong positions in such industries as the automobile, consumer electronics, computer and mobile phone industries, have lost power when new technology is introduced; at the same time, supplier firms have taken over the power and gained value in the industry. We characterize this phenomenon as *value-shift*. Many industry experts have intuitive understandings of this phenomenon but not many scholars have identified its mechanism with a full-fledged theory. This paper identifies a mechanism that causes *value-shift* within the TV set industry, suggesting its application to other industries. This thesis then proposes a clear spectrum of strategies for incumbent assembly firms to prevent value-shift. At the same time, it indicates a set of strategies for supplier firms to take over the industry leadership.

The work firstly defines *value-shift* and presents evidences that it exists in various industries by calculating the transition of value-added. By quantifying the impact of the value-shift with this calculation, the thesis urges incumbent firms to take immediate actions to defy the value-shift. Then the thesis closely examines recent technology transition from the Cathode Ray Tube to the Liquid Crystal Display and describes how the value-shift took place in the TV set industry. From this industry analysis, the thesis describes the mechanism of the value-shift and discussed the possible strategies that incumbent firms could use to maintain their power over the industry. Finally, the thesis suggests the generalized mechanism of value-shift as an evolution in four stages using the modularity theory. The thesis implies the proposed mechanism is generally applicable by citing examples from other industries and suggests possible actions for both parties: for the incumbent firms to defy the value-shift and for the supplier firms to obtain industry leadership.

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Chapter 1: Introduction

1.1 Incumbent Assembly Firms Often Replaced by Suppliers with New Technologies - Scope of the Thesis

Historically, in assembly industries such as the automobile, consumer electronics, computer and mobile phone industries, incumbent assembly firms have built the industry from the ground up. To provide final products from scratch, these firms have developed new technologies or sourced necessary technologies from outside; they have established supply chains for components; they have coordinated the development and production with outside firms; they have built distribution channels to deliver the final products to customers. In short, incumbent assembly firms have established the industry *value chain* – the chain of the value-adding activities to provide final products. Therefore, those firms tend to have a strong power and control over the entire industry. However, incumbent assembly firms have often failed when facing the emergence of new technologies. Such firms have often been replaced by other players in the value chain or by new entrants that bring new technologies to the industry.

Two major players have been replacing incumbent firms (Figure 1.1). First, incumbent assemblers are often replaced by new assemblers that totally replace the product with a new technology. For example, Kodak was the most notable assembler of portable cameras but it was replaced by Canon and Nikon, who offered digital still cameras that totally changed the product architecture. Another example is photolithographic aligners in semiconductor fabrication, as discussed by Henderson and Clark[1]. The assembly firms always had been always substituted by new type of assemblers with new technologies for the five generations.

[1] Rebecca M. Henderson and Kim B. Clark (1990)

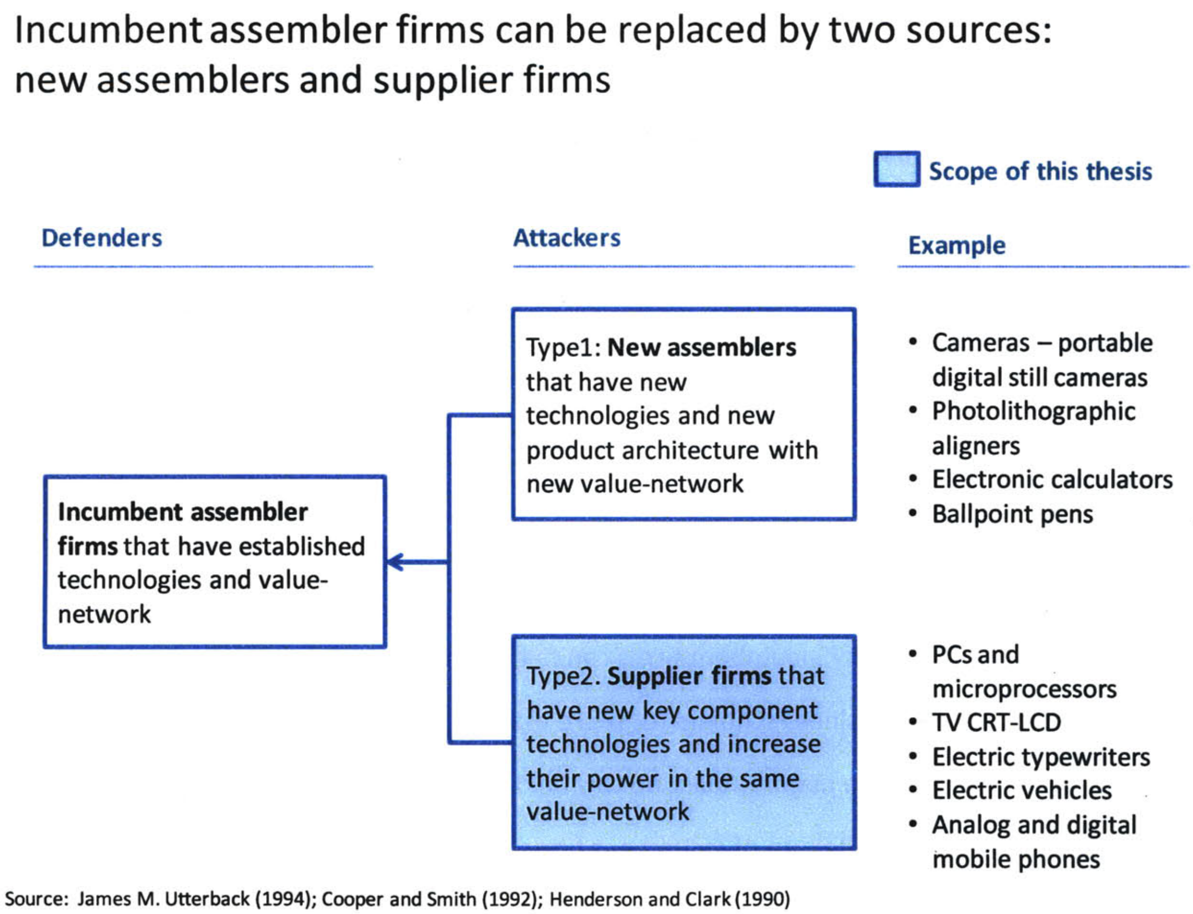

Figure 1.1: Scope of Thesis

Incumbent assemblers are also frequently replaced by suppliers. For instance, IBM dominated the computer industry until the 1980s, when the ruling position was taken over by key component suppliers such as Intel and Microsoft. Sony and Panasonic (formerly Matsushita) were the two strongest assemblers in the CRT TV set industry, but they were gradually replaced by Samsung, LG, and Sharp, who owned the LCD panel components. The details of the TV industry case are discussed in Chapter 3.

The scope of this thesis is the latter case: incumbent assemblers being replaced by suppliers. In this type of industry change, an incumbent assembly firm gradually loses its controlling power over the value chain, and a supplier firm that has the key strategic component of the product gains the value in the industry. In other words, the value shifts from incumbent assemblers to supplier firms. This thesis characterizes this phenomenon as a *value-shift*, clarifies the mechanism behind it, and suggests a set of strategies to incumbent assemblers to resist this phenomenon. The thesis also suggests strategies for supplier firms to take over the industry leadership from assemblers.

1.2 Literature Review: Why Do We Need a New Theory for Losing Incumbents Face with New Technologies?

The question of why incumbent firms can fail when new technologies emerge has been generally discussed by business scholars for more than two decades. In this section, I review several theories that had a major impact on this field and explain why I believe that we need a new theory to explain the failure of incumbent firms.

First several theories, although very convincing, do not separate assembly and non-assembly products, nor distinguish between type 1 (replaced by new assemblers) and type 2 (replaced by suppliers) as suggested in Figure 1.1.

Foster (1986)[2] described these industry changes with an S-curve and argued that new technologies often start with lower performance than established technologies (Figure 1.2). Therefore, incumbent firms tend to hesitate to shift to new technologies and decide instead to improve old technologies. At the same time, attackers have the advantage of investing in new technologies because they do not have assets associated with old technologies. Finally, the performance of the new technologies surpasses that of the old technologies; as a result, attackers offering new technologies replace the incumbent firms. Foster also pointed out the

[2] Richard N. Foster (1986)

dilemmas of the incumbent firms and argued that they can strike back by investing in alternative new technologies to replace the new ones and creating a separated organization for the new technologies from original one for old technologies to avoid internal conflict.

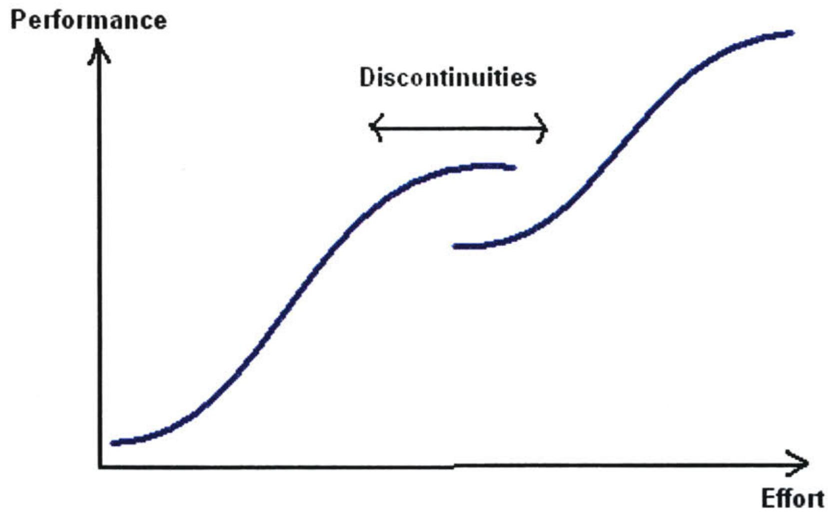

Figure 1.2: S-Curve and Technological Discontinuities

The same year, Tushman and Anderson (1986)[3] investigated three different industries and claimed that incumbents often lose in the face of new technologies not only because discontinuities exist between old and new technologies but also because the new technologies are often *competence-destroying* for the incumbent firms. The question that whether the new technology is *competence-destroying* and *competence-enhancing* leads to a different impact on incumbent firms.

Cooper and Smith (1992) observed incumbent firms' problems more carefully and added other strategic reasons that they fail when up against new technologies: 1) Incumbent firms have new technologies but they release products too early with incomplete technologies; 2) They make smaller commitments to new technologies in the early stages of product

[3] Michael L. Tushman and Philip Anderson (1986)

development; 3) They keep the same organization as with the old technologies; 4) They use the same strategy and business model as with the old technologies. Their argument illustrates the essences of incumbent firms' strategic problems that were later discussed by Christensen and other scholars in 1990s. Christensen enhanced Cooper and Smith's argument with his close investigation into the disk drive industry.

In the 1990s, scholars started to distinguish between assembly and non-assembly products and their focus shifted more to the assembly products category. However, their argument was mostly limited to cases where incumbent assemblers were replaced by new assemblers (type 1 in Figure 1.1), with the exception of Utterback (1994)

Utterback (1994) [4] clearly distinguished between assembly and non-assembly products and showed that incumbent assembler firms have lower track record of surviving in the new technologies than non-assembling incumbent firms. In addition to the axis of 1) competence-destroying and competence-enhancing suggested by Tushman and Anderson, 2) the axis of assembled products or non-assembled products and 3) that of substituting or market broadening are determining the survival rate of incumbent firms. He argued that when the technology is more competence-destroying, more assembled, and more substituting, the survival rate of incumbent firms is lower in face of the new technologies. Utterback did not make a clear distinction between type 1 and type 2 case (see Figure 1.1), although his investigation refers to the cases where supplier firms with new component technologies took over the industry leadership from incumbent firms, such as electric typewriters and Eastman's system at Eastman-Kodak.

Henderson and Clark (1990) focused on the replacement of incumbent assemblers with new assemblers with new technologies (type 1 in Figure 1.1) and argued that this phenomenon

[4] James M. Utterback (1994)

occurs when the innovation is an *architectural innovation* (Figure 1.3). Drawing on Abernathy and Utterback's discussion[5], they argued that as the *dominant design* of a product becomes crystallized and architectural knowledge becomes stable, the architectural knowledge tends to become embedded in the organization of the assembler firms, such as communication channels, practices and procedures. Therefore, those incumbent assembler firms do not come up with innovations that completely change the embodied architectural knowledge.

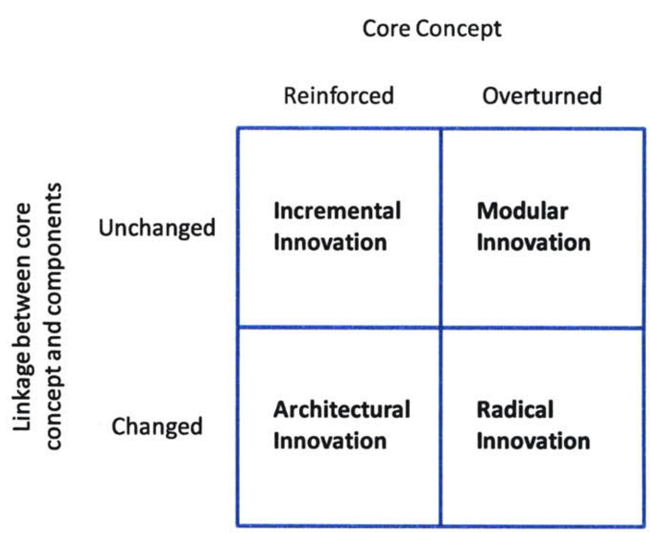

Figure 1.3: Henderson and Clark's Framework for Architectural Innovation

However, a *modular innovation* can also have a fatal impact on incumbents as I discuss in chapter 3 of this thesis. Most of the *value-added* to final products is added by incumbent assemblers; however, as the key component was taken by supplier firms through the introduction of new key component technology (i.e., modular innovation) the value is taken by the supplier firms. This *value-shift* deprives incumbent firms not only of their ability of maintaining current cost structure but also of their industry leadership.

[5] William J. Abernathy and James M. Utterback (1978)

Henderson and Clark's idea was articulated more clearly and expanded industry-wise by Christensen and Rosenbloom (1995)[6]: they called the relations among suppliers, assemblers, distributors, and customers a *value network* and argued that the value network is crystallized along with the architectural knowledge when the dominant design crystallizes. Christensen (1995) [7] further argued that *disruptive technologies* that disrupt the incumbent firms' competence come with a new *value-network* with a new set of suppliers, business relations, and new customers. Therefore, incumbent firms that comfortably live in the *value-network* of old technologies are not aware of and tend to ignore such disruptive technologies.

Christensen (1997) also enhanced Cooper and Smith's argument with his concept of *innovators' dilemma,* which emerged from his detailed investigation of the disk drive industry. Christensen suggested that incumbent firms should establish a separate organization for *disruptive technologies*. In addition to Cooper and Smith's point that the new technologies generally require different strategy and business models, he added other two reasons that incumbent firms should institute a separate organization: 1) The market for disruptive technologies is generally small, so it does not make sense for large incumbent firms to invest heavily in the new technologies that threaten their old technologies base. However, if the firm creates a small new company focusing only on the new technologies, the size of the new market does not matter; 2) as discussed above, customers for disruptive technologies are different from those of the incumbent firms, so the firms tend to ignore the effect of disruptive technologies. By creating a separate organizational unit for new disruptive technologies, the new firm can focus on the right customer and right technologies.

Although Christensen's argument is compelling and applicable to many different cases, it is limited to cases where new technologies totally replace the value chain or value network.

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[6] Clayton M. Christensen and Richard S. Rosenbloom (1995)
[7] Clayton M. Christensen (1997)

However, when suppliers with a new component technology take over the power of incumbent assemblers, this occurs as the *value-shift* in *the same value-chain*. Nevertheless, as I discussed above, *value-shift* has a significant negative impact on incumbent assemblers. This phenomenon is often seen in various industries, but as shown in this section, not many scholars have explained this concept clearly and its mechanism has not been clearly elucidated.

In summary, most of the theories offered by business scholars are generally fitted to any industry and any case. The theories proposed in the 1990s focus on assembly products, but their focus is more on type 1 case in Figure 1.1: the replacement of incumbent assemblers by new assemblers with different value-network. Few theories suggest the technological changes that occur in the same value chain can have a fatal impact on incumbent firms – *value-Shift*. Therefore, the purpose of this thesis is to offer theoretical foundation of value-shift and to describe its mechanism using examples from various industries.

It is also important to urge incumbent firms at risk to take immediate actions to *defy the value-shift*. I do so by illustrating how incumbent assembly firms' values are being *ripped off* by suppliers in the same value chain and how it becomes difficult for them to maintain their current lucrative organizational structures.

1.3 Initial Evidence of Value-shift

In this section, I show several examples that illustrating the concept of value shift. These examples are drawn from textbooks, Sloan MBA courses, and discussions with team members in those courses. Those are valuable sources for developing the concept of value-shift.

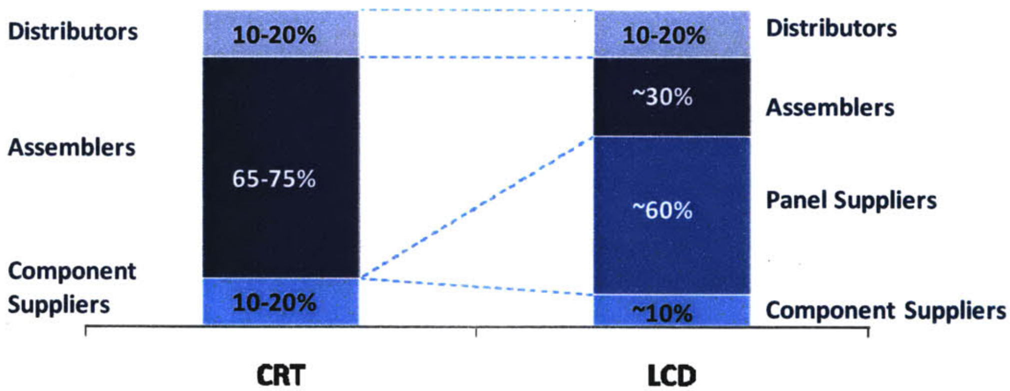
1.3.1 TV set industry: CRT assemblers lose value; LCD panel suppliers gain value

Since commercialized in 1941, Cathode Ray Tube (CRT) had been the dominant technology in the TV set industry for about 60 years. Although there was a substitution of top U.S. assemblers by European and Japanese players[8], it was always the assemblers who added the biggest share of the total value in the industry by owning key technologies for the production of TV sets. The industry was largely vertically integrated and more than 65% of the total value-added came from by assemblers (see Figure 1.3). The lucrative gross margin enabled CRT assemblers to invest significantly on their R&D activities. This situation allowed the incumbent assemblers to lead the development and maintenance of the entire product architecture and to ensure that components supplier followed the requirements of the assemblers. CRT assemblers were the technology leaders in the TV set industry.

However, with the emergence of flat panel displays in the late 1990s, especially since Liquid Crystal Display (LCD) became the dominant design in this industry in the early 2000s, the situation has changed. The industry structure has become clearly more horizontally divided and newly emerged LCD panel suppliers have become the ones who add the biggest value to the industry (Figure 1.3). The incumbent CRT TV assemblers – now flat TV assemblers, such as Toshiba, Sony, Panasonic (LCD) and Philips, could no longer enjoy the high gross margin. Only the top few LCD panel suppliers, such as Sharp and Samsung, could gain high margins from their panel businesses, maintain their large R&D investment, and lead the industry standard. This standard is called "Global Industry Standard Panels" and is followed by smaller panel suppliers. At present, the source of the value-added and technology leadership has clearly shifted to the top LCD panel suppliers.

[8] Alfred D. Chandler, Jr. (2001)

Total value-added by assemblers was significantly reduced in LCD technology. Panel suppliers became the strongest



	CRT	LCD
Industry Leadership	Assemblers	Panel Suppliers
Key success factors for assemblers*	High R&D investment and local customization (= high overhead cost)	Global panel procurement and thin operation

Source: Expert interview; USITC "*Industry and Trade Summary – Television Picture Tubes and Other Cathode Ray Tubes*" (1995); Display Search (2008); DWS Display http://dwsit.egloos.com/5282006

Figure 1.4: The Share of Value-Added in the TV Value Chain

I originally conceived the idea of value-shift from this TV set example, which I investigated in the class project in 15.365 *Disruptive Technologies – Predators and Prey*. Our team focused on the technological transitions in the TV industry. Later I chose this industry to investigate in detail to clarify the mechanism of value-shift. This research is described in Chapter 3.

1.3.2 PC industry: PC assemblers lose value; microprocessor and OS suppliers gain value

When personal computers (PC) were developed at a small IBM subsidiary in Florida in 1981, IBM tried totally new product architecture. IBM outsourced the design of most of its major components to non-IBM manufacturers, which was an unusual action for this heavily-vertically-integrated company[9]. The microprocessors were from Intel and the operating system was from Microsoft. Through this strategic outsourcing, IBM did not need to wait long to gain expertise and could launch a new product only 15 month after development[10]. This decision enabled IBM to secure the industry leadership position (its market share was 50% in 1985) and gain hefty profits from the product. IBM, together with Compaq, was the value chain orchestrator who decided all the architectures and roles of suppliers, thus maintaining strong bargaining power until the late 1980s.

However, frustrated with the slow platform evolution and frequent changes required by the assemblers, Intel developed the PCI bus system and distributed within the industry through its aggressive collaboration with other players[11]. Then Intel replaced PC-AT bus that ruled the old architecture developed by IBM. IBM's slow movement allowed Intel to take over the architectural leadership. Together with Microsoft, Intel has become an industry orchestrator who decides the pace of technology evolution in the industry and takes the biggest value-added with the highest profit margins in entire industry value chain[12]. PC assemblers have lost their technology leadership and therefore they have also lost their source of the value-added. This is another example of the value-shift.

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[9] Alfred D. Chandler, Jr. (2001)
[10] Peter L. Grant (2000)
[11] Annabelle Gawer and Michael A. Cusumano (2002)
[12] Intel's profit margins in typical years are 20-30%

I developed this idea mainly from Gawer and Cusumano (2002) and the discussions with Professor Cusumano at MIT Sloan School. I used this industry example to describe the supplier's strategic movement to take over the industry leadership from incumbent assemblers. A detailed discussion of this phenomenon is provided in Chapter 4.

1.3.3 Mobile handset industry: Mobile assemblers lose value; chip and application software suppliers gain value

Since Motorola's invention of analog mobile handsets in 1983, the company has successfully maintained an undisputed position until 1993[13]. Motorola was a vertically integrated assembler and its intellectual properties were protected. Therefore there were high entry barriers for new entrants; new entrants had to develop an entire range of technologies, from radio signal technologies to semiconductors. Motorola also had a strong brand in the pager business and long-term exclusive contracts with service operators. The dominant position in analog handset industry enabled Motorola to gain a lucrative profit margin and control over the whole value chain.

However, the next generation digital mobile handset technologies – 2G and 3G – required totally different game rules. It became common for handset assemblers to purchase the chipsets and key components from outside suppliers. At the same time, the pressure to lower handset prices and increasing costs of chip and software made it difficult for assemblers to maintain the same level of large margins the company enjoyed with analog handset. The industry average gross margin fell significantly. On the other hand, mobile chip vendors, such as Qualcomm, gained larger margins than assemblers because they owned key technologies and had a dominant share in the total mobile patent pool[14]. Therefore, the value shifted from

[13] Nabil Al-Najjar and David Besanko (2004)
[14] Discussion with the expert in the mobile industry

incumbent assemblers such as Motorola to chipset or application suppliers. The mobile industry clearly shows a *value-shift* from vertically integrated assemblers to component suppliers.

There are several reasons that Motorola lost leadership in the 2G and 3G mobile handset, but one of the most significant reasons is that it did not notice this industry change and tried to maintain the costly vertically integrated operation. For example, the development cost of the mobile software ballooned due to the increasing complexity of handling several ICs and increasing need for better user interface. Therefore, it became common for handset assemblers to develop an industry standard OS to reduce total development cost. Several handset assemblers, including Nokia and Sony Ericsson, co-developed an open industry platform, Symbian OS. In this common platform, assemblers could modify the system and differentiate themselves by offering unique user interfaces built upon a common platform at a minimum cost. On the other hand, Motorola developed its own embedded software on its own chip, which required significantly high overhead costs for keep highly-skilled embedded software engineers in-house. Motorola's actions entailed a much higher total cost than industry average; therefore, it lost its price competitiveness. Motorola finally made a huge loss in the mobile handset business and ended up laying-off significant number of engineers.

These observations are mostly derived from the team project in *15.912 Technology Strategy* and from discussions with two team members from telecom industry.

1.3.4 Automotive industry: Car assemblers lose value; electronics suppliers gain value

In the automotive industry, the design and production of electronics parts and software were traditionally separated and delegated to *tier 1* suppliers (such as Denso and Bosch) so that car assemblers could focus on the overall design and assembly. Traditionally, all the inputs from the accelerator, handle and brake pedals were transmitted mechanically to the output;

therefore the key components were those mechanical parts. However, the electronics parts and software have become more and more important in maintaining the total product quality. Inputs from the accelerator, handle, and brake pedals are calculated by software and controlled electronically; for example, the software calculates how a car should use its engine to be most fuel-efficient, and this information is transmitted electronically to the engine. Therefore, automotive electronics and software have become the key components in determining overall product performance and have become more valuable in the total car architecture.

This shift of values from mechanical parts to electronic parts and software automatically causes a *value-shift* from the car assemblers (OEMs) to the electronics parts suppliers. According to McKinsey and Company's studies in 2006[15], the average car assembler's total value-added is estimated to drop from around 35% of the total car value in 2006 to 25% in 2015 (see Figure 1.4). Moreover, car assemblers do not possess the technology or the expertise of automotive electronics and software, so their power to control the suppliers will decrease.

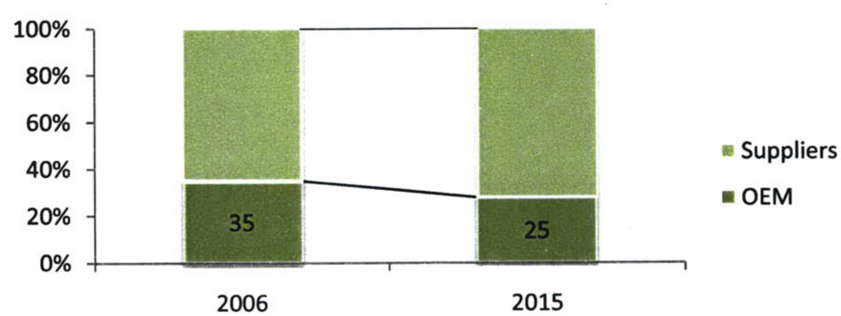

Figure 1.5: Change in the share of value-added by OEMs (Numbers in percentage)

It is worth noting that Toyota could manage supplier's bargaining power and maintained control over the whole value chain, even they had traditionally outsourced around 70% of the

[15] McKinsey & Company (2006)

total value-added to suppliers[16]. But even for Toyota, it is becoming difficult to maintain bargaining power over the electronics suppliers such as Denso. The author estimates that the value-shift will be more obvious and significant within the hybrid car and electric vehicles (EV). Toyota is now combating this shift by absorbing technologies from suppliers; however it is not clear whether Toyota can continue this same strategy with EVs.

1.4 Thesis Structure

As this chapter has shown, we observe *value-shift* – the phenomenon that incumbent assembly firms lose power when new technology is introduced and supplier firms take over the power and gain value in the same value chain – in many assembly industries. However, not many business scholars have identified its mechanism with a full-fledged theory. In this thesis, I identify the mechanism that causes *value-shift* within the TV set industry and suggest its application to other industries. Then I propose a set of strategies for incumbent assembly firms to prevent the value-shift and for supplier firms to take over industry leadership from incumbent assemblers.

Chapter 2 redefines the concept of *value chain* used in this thesis to illustrate *value-shift* quantitatively and more clearly; I use the simplified expression of value chain, omitting less significant parts and integrating several activities. Then I define the *value-added* in the industry using accounting terms and calculate the *value-added* in the automotive industry as an example. By calculating the transition of value-added, I quantify the impact of value-shift clearly. Finally I define *value-shift*.

[16] Takahiro Fujimoto (1999)

Chapters	Contents
Chapter 1: Introduction	• Scope of the thesis • Early evidence of *value-shift* • Thesis structure
Chapter 2: What is Value-Shift ?	• Definition of key concepts – *Value chain* – *Value-added* – *Value-shift*
Chapter 3: Value-Shift in TV set Industry	• Close investigation of one industry example • Value-shift mechanism in TV set industry • Set of strategies for incumbent firms to defy each step of the value-shift in TV set industry
Chapter 4: Value-Shift Mechanism	• Generalization of value-shift mechanism in four steps • Other industry examples • Strategies for incumbent firms and suppliers
Chapter 5: Conclusion	• Impact of the thesis • Next step

Figure 1.6: Thesis Structure

In Chapter 3, I closely examine the recent technology transition from CRT to LCD and describe how the value-shift took place in the TV set industry. I first describe why CRT TV assemblers had to be vertically integrated, by illustrating the history of CRT TV industry. Then I discuss the mechanism of *value-shift* with the emergence of the LCD technology in three stages. First, the product architecture became more modularized and the industry came to be horizontally divided as LCD became the dominant design in the flat panel TV industry. Second, the LCD panel became the most important component in the TV set architecture because the LCD panel has been the *bottleneck*; the development of only the LDC panel significantly improved the overall performance. Lastly, Incumbent assemblers finally lost *the design rule* that controlled the overall architecture. Concluding the chapter, I suggest strategies for incumbent assembly firms to defy the *value-shift* stage by stage.

In Chapter 4, I suggest a generalized mechanism of value-shift as an evolution in four stages, using the modularity theory proposed by Baldwin and Clark[17]. The first three stages are drawn from the study of the TV set industry discussed in Chapter 3; the last one stage is inferred from Intel's activities to take over the platform leadership[18]. I also show, by citing industry examples, that the proposed mechanism is generally applicable to other assembly industries. For each stage of value-shift, I suggest possible actions for both parties, i.e., for the incumbent to defy the value-shift and for suppliers to strategically take over the value and industry leadership.

Chapter 5 concludes the thesis by discussing the impact of the thesis and proposing applying the theory to forecast on-going or future industry changes. I suggest using the theory to forecast the current technology transition in three different industries where incumbent firms need to take immediate strategic actions.

[17] Carliss Y. Baldwin and Kim B. Clark (2000)
[18] Annabelle Gawer and Michael A. Cusumano (2002)

Chapter 2: What is Value-Shift?

In this chapter, I first redefine *value chain* in a simplified and general way so that I can generalize the concept of *value-shift* to many industries. Then I define *value-added* using accounting terms so that I can quantify the *value-shift* from incumbent assemblers to suppliers in the same *value chain* in real numbers. Quantifying this concept is important because although many people have an intuitive understanding that a value shifts from incumbent companies to other players in the same value chain as the industry matures; this phenomenon has not been shown in numbers. By calculating the numerical impact of *value-shift*, I clearly show that the problem of value-shift for incumbent assembly firms is that *they lose the source for maintaining their current high overhead cost structure*.

2.1 Value Chain Redefinition

Value is the amount that buyers are willing to pay for products or services that a firm or an industry provides to them. It is normally measured by total revenue, a reflection of the price a firm's product command. A *value chain* is a chain of activities carried out by a firm or an industry where those products or services gain *value* with each activity. Michael E. Porter originally defined this term as meaning the set of activities *in a firm* and argued that the value chains are different among competitors even in the same industry and that this difference is an important source of a firm's competitive advantage[19]. I completely agree with his viewpoint; however, in this thesis I use the term to refer to a more generalized concept beyond an individual firm.

[19] Michael E. Porter (1985)

I define *value chain* as the set of *activity steps* done by *all the firms involved in creating the total value of the final products (or service),* from upstream suppliers to downstream distributors; each *activity step* is a set of activities done by one firm or sometimes by several firms. In an industry that has complex firm networks, I extract only the major steps that represent most of the values of the final product and include other miscellaneous activities in the represented steps. Then I juxtapose the steps using the industry hierarchical order *from incumbent assembler's perspective*.

Here I show how this definition of value chain works in the automotive industry. The automotive industry is one of the most complex assembly industries; as such, it includes many different levels of value-adding activities. Generally, more than 1,000 firms are involved in delivering one car to end customers[20]. There are component suppliers, electric parts suppliers, wire harness suppliers, tire suppliers, rubber suppliers that supply rubber to tire suppliers, steel suppliers that supply steel products to both assemblers and components suppliers, and so on. Although this scheme appears very complicated, the suppliers can be classified into several buckets from the perspective of assemblers' (normally called *OEMs*). First, there are suppliers that trade directly with OEMs and usually supply the set of component systems to OEMs. Those suppliers are called *tier 1* suppliers. Tier 1 suppliers purchase materials and parts from *tier 2* suppliers, and tier 2 suppliers purchase from tier 3 suppliers, continuing in the same way. At the most upstream, there are raw material suppliers, such as glass producers or steel manufacturers that supply their products to all of the OEMs and suppliers.

For the purpose of calculating the effect of value-shift, I simply group these suppliers into three categories: 1) *component suppliers*, 2) *other parts suppliers*, and 3) *raw material suppliers,* as shown in Figure 2.1. 1) *Components suppliers* are mostly tier 1 suppliers to whom

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[20] The interactions within the *value-network* in the automobile industry is discussed precisely in Jianxi Luo, Daniel E. Whitney, Carliss Y. Baldwin, and Christopher L. Magee (2009)

OEMs delegate most of the core components. I classify tier 2 and upstream suppliers, except material suppliers, as 2) *other parts suppliers*. I classify materials suppliers and most other upstream players as 3) *raw material suppliers*, even though some of them trade directly to OEMs (e.g., steel manufacturers). Many trading companies and logistics companies are associated with the whole value chain, but I do not describe them explicitly in the value chain, assuming their contributions to the total value are small and included in other players' value-added. Also I eliminate industrial machines and robots suppliers from this value chain and add their value in the OEMs' value-added as their operational cost because value-shift seldom occurs between these types of suppliers and incumbent OEMs.

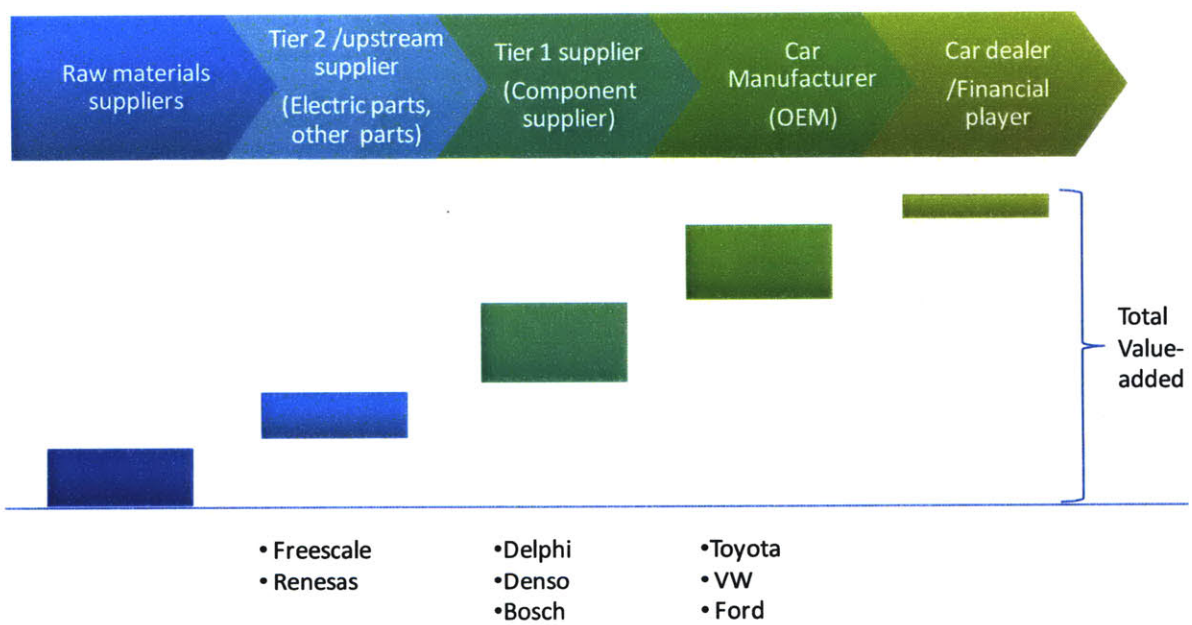

Figure 2.1: Value Chain Example: Simplified Automotive Industry Value Chain

On the downstream of automotive OEMs, there are distributors such as car dealers and car trading firms before getting to end customers. Financial players who provide loans also add value to final products that consumers purchase. I place these players in the same bucket as *car dealer/financial player* to simplify my scheme. I eliminate second-hand car dealers, insurance companies and aftermarket firms from the value chain, assuming these are not included in the final product value. However, I note that these three categories enjoy the largest share of the industry profit pool[21]; therefore, going downstream is a lucrative strategy in the manufacturing industry[22].

With this simplified definition, we can categorize the whole value-adding activities into five steps, as described in Figure 2.1. Generally, a detailed value chain differs according to region and OEM firm; this difference is the source of the competitive advantage, as Michael Porter has suggested[23]; however, the simplified automobile value chain is applicable to any OEMs in any country.

In some industries with a complicated network of firms, it is hard to describe the whole system as a single flow of a value chain. Some scholars have proposed that *value-network* is suitable to describe a complicated industry where the network of complement suppliers is more important than firms' internal activities, such as banking, insurance, advertising, and mature mobile industry[24]. However, as Christensen and Rosenbloom implied in their 1995 article, there is generally a hierarchical nested system in the value network[25]. Therefore, we can *project* the two-dimensional value network onto one-dimensional value chain using this hierarchy as we discussed in the automotive case in the previous section. As our definition of value chain is a very simplified expression, we always have to extract only the categories that play the most important roles in value-adding activities. The purpose of simplifying the value chain is to show the *value-shift* in the industry*; incumbent assembly firms are losing their value-added, which is being taken over by suppliers in the industry*; therefore, I select only

[21] Profit pool is the accumulation of profit margins by all the players in the industry
[22] Orit Gadiesh and James L. Gilbert (1998)
[23] Michael E. Porter (1985)
[24] Jeffrey L. Funk (2009)
[25] Clayton M. Christensen, Richard S. Rosenbloom (1995)

appropriate player that plays an important role in *value-shift* representing other players in the value-chain.

2.2 Value-Added in Value Chain and Industry Cost Structure

Each step of the value chain adds value to a firm's products or services. *The value-added of one step is defined as the value of the products that one step is producing minus the aggregated value-added in the previous steps*. For example, the *value-added* of OEMs is the value of the car they sell to distributors minus the total purchase cost of materials[26]. Considering that by definition the value of a product is equal to the price of the product sold downstream, we can define the value-added as *price minus purchasing cost*. Therefore, if we depict the value-added by each step of a value chain as the water-fall graph shown in Figure 2.2, this is equivalent to the *industry cost structure*.

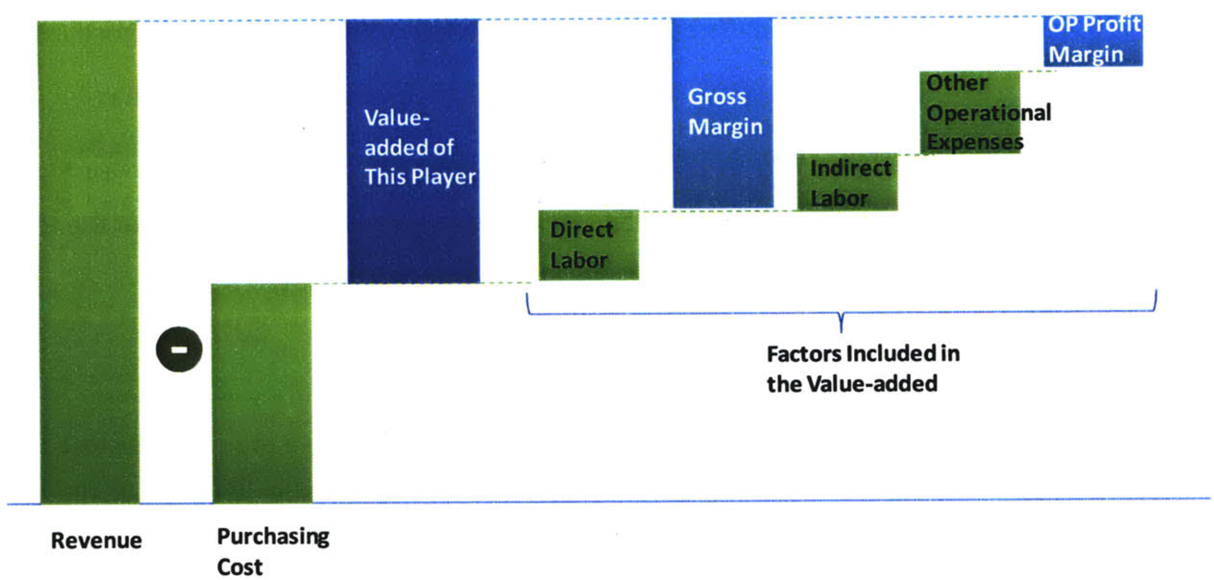

Figure 2.2: Definition of Value-Added Using Accounting Terms

[26] The purchasing cost of industry machines or robots is not counted

Here I emphasize that *value-added* is different from *profit margin*. Profit margin is defined as price minus *all of the operating costs*, but value-added is price minus only the *purchasing costs of materials and components*. Value-added, therefore, includes both the direct labor and the indirect labor, such as R&D, sales and promotion, operational expenses[27] and other overhead costs. Value-added also includes profit margin. By using *value-added* instead of *profit pool*, we can argue that a *value-shift* not only eats up all the profit margin but also accounts for the huge decrease in incumbent firms' source of value-added, such as operating and labor costs. I intend to offer a strong message to the management of incumbent firms facing the threat of value-shift: they need to take immediate actions for either to defy value-shift or to reduce their total cost structure.

With this definition of value-added using accounting terms, we can calculate the share of value-added by each step of value chain using IR data of the firms or the cost structure data given by industry research organizations. For example, we can estimate the share of value-added in the automotive value chain around Toyota in the late 1990s, as shown in Figure 2.3. The OEM's share of value-added differs slightly by region. For example, as Fujimoto has shown[28], the suppliers' share of value-added out of the total production cost is roughly 70 percent (55% of the total car price) in Japan and United States and 60 percent (50% of the total car price) in Europe. Also, within Japan, the share of value-added varies by OEMs; for example, Toyota's share of value-added is lower than Nissan's[29].

Another method of calculating the share of value-added is to use the cost structure data per unit. In the consumer electronics industry, such as TV sets, mobile handsets, and PCs, it is very common for technology journalists to decompose devices when new products are released

[27] If we see suppliers of the manufacturing equipment and plant developers as one of players in the value chain, we should exclude depreciation from value-added and add those players into the value chain
[28] Chapter 5 in Takahiro Fujimoto (1999)
[29] Takahiro Fujimoto (1999)

and to estimate their cost structure according to the parts used in the device. This data shows how much an assembly firm spends for purchasing from outside, so a firm's value-added is calculated as selling price minus purchasing cost. This ratio is equivalent to the definition using accounting terms.

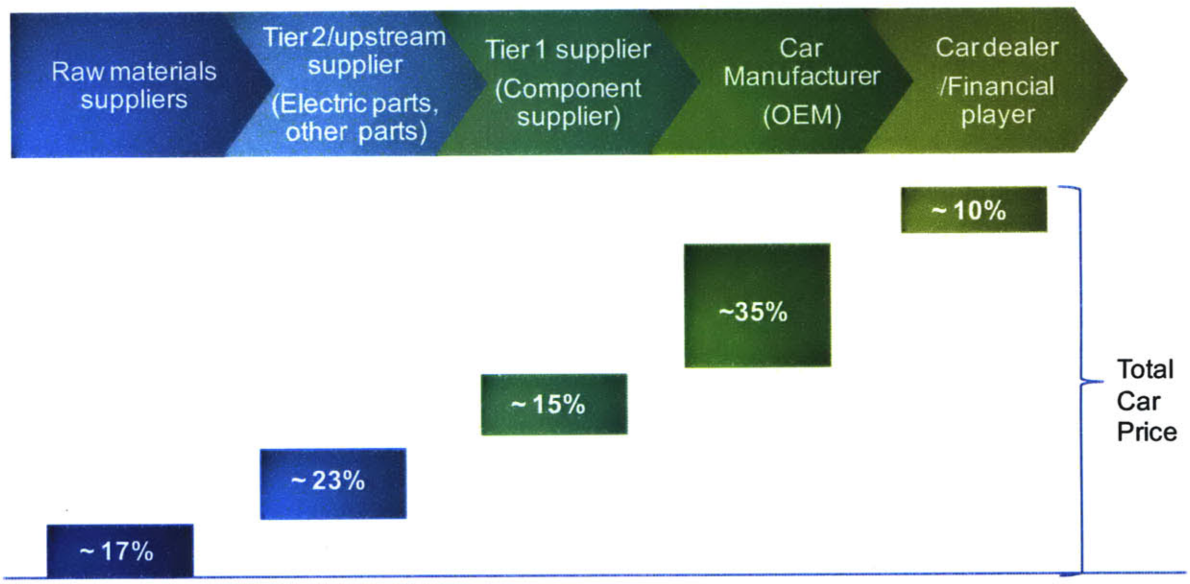

Figure 2.3: Estimated Ratio of Value-Added in Toyota's Value Chain in Late 1990s[30]

2.3 Value-Shift

When a new industry emerges, there is always a firm that creates the whole value chain to provide final products or services to its end customers. Because a firm normally cannot itself create everything from scratch, it has to find suppliers to provide components or raw materials. Then the firm assembles components and materials into the final products. Sometimes

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[30] I estimated dealer margin at roughly 10%. Within the wholesale price (90% of the total car price), the sum of 10% profit margin by Toyota (late 1990s) and 30% of the total production cost (81% of the total car price) is the value-added by Toyota. Therefore the total value-added by Toyota is roughly 35% of the total car price. Of Toyota's total procurement cost (55% of the total car price), I assume that 30% is from raw materials. According to Denso's IR data, the profit margin is roughly 5% of total revenue (39% of total) and the procurement cost is 67% of its cost (37% of total). By representing Denso as tier 1 suppliers, we estimate tier 1's value-added at roughly 15%. Denso's data is 2000: http://www.denso.co.jp/ja/investors/financial/fact_book/2000/files/non_con_2000_3.pdf

assembly firms need complementers, who allow the firm's products and services to be more useful for end customers. In addition, the firm needs distributors, who sell its products to customers. The assembly firms that created the whole industry value chain generally become the most powerful incumbent firms, controlling and orchestrating the value-chain. In assembly product industries, those firms are generally vertically integrated. Incumbent assembly firms can formulate the value chain so that they can add the biggest value to the industry and take the most profitable part at the same time. (Note: the value chain creator is not always the player who first invents a technology or first brings products to the market. The value chain creator can purchase necessary technologies and thereby successfully create a value chain.)

I offer some examples of incumbent assembly firms that are vertically integrated and control the value-chain. Motorola commercialized the first analog mobile handset and took the biggest share of the value-added in the industry, delegating only a marginal portion to parts suppliers[31]. IBM created and orchestrated the entire IBM-compatible PC value chain and took the biggest share of value-added until those values were usurped by microprocessor and OS suppliers. In a recent case, Apple re-created its own value chain for iPhone by finding non-established suppliers for the microprocessors instead of existing mobile phone suppliers and strengthened its power in the value chain.

Even if an industry started vertically and value chain creators took over the biggest share in the value chain, value chains are generally divided more horizontally over time. Each step in value chain is separated into several different steps and new players that specialized only in one or two of the steps will emerge. Vertically integrated incumbent assembly firms gradually lose their power over the value chain and lose their share of value-added. Instead, horizontally specialized supplier firms take more share of value-added. This phenomenon is

[31] Nabil Al-Najjar and David Besanko (2004)

commonly observed in assembly industries as seen in Chapter 1, and I call this phenomenon *value-shift*. I will discuss the mechanism of *value-shift* further in Chapter 3 and 4.

I discussed this phenomenon often with my colleagues at McKinsey and my clients in the assembly industries. Most of them argued that horizontal division of labor or modularization in the industry is the reason that incumbents are losing their power and value-added. As discussed later in this thesis, I argue that horizontal division is just *a trigger* for value-shift, but it is not the only reason. Modularization is inevitable to keep complex assembly industries evolving at fast pace and to increase the total value of innovations in the industries[32]. However, *value-shift* is a phenomenon that firms can avoid strategically, even when the industry has become modularized. In this thesis, I identify the mechanisms using four stages that explain how *value-shift* occurs and intensifies. In each of the four stages, incumbent firms can take strategic actions to defy the value-shift.

2.4 Summary

In this chapter, I redefined the value chain to apply the concept of *value-shift* to even a very complex industry. Then I defined *value-added* using accounting terms and cost structure. This approach attempts to clarify how much incumbent assembly firms lose their value-added needed to maintain their current organizational cost structure. On-going horizontal division of labor is only the trigger for value-shift. Before moving on to explicate the mechanisms of value-shift in detail, I will dive deeply into one consumer electronics industry to give a clearer picture of the entire discussion.

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[32] Carliss Y. Baldwin and Kim B. Clark (1997); Carliss Y. Baldwin and Kim B. Clark (2000)

Chapter 3: Value-Shift in the TV Set Industry

In this chapter, I look into recent TV set industry changes from Cathode Ray Tubes (CRT) to flat panel displays and discuss how this technological change resulted in a large value-shift from TV assemblers to panel suppliers. The CRT TV industry had been highly vertically integrated since its inception and assemblers added most of the values to the final products. In the early 2000s, CRT was replaced mostly by flat panel displays, and LCD (Liquid Crystal Display) became the dominant design in the flat panel displays. Along with this technological change, the industry dynamics also changed. The LCD TV industry is more modularized than the CRT industry. Then incumbent assembly firms lost their source of value-added and component suppliers instead added the largest value. I explain the mechanism behind the phenomenon later in this chapter and generalize it to apply to other industries in next chapter.

Note that the change from CRT to LCD is *not* the *architectural innovation* that Henderson and Clark have defined. Rather, this change is classified as a *modular innovation* (Figure 3.1) because it changed only the core design concept and left the product architecture unchanged[33]. However, in this type of innovation, major assembly firms are also replaced and values shift to new players.

[33] Rebecca M. Henderson and Kim B. Clark (1990): Henderson and Clark picked the replacement of analog with digital telephones as an example of modular innovation.

The technological change from CRT to flat panel is best described as a "modular innovation"

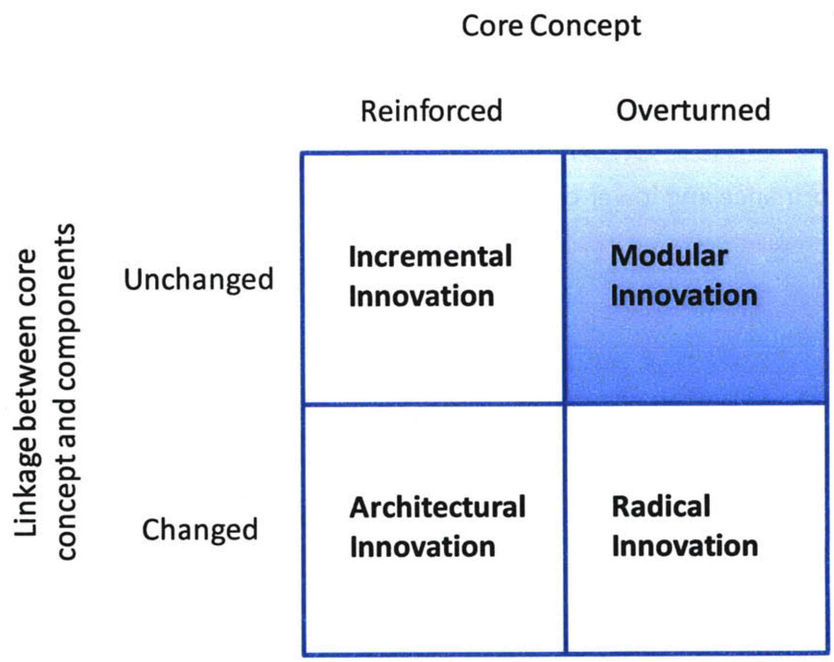


Figure 3.1: Henderson and Clark's framework

3.1 The CRT TV Industry Was Highly Vertically Integrated

Since the 1941, CRT had been the dominant technology in the TV set industry[34]. First, the black-and-white television was commercialized by RCA and it proliferated rapidly after World War II. RCA utilized the technology developed for the war-time effort and accelerated the proliferation by creating the industry standard with FCC authorization. RCA's standard was soon followed by other suppliers such as Philco, Zenith, and Motorola and the product was commoditized quickly. In the early 1950s, as the black-and-white television market settled into maturity, the color television became the next focus of the industry. To make the transition

[34] Alfred D. Chandler, Jr. (2001)

from black-and-white to color smoothly, RCA sought to develop a color television set compatible with the black-and-white technology, but this was a huge technological challenge. To use the limited bandwidth effectively, it also had to broadcast more information than in black-and-white in a narrower bandwidth, which was another major challenge. Those challenges made RCA take a highly vertically integrated approach. It fully utilized the basic scientific research in RCA Laboratories not only to solve such technological challenges[35] but also to improve performance and lower costs in the production of the cathode ray tubes for further proliferation.

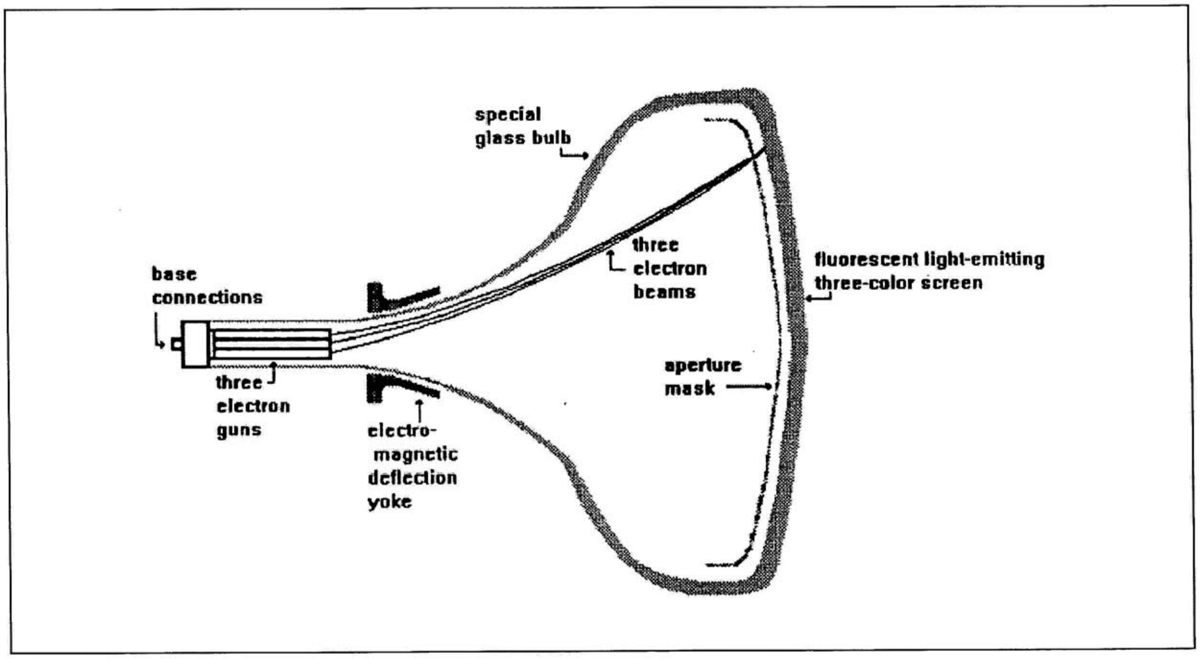


Figure 3.2: Basic Elements of CRT[36]

[35] Wikipedia "Color Television": RCA introduced new encoding system that separate color information and brightness information and reduce the resolution of color information to preserve bandwidth. Also it developed new decoding system that combine high resolution brightness information from black-and-white and lower resolution color image information.
[36] The picture is from USITC (1995)

Here I briefly explain the structure of the CRT TV set. An electromagnetic wave is received by the *tuner*; then it is processed by the *demodulator* (or decoder), which recovers information from electric signals and divide them into sound and picture information; the picture information is further processed by demodulators and separators and then displayed in the CRT. The CRT is the most valuable component in a TV set, consisting of about 50 % of the total value in 1993[37] and 44% in 2008[38]. As shown in Figure 3.2, the basic elements of a CRT are a glass bulb (works as an envelope), an electric gun (produces and focuses an electric beam onto screen) and a phosphor screen (also called an "aperture mask". It emits light when it receives an electric beam).

RCA produced almost all of these components in-house. It had expertise in the tuner technology that it developed at its radio receiver business and its war-time radar efforts; therefore RCA produced the tuners in-house. In terms of the demodulators, encoding and decoding of color images were the biggest obstacles to commercializing color televisions. RCA resolved those problems with a vertically integrated approach, as discussed above; therefore, RCA also kept this component in-house. The electric gun and the phosphorous-screen were the major components needed for achieving better resolution, brightness and power consumption; therefore, RCA also maintained the production of these components as a source of competitiveness. Although other companies sourced glass bulbs from outside vendors, RCA produced them in-house[39]. Hypothetically there were two reasons that RCA do so: 1) RCA had established high-level glass tube technologies in the vacuum tube business; 2) the glass bulb was still an important source of cost reduction. Improving product performance and reducing cost for all the CRT system therefore required a high level of integration of the basic research done in RCA Labs and the consumer electronics division. As we have seen above, CRT TV set

[37] USITC (1995)
[38] Display Search (2008)
[39] Inferred from the fact that Thomson still have glass production facility when it purchase RCA from GE

production in the early days was highly vertically integrated by assemblers; RCA added the biggest value in TV production.

The vertical integration of the TV set industry was a continuing trend for other players after European and Japanese players took the market share from RCA in the world market. Except the glass bulb, the major part of the value-added was added by assemblers. For example, all seven television set manufacturers that operated in the U.S. in the 1990s[40] developed their CRT in-house. Demodulators and other devices for imaging were replaced by IC transistors, but manufacturers kept the production of these ICs in-house as well. Especially the manufacturers from Japan, which represented more than 60% of the world CRT production in 1990s, continued the in-house development and production of ICs. This was not only because Japan's Ministry of International Trade and Industry (MITI) politically urged them to maintain the facilities for IC production in order to develop Japan's IC industry as a basis of the nation's industrial development[41] but also because the integration of the IC and the CRT imaging was necessary for manufacturers to maintain their cost competitiveness and increase their worldwide market share. As Gene Gregory noted[42], this vertically integrated strategy was important "to reduce the number of components used in the final product; design changes which reduce the number and complexity of assembly operation; and extensive automation, which reduces the number of workers required."

An estimated typical share of the value-added by CRT assemblers was 65-75% of the total industry value-added; assemblers took the most value-added in the industry (Figure 3.3). As we have seen, this level of vertical integration was important for TV set assemblers to

[40] Hitachi, Matsushita, Sony, Toshiba, Philips, Thomson (acquired RCA in 1980s), and Zenith

[41] The IC industry has been called "rice for industries." As rice is the staple food of Japanese people, so ICs are the staple of Japanese industry. MITI negotiated with Texas Instruments (TI) in 1963-1968 for the use of TI's Kilby patent and other IC technologies for all Japanese firms in return for letting TI enter the Japanese market. *Mainichi Newspaper* Oct. 27, 1973

[42] Alfred D. Chandler, Jr. (2001)

maintain their competitiveness. As we discussed in chapter 2, value-added is equivalent to the sum of labor cost, other overhead costs, operational expenses, and profit margin; therefore, having the largest value-added means that assemblers have the largest labor resources, and most of the time the largest investment in R&D. This enabled assemblers to be more technologically advanced than the suppliers or complementers to and lead the technology standard that components suppliers had to follow.

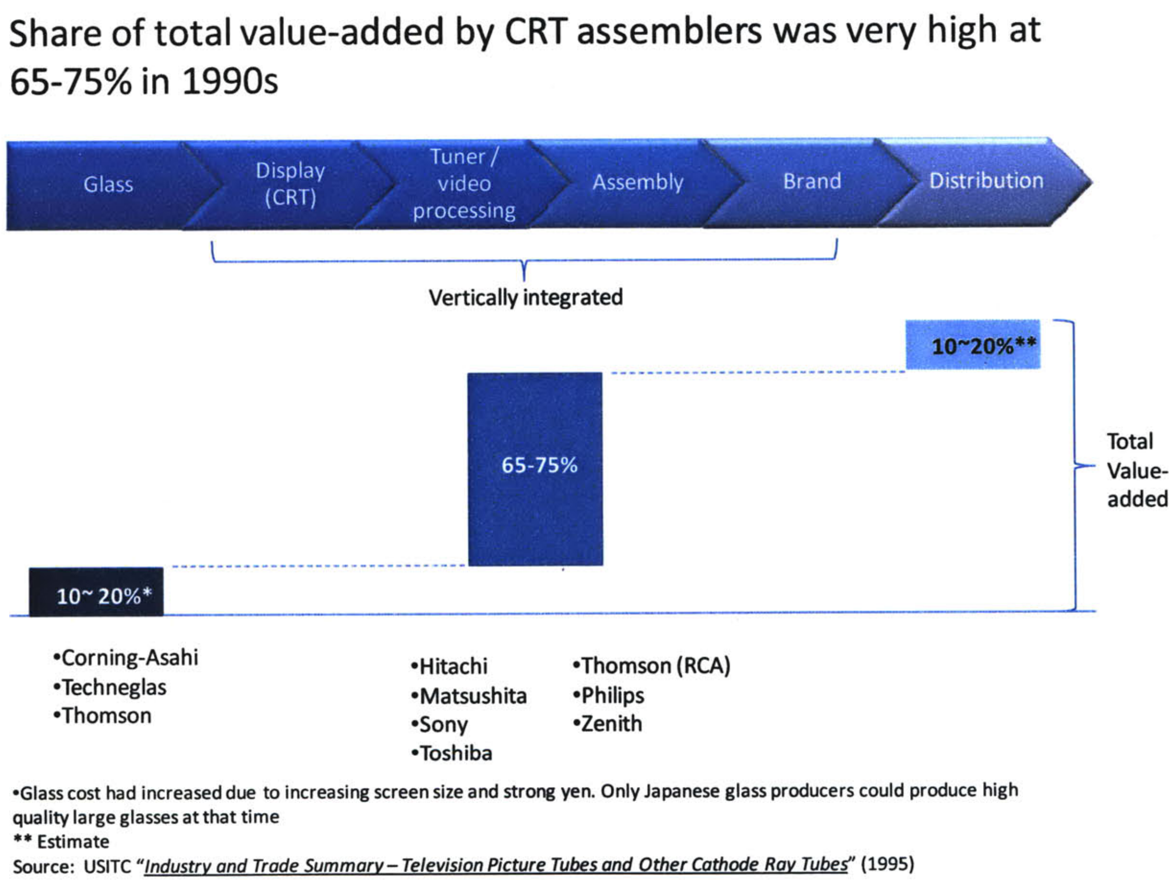


Figure 3.3: Share of Value-Added in CRT TV Industry in 1993

Note that the modularization had already started in low-end small CRT TVs in the 1990s. Given the tremendous capital investment in the production of picture tubes, it was not economically feasible for all tube manufacturers to make every size of tube. For example, there were no CRTs smaller than 19 inches being produced in the United States in the 1990s. TV manufacturers in the U.S. imported tubes from the affiliated plants abroad or bought tubes from other U.S. tube builders[43]. In Japan, CRTs for low-end to mid-range products were primarily acquired from Korea. Some of those suppliers, such as Samsung became major players in the flat panel TV industry.

3.2 The Value Chain Divided in the Flat Panel TV Industry

In the late 1990s, several flat panel display standards were proposed by Japanese CRT TV manufacturers; Plasma Display Panel (PDP) was developed by Panasonic (former Matsushita), NEC and Hitachi; Liquid Crystal Display (LCD) by Sharp; Surface conduction Electron-emitter Display (SED) by Canon and Toshiba; and Organic Light-Emitting Diode (OLED) by Sony. Among those new standards, PDP and LCD were commercialized earlier than other standards and replaced CRT within 10 years. In 2010, LCD is the practical dominant design in the TV set industry with ten times more production of PDP; therefore, LCD industry practically represents the TV industry. I will explain the industry dynamics of LCD in this section.

[43] USITC (1995): Most of those tube builders provide mostly for non-TV uses; PC display, military and science equipment.

表示部に液晶を採用した世界初の液晶表示付きCOS化ポケット電卓「エルシーメイト」(EL-805)と、内部のガラス基板。
(1973年/昭和48年)

目にやさしいペーパーホワイト画面のＤＳＴ型液晶を搭載したワープロ(WD・820)。248,000円。
(1987年/昭和62年)

世界初のアイデアを盛り込んだ「液晶ビューカム」<VL-HL1>(210,000円)大好評
(1992年発売)

Figure 3.4: Sharp's Products with LCD (Calculator, Word Processor and Camcorder) [44]

RCA developed first LCD TV in 1964 in its laboratory, but it was Sharp that first commercialized a 20-inch LCD flat panel TV that challenged the CRT TV market in 1999 with its TFT (Thin Film Transistor) technology. Since Sharp commercialized LCDs for its pocket calculators in 1973, this Japanese firm continued its effort to develop and commercialize larger and brighter displays in many product fields, such as digital watches, word processors, portable televisions, displays for camcorders and PDAs (Figure 3.4).

After the release of Sharp's 20-inch LCD TV, many other CRT TV manufacturers accelerated their investments on the development of the LCD TVs and the competition increased. The manufacturers that invested in other standards also started producing LCD TV sets. The CRT market was replaced within only five years by the LCD technology (Figure 3.5).

[44] Sharp's Corporate History: http://www.sharp.co.jp/corporate/info/history/h_company/index.html (in Japanese)

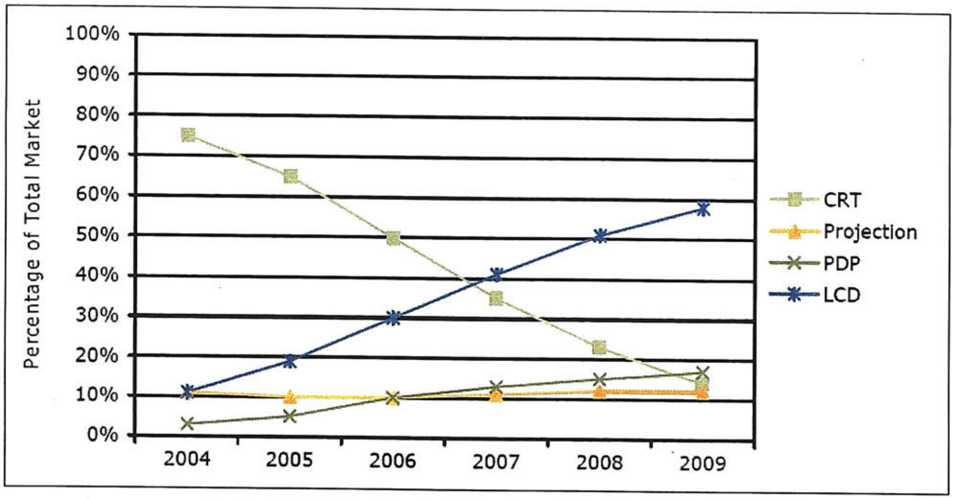


Figure 3.5: Percentage of Total Market by displaying technology

To match the increasing demand of other manufacturers that entered the LCD TV market, Sharp started providing LCD panel components in 2001. Sharp soon became the biggest LCD panel supplier in the world. Then Samsung Electronics, a producer of LCDs for personal computer displays, followed this move, and launched production of larger LCD panels in 2002. Because the production of the TFT LCD technology is technically similar to that of semiconductors, Samsung Electronics was able to use several identical technologies from its semiconductor manufacturing, and rapidly achieved the industry's lowest production cost. Several Taiwanese producers also started selling low-cost LCDs for incoming TV manufacturers. In 2005, Sony, the largest CRT TV incumbent, delegated its LCD panel production to Samsung Electronics in full scale via S-LCD, the joint venture between Sony and Samsung. After this event, the separation of panel production, IC production, and TV assembly became typical in the industry. The originally vertically integrated industry was now clearly divided into several different layers (Figure 3.6).

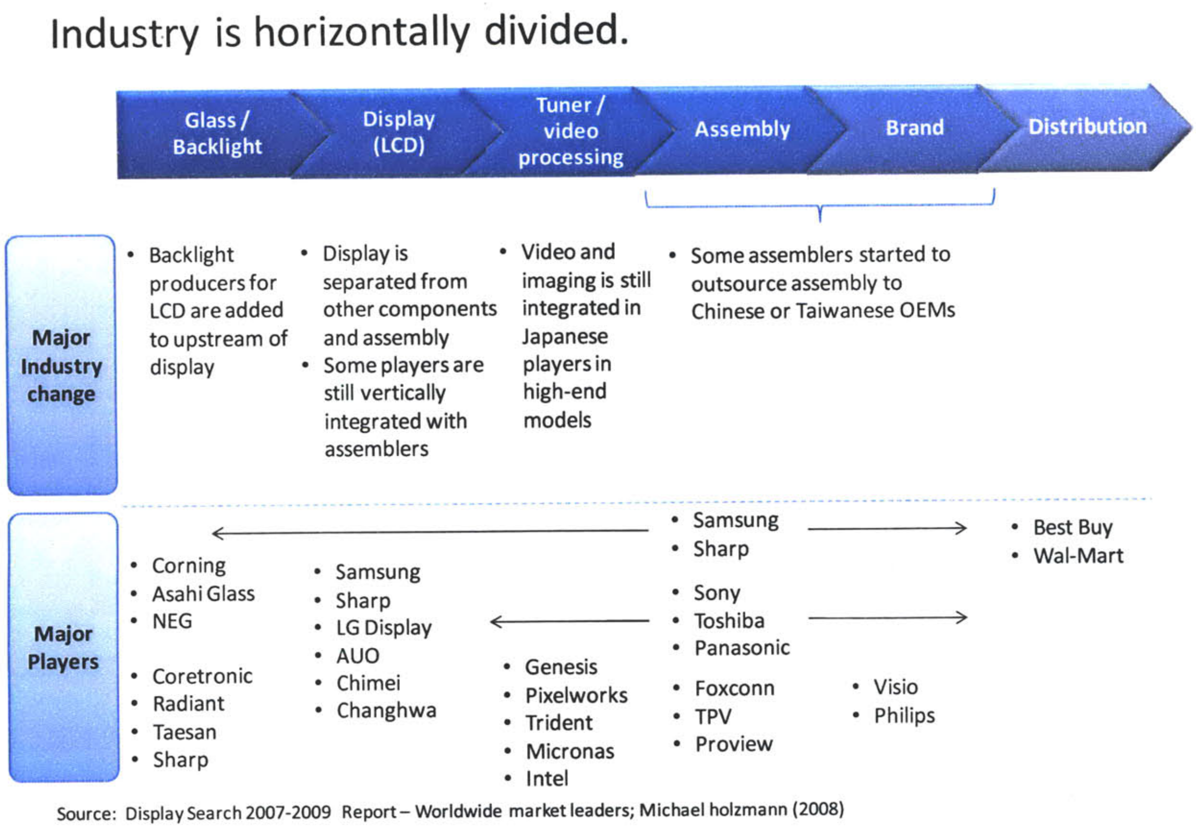
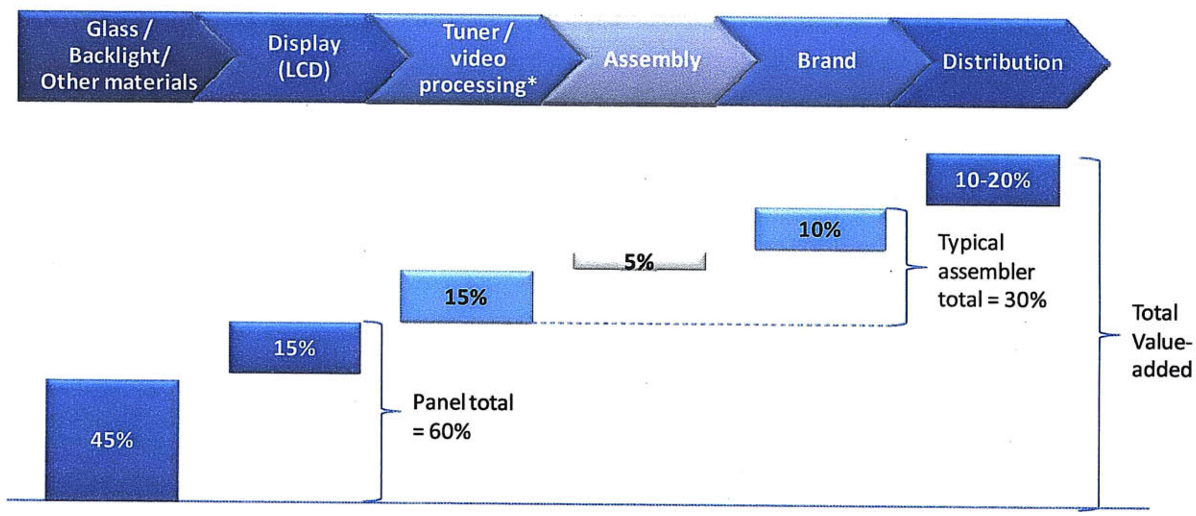


Figure 3.6: LCD TV Value Chain Is More Horizontally Divided

3.3 Value Shifted from Assemblers to Panel Suppliers

An estimated typical share of the value-added in the LCD TV industry is shown in Figure 3.7. The share of assemblers decreased significantly, from 65 to 75% in the CRT TV industry to 30% in the LCD TV industry. Obviously one of the reasons is that assemblers outsourced some components (such as panels) to suppliers and lost the value-added of these components. Another possible reason is that the value of assembly itself had decreased.

Share of the value-added by CRT assemblers is squeezed. Panel suppliers now take the biggest share
(Cost structure of 42" HDTV)

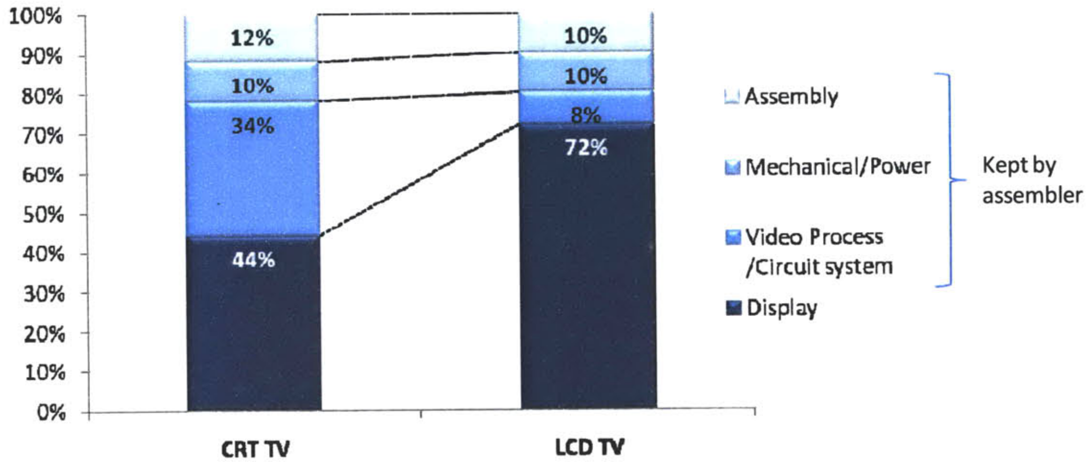


•Include other material cost, such as mechanical shields
Source: Display Search (2008); DWS Display http://dwsit.egloos.com/5282006

Figure 3.7: Share of Value-Added in LCD Industry

Although historical comparison of the assembly value is difficult, we observe the differences between the current CRT TV and the LCD TV (Figure 3.8). The value-added of the video process and the circuit system that is normally done by assemblers is extremely squeezed (34% → 8%) as well as the decrease in the assembly values (12% → 10%). Because the video processes and circuit systems included a high-level of technological integration with the CRT, we can say that the value of the assembly itself had decreased based on the data. For the above two reasons, the value-added by assemblers greatly decreased in the LCD industry.

In CRT TVs, TV assemblers can control 56% of FOB cost but only 28% in LCD TVs
(2008 TV FOB Cost Structure)



Source: Display Search (2008);

Figure 3.8: FOB Cost Structure Comparison in 2008

The impact of the value-shift was huge for the incumbent assemblers such as Sony, Philips, and Toshiba. As we have seen previously, the loss of value-added entailed the loss of the financial resorces for the overhead costs and R&D. Therefore, those firms had to drastically decrease the cost of assembly per unit and have a thinner operation compared to the CRT era. This was the biggest consequence of the *value-shift* for incumbent firms: they could not maintain ample resources when the value was shifted to the other part of the value chain. Some firms quickly responded to the value-shift; among CRT incumbent firms that still remain in Top 10 LCD brands, Philips started outsourcing its assembly of TV sets to low-cost OEM makers in China and Taiwan and shut down its own facilities in Europe. Philips's outsourcing ratio reached 62% in 2009. Also, Toshiba, the company first focused its R&D resources on SED but later withdrew from this technology, has kept its outsourcing ratio very high.

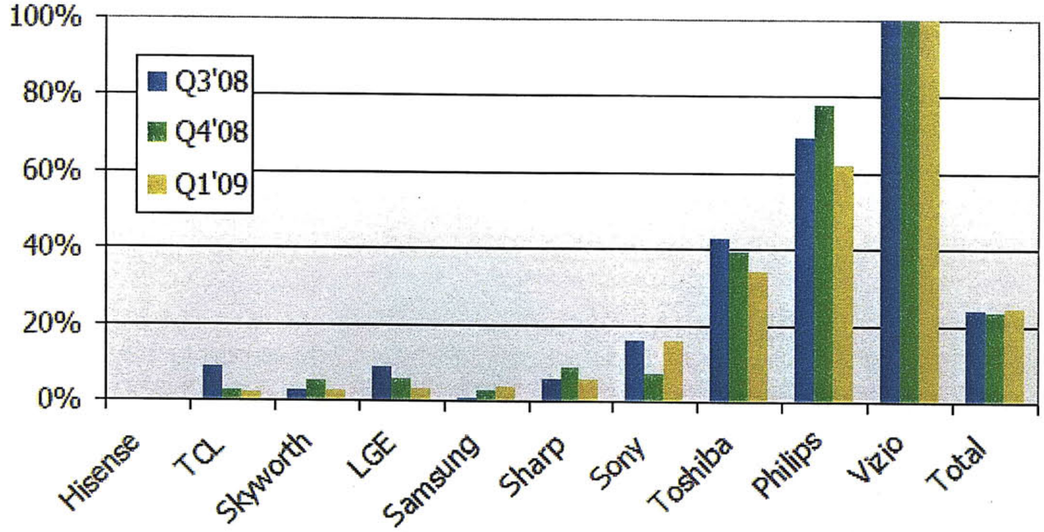


Figure 3.9: Top 10 LCD TV Brands' Outsourcing Ratio, Q3'08 - Q1'09[45]

Along with losing the value-added in the industry, the incumbent assemblers also lost technological leadership. It is now the panel suppliers that define the performance of the next generation of TV sets and the timing of product releases. Especially for low-end LCD TVs, the panel suppliers produce the "Industry Standard Panels" twice a year and the TV assemblers adjust their facilities to those standards. The power to control the whole industry now resides within the panel suppliers.

3.4 Mechanism of the Value-Shift in the LCD TV Industry

Can CRT incumbent firms defy *value-shift*? To answer this question, I will explain the mechanism behind value-shift in this industry. Three major stages were observed.

1. **Further splitting of the product architecture and the division of the value chain.**
   The architecture of the LCD TV has been split into smaller subsystems and the

[45] DisplaySearch News; DisplaySearch Quarterly LCD Value Q3'08 – Q1"09

industry value chain has been divided. The *interfaces* between the subsystems are defined clearly and the *interrelations* between them have disappeared.

2. **Centralization of the product values in single subsystem.** The value of the product has been centralized only in the LCD panel because product performances highly depended on the quality of the panel. In comparison, the other components have lost the value.
3. **Losing the "Design rule" or failing to build it**: The assemblers have lost control over the whole architecture, especially over the LCD panel, now that makes the biggest contribution to the final product. Using Baldwin and Clark's term[46], the assemblers have lost the *design rule* of the architecture or failed to build it.

3.4.1 Further split of the product architecture and the division of the value chain

As discussed earlier, the development and production of the CRT TV was vertically integrated. Within the whole product architecture, the CRT display required many interrelations with the other major subsystems, such as demodulators and imaging processors, because the picture quality depended on all of these components and the interconnections between them. However, the LCD panel was independent in the product architecture in 2004, when many panel supplier firms started to provide LCD panels independently from assembly of TV sets. The product architecture was more divided; and the split product architecture enabled the further division of the value chain in this industry. Here I propose two hypotheses to explain why the architecture had to be split.

[46] Carliss Y. Baldwin and Kim B. Clark (2000)

Hypothesis: The display technology had to be separated from other components to accelerate the evolution of the LCD panel technologies while utilizing other component technologies that were already well developed.

When the industry shifted from the CRT to the LCD, component technologies such as electromagnetic receivers or imaging processors were already highly advanced in the CRT TV industry. Therefore, it was natural for the firms to utilize those technologies for LCD TVs. To replace only one component in the system, two goals had to be achieved: 1) the *interfaces* between the subsystems had to be defined more clearly and 2) the *interrelations* between subsystems had to be reduced. This transformation is conceptually drawn in a task structure matrix[47] as shown in Figure 3.10. The gray cells represent interrelations between the two tasks. When the CRT was replaced by the LCD, interrelations between the tasks in the display unit and those in the imaging units were significantly reduced and the information of each component became *hidden* within each subsystem. Baldwin and Clark argued that if a component is independent and *hidden* from other components, changes to the components can be made without changing rest of the system.

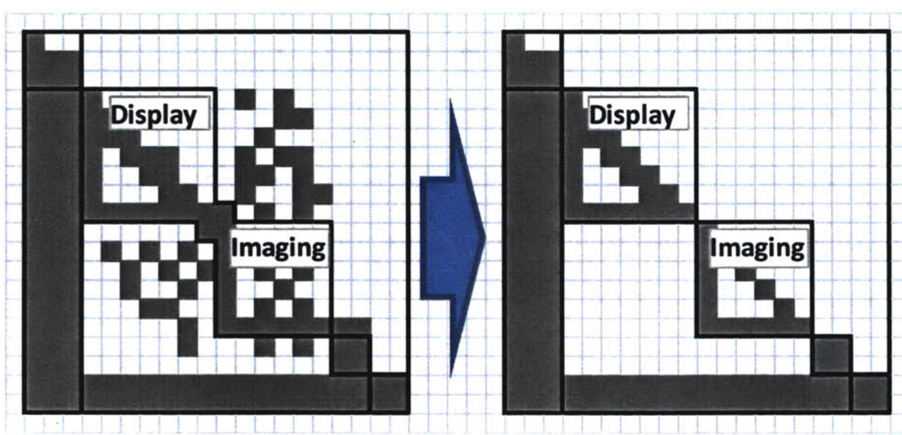


Figure 3.10: TV Set Components Modularization to Allow Component Replacement

[47] A task structure matrix is topologically identical to a design structure matrix most of the time. The definition of the matrix is explained in Carliss Y. Baldwin and Kim B. Clark (2000)

There was another major motivation for LCD TV firms to separate the LCD panel from other components and accelerate its development at a faster pace. In the early 2000s, the market evaluation of LCD TVs was much lower than that of PDP (Plasma Display Panel) TVs. Many industry experts at that time believed that the performance of LCDs could hardly surpass that of well-developed CRT technologies. They believed it was more feasible for the PDP technology to replace the CRT technology. If the LCD technology had allowed the PDP technology to take over the rapidly growing flat panel market, the LCD technology could have not become the dominant design in this industry. Therefore, it was the number one priority for LCD manufacturers to separate the LCD panel from other components to achieve its evolution at a faster pace.

It is common for a system architect to separate *bottleneck* subsystems from other components to allow changes within the component. For example, as Gawer and Cusumano described[48], Intel aggressively separated its processor from other PC components and developed an interface to *hide* core processor functions in order to accelerate the evolution of processors faster than other slowly developing modules.

Hypothesis 2: The production of the LCD is more capital intensive and has a huge economy of scale; centralizing its production to the limited number of manufacturers could significantly reduce capital investment per unit industry-wide.

The production of TFT-LCD panels became capital intensive because it required technology-intensive expensive fabrication equipments as in the semiconductor industry. Therefore, shortening the processing time per unit and producing at a larger scale are the key sources of cost reduction. As shown graphically in Figure 3.11, the TFT-LCD therefore has a

[48] Gawer and Cusumano (2002)

larger economy of scale than the CRT. Assemblers need various sizes of LCD panels, producing of each size at a small scale for their own-use becomes economically unfeasible. This trend led further division of the entire value chain. The separation of capital intensive subsystems within an industry is very common in other industries, such as semiconductor production in the computer industry.

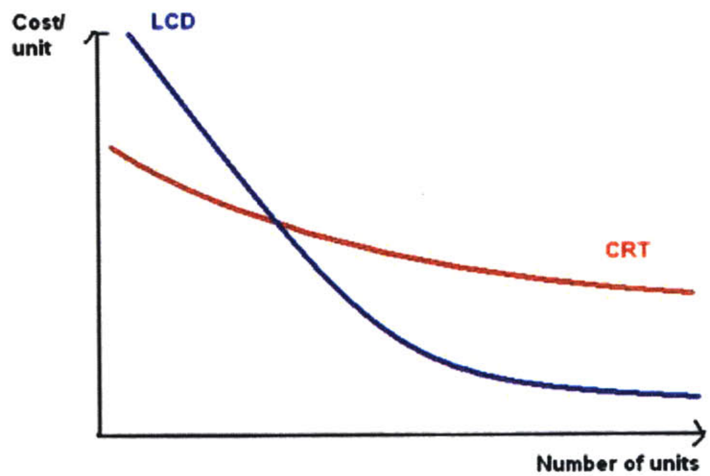


Figure 3.11: Cost of Production per Unit in CRT and LCD

In summary, two hypotheses may explain why the division of the value chain had been accelerated in the LCD TV set industry: 1) to replace only CRT displays with LCD panels in the TV set architecture and accelerate the development of only the LCD component; 2) the industry level economy of scale. As we have seen, these hypotheses are supported by some evidence, but will need stronger evidence based on interviews and other sources in future research.

3.4.2 Centralization of the values to one module

The split of the architecture and the division of labor is not the only reason why incumbent assembly firms lost their values. In addition, LCD panels became the most valuable component in the architecture but the incumbent assembly firms lost access to them. Below is my hypothesis to account for this phenomenon.

Hypothesis: The *bottleneck*[49] of the system is more valuable than other subsystems because the firm can increase the value of the entire system by improving only the *bottleneck*. The LCD was the *bottleneck* of the TV set; therefore the value has shifted to the LCD panel.

Generally a *bottleneck* in a system means the location or component that constrains the performance of entire complex system[50]. I use this term in the thesis specifically meaning a subsystem that determines the performance of the entire system and has a large improvement potential. As Carliss Baldwin discussed in her recent paper[51], historically there were successful companies that separated *bottlenecks* from the whole system and achieved improvement of the whole system by focusing their resources only on the development of the bottleneck components. Having a bottleneck component in-house is the biggest source of the value for firms because a firm can improve the performance of the entire system if it succeeds in improving only the bottleneck component.

Below I present evidence that the LCD panel in the early period was clearly the bottleneck in the TV set. As shown in Figure 3.12, all the important performance measures were lower than in other competing standards*, and all of them resided in the LCD panels.* The critical issues for LCD were the screen size and the response ratio. As shown in Figure 3.12, the biggest LCD screen size available in 2001 was only 20 inches; therefore, the LCD TV was believed to serve only personal uses rather than the living room use served by the CRT TV. Another critical issue was response time, which is the amount of time it takes for one pixel to

[49] Carliss Baldwin redefines "bottleneck" in her recent working paper: Carliss Y. Baldwin (2010)
[50] Sendil K. Ethiraj (2007)
[51] Carliss Y. Baldwin (2010)

go from active to inactive. Until 2001, the response time was more than 20 milliseconds and it caused motion lag, trailer effect, fast motion blur, and smearing, especially for action scenes, sports, and video games. Lower contrast ratio and smaller color spectrum coverage led to the bad reputation of LCD technology compared to PDP: "LCDs was dim and dark"[52].

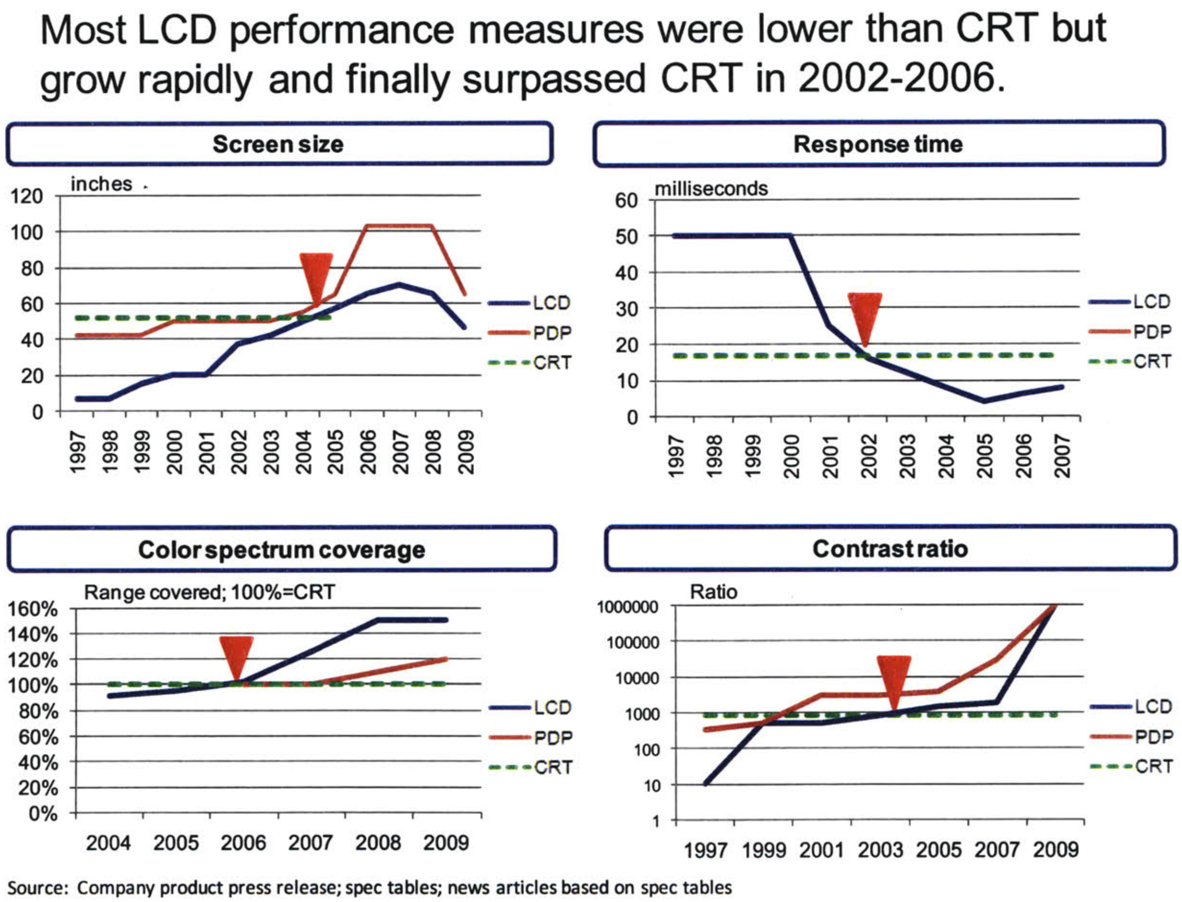


Figure 3.12: Improvement in Performance Measures in LCD and PDP technologies

Despite all these concerns in the early 2000s, LCD achieved better performance in those four critical measures than CRT and some even surpassed the level that human beings can

[52] From the web-news in 2001

recognize[53] from 2002 to 2006. Consequently, as we have seen in Figure 3.5, the share of LCDs in the total TV market exceeded that of PDPs in 2004 and ensured LCDs' success as the dominant design in flat panel TVs.

Therefore, not only did the LCD panel have to be separated from other components, but owning this *bottleneck* component and continuously developing the performance of the component were sources of the competitiveness. In other words, other components were commoditized and the value of the product was centralized in this independent module (Figure 3.13).

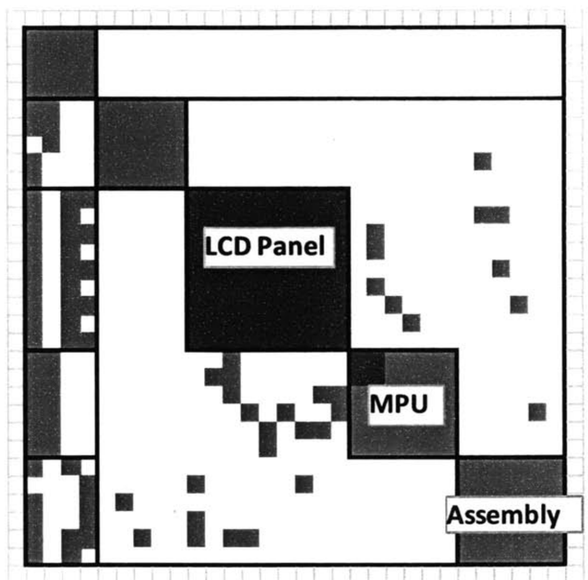


Figure 3.13: The Source of the Value Was Centralized in the LCD Panel

At present, major competitiveness shifted to other measurements, such as thinness of the display and lower power consumption, after LCD reached the CRT-level performance. However *all of the important performance measures still reside in the LCD panel.* More specifically, the source of value is even more centralized only in the backlight component of the

[53] Response time was improved to 4ms in 2005, but the difference between 4ms and 8ms is hardly recognized by humans; therefore, the response time of major models scaled back to 8ms.

LCD panel (accounting for 20-30% of the total cost of the LCD panel.)[54] In other words, the backlight is becoming the *bottleneck* of the entire system and maintaining the development and production of backlight components in-house has become the source of competitiveness.

3.4.3 Losing the "Design Rule" or Failing to Build It

Baldwin and Clark defined *design rule* of a system as "the privileged parameters" that "affect other parameter choices (in the system) but they themselves cannot be changed"[55]. In other words, a *design rule* is a set of parameters that controls the role and the behaviors of all the modules in the system. In the ideal modularized industry, there is always a *design rule* that defines and addresses the following categories of the design information:

- *Architecture*: what modules will be part of the system, and what their roles will be;
- *Interfaces*: detailed descriptions of how the different modules will interact, including how they will fit together, connect, communicate, and so forth;
- *integration protocols and testing standards*: procedures that will allow designers to assemble the system and determine how well it works, whether a particular module conforms to the design rules, and how one version of a module performs relative to another.

If an assembly firms possesses this type of *design rule*, the firm is able to control the amount of the value that each component supplier adds, even when the firm does not own the bottleneck component (such as an LCD panel). This is because the design rule by definition can define the role of each component supplier and the relations between them. Owning a design rule is the source of the value of the assembly. Therefore, if an assembler firm could successfully build the *design rule* of the entire LCD TV architecture through defining the role of

[54] DisplaySearch (2005)
[55] Carliss Y. Baldwin and Kim B. Clark (2000)

all component suppliers and controlling the *interfaces* and *interactions* between components, the firm would be able to maintain higher value of the assembly.

However, technically there were no incumbent assemblers that possess the *design rule* over the entire LCD TV architecture. At present, most of the interfaces between components are determined by different players in the value chain. For example, industry standards in encoding and decoding such as MPEG-2 or MPEG-4 are proposed mostly by media content providers. Digital signal receiver protocols are called HDMI and are normally determined by assemblers, with each assembler having a different standard; Panasonic uses EZ-Sync, Samsung uses Anynet+, Sony uses Theatre Sync, Toshiba uses CE-LINK, LG uses SimpLink, etc[56]. The interfaces between imaging processors and LCD panels are often proposed by semiconductor suppliers. Therefore, there is no ideal design rule owner in the LCD TV industry and the assemblers are failing to control the whole value chain; in consequence, they are losing assembly's value itself. This contrasts to the fact that IBM and Compaq could at least maintain assemblers' values in the PC industry by controlling the design rule such as PC-AT bus systems, as discussed in Chapter 4.

In this section, we have seen that there are three steps in the mechanism explaining why the value of the assembly was squeezed and shifted and centralized only to the LCD panel component. An important message of this section is that *value-shift* is driven not only with the division of the value chain; the further splitting of the product architecture and resultant division of the value chain is the trigger for the value-shift, but there are other important stages that cause value-shift. Two main reasons that the incumbent assembly firms lost their values are: 1) the LCD component was the bottleneck for the total value of the product and; 2) assemblers failed to possess the *design rule* of the entire LCD TV architecture.

[56] http://www.crutchfield.com/S-SX0v2DDxfZy/learn/learningcenter/home/tv_glossary.html

3.5 Conclusion – What Can Incumbent Companies Do to Defy Value-Shift?

The TV industry was originally vertically integrated when the CRT technology was the dominant design; therefore, the incumbent firms of the CRT era had all the resources from the production of components to the assembly of the final product. However, since the industry shifted to the LCD technology, the value chain has been divided and the value has shifted to only one of the component suppliers – the LCD panel suppliers. The panel suppliers now add more value to the final product and began to control the industry trend. On the other hand, the value-added provided by the assemblers has been squeezed and the CRT incumbent firms have had to change their operation to reduce the production cost per unit significantly.

What can those CRT incumbent firms do to defy value-shift? To answer this question, I argue that there are three stages in the mechanism of value-shift: 1) the LCD TV product architecture was split into several independent components and the entire value chain was divided further; 2) the source of the value was shifted only to the LCD panel because it was the *bottleneck* in the entire architecture and the incumbent assembly firms lost access to the component; 3) the assemblers failed to own the *design rule* to define roles of the components suppliers and control their value-added. Considering these three steps, there are logically four potential solutions for the incumbent firms to defy value-shift.

3.5.1 Strategy 1: Stop the splitting of the value chain

The first possibility for the incumbent firms to defy the value-shift is to stop the industry trend of splitting the product architecture and to keep the value of the assembler. Because normally a vertically integrated assembler has a control over the whole architecture, it can control the level of the clarity of the interfaces and the level of interrelations between components. One example of an incumbent assembler maintaining its power over the value chain by deterring modularization is Toyota's supplier management. In Toyota's case, it defines the interfaces between components clearly and delegates each module to the supplier firms completely; however, it maintains a high level of interrelations between components provided by different supplier firms[57]. Supplier firms should relate to each other under Toyota's control and modify their products to fit with other components. Other Japanese car assemblers, such as Nissan, take a similar supplier management strategy. Consequently, the level of the interrelations between the supplier companies in Japanese car industry is very high compared to the other industries such as the electronics industry[58].

However, in this TV industry example, the further split of the product architecture seems inevitable. The option value gained by the entire industry through modularity was bigger than the other costs associated with modularization. As discussed above, other components in the TV sets, such as processors, were highly developed and it is more economically feasible to use existing processor technologies. Also, to lower the capital investment per unit, centralizing the production of panels to only some of the panel suppliers make sense for the entire industry. Therefore, avoiding the further splitting of the architecture is not a feasible strategy for an incumbent to take.

3.5.2 Strategy 2: Disperse the value of the product to several components

The second possible solution that incumbent firms can employ is to let other components take on a major functionality and lower the relative value of the LCD panel in the entire TV set system; in other words, to make other components the "bottleneck" of the system by achieving significant improvement. It is especially important to shift the values from LCD to the components that the incumbents still owns.

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[57] Takahiro Fujimoto (1999)

[58] Jianxi Luo, Daniel E. Whitney, Carliss Y. Baldwin, and Christopher L. Magee (2009)

This strategy has already been adopted by some incumbent assembly firms. For example, since 2005, Sony has tried to achieve some of the important performance measures, such as colorfulness and power consumption, in the components that it develops and produces in-house, such as imaging processors or its advanced film technologies[59]. It tried to shift the source of the value from the LCD panel suppliers to itself by making processors and thin films more valuable than the panel. However, as we have seen in Figure 3.12, colorfulness (color spectrum coverage) or brightness (contrast ratio) of LCD TVs has already surpassed the levels of CRT TVs and what the imaging processors and thin films can achieve was marginal. Also, Sony tried to lower power consumption by changing the image processing mechanism in the processors and using better quality thin films. However, before achieving significant improve through such attempts, Sony decided to source its core processors from Intel in 2010[60]. Toshiba also employed a similar strategy and in 2009 introduced an LCD TV set using its low power consuming processor "CELL" that this company developed together with Sony and IBM[61]. The consequences of this strategy are not clear yet.

3.5.3 Strategy 3: Build the Design Rule in the whole TV set architecture

The third strategy that TV set assemblers can employ is to set the *design rule* in the industry by defining the standard interfaces between the major components across the entire architecture and controlling the power of all the suppliers. One of the firms that successfully owned the design rule of the product system and took over the value from the industry was Intel in the PC industry. Intel successfully took over the design rule from assembly firms by determining the industry standard interfaces called the PCI bus and the USB, which realized faster information transfer between components than the interfaces formerly provided by

[59] Company news release
[60] Company news release; March 2010
[61] Company news release; October 2009

assemblers, such as IBM[62]. Building an end-customer's pull with marketing campaigns such as "Intel Inside" and establishing a strong bargaining power were also keys in maintaining the power of the design rule and taking control across the industry. I will discuss this case in more detail in Chapter 4.

In the LCD TV set industry, however, there is no single player that builds the design rule for the entire system and successfully controls the power of suppliers. Incumbent assembly firms can take further actions to take over the role of determining design rules of the whole system.

Note that interlinks between components in a TV set is no longer a major source of competitiveness as in the PC industry in the 1990s when Intel developed the PCI bus. Therefore, adopting this strategy solely is not an effective option; this strategy must be employed along with other strategies.

3.5.4 Strategy 4: Maintain or re-enter the components with the biggest value

Even after the value chain is divided and the value-added is completely taken over by one of the components, there is one more strategy that incumbent assemblers can take. By possessing the development and the production of the LCD panel through a merger and acquisition, assemblers can add the biggest value in the value chain and it will be easier for them to take over technology leadership and control the other players.

This is actually the strategy that panel suppliers are now taking to preserve the value of their LCD panels. The source of the performance measures is now shifting to the backlight component of the LCD panel, and the backlight panel is taking the biggest share of the value-added in the LCD panel (20-30% o total LCD panel value). Therefore, LCD panel suppliers such as

[62] Annabelle Gawer and Michael A. Cusumano (2002)

Samsung and Sharp are aggressively acquiring the backlight companies and develop and produce most of the backlight in-house. By doing this, Samsung and Sharp can maintain their technology leadership in the panel industry and control the design rule in the panel components.

Another example of an assembler engaging this strategy and successfully possessing the value-added is Toyota in the hybrid car industry. The source of value in the hybrid car industry is shifting to the battery technology because the battery is the *bottleneck* of the system to improve the value of the hybrid car. Toyota first created a fifty-fifty joint venture with Panasonic, a Japanese electronics manufacturer with significant expertise in lithium battery technologies, and developed the battery technologies for the hybrid car. However, now Toyota is increasing its share of this joint venture to 60% and integrating the core technologies from this company into Toyota.

A possible action that TV assemblers could take is to acquire smaller panel suppliers in Taiwan or in China; however, it might be difficult for the assemblers to take such a bold move because most of them are suffering from the loss of cash flows.

Among these four possible strategies that assembler firms can take to maintain their high share of the value-added, strategy 2 through strategy 4 are meaningful actions. In the next chapter, I will generalize the mechanism of value-shift and examine the strategies using other industry example.

Chapter 4: Value-Shift Mechanism

As seen in the TV set industry, incumbent firms can lose their value in the industry by losing access to the *bottleneck* components that are the keys to improve the total performance of the product and also by losing control over the *design rule* that determines the role of the players in the value chain. This phenomenon is also common in other assembly industries, such as the personal computer, the mobile handset, and the automotive industries. In this chapter, I describe the general mechanism and the evolution of the value-shift in four stages, suggested by the analysis of the TV industry in the previous chapter. I also describe each stage of the value-shift with examples from other industries. Then I propose the alternative strategies the incumbent firms could take to resist value-shift trends.

Incumbent firms did not lose its value-added only at one time. They lose most of the value-added through several wrong strategy decision-makings, not only once. Therefore, clarifying the mechanism of each stage of the value-shift is valuable to find the set of strategies that incumbent firms should take to defy value-shift.

4.1 Stage 1: Product Architecture Modularization and the Division of the Value Chain.

The first stage of the value-shift is further division of the labor in the industry. This industry dynamics occurs along with modularization of the product architecture. In the previous chapter I described further *splitting* of the TV sets architecture is the first stage; here I use the word *modularization* instead of *splitting*. *Modularity* includes the concept of splitting the architecture into subsystems but is defined in the more generalized way. Baldwin and Clark argued that the modularity is captured by *the idea of interdependence within and independence* *across modules* and the tree terms: *abstraction, information hiding and interface*[63]. Moreover, they describe modularity as following; *if the structure has the form of a nested hierarchy, is built on units that are highly interconnected in themselves, but largely independent of other units; if the whole system, then, by our definition, the thing is module*[64]. The essence of modularity is defined by following three characteristics:

1. **Nested subsystems** : subsystems exist in the system in a clear hierarchy;
2. **Reduced interdependence and the design rule**: the interrelations between subsystems are reduced so that the subsystems' information is "hided" from the whole complex system; as a consequence, some requirements are extracted from subsystems and generalized as a "design rule"
3. **Clearly defined interfaces**: the interfaces between subsystems are clearly defined.

For example, in the LCD TV set case, these characteristics were met when CRT displays were replaced by LCDs. The interrelations among a display and other subsystems were defined and eliminated and the interfaces between them were clearly determined. This modularity allowed the CRT displays to be replaced by the LCD panels without affecting other components such as demodulators, imaging processors or tuners. The interrelations between components are represented by the off-diagonal color cells in Figure 4.1. At least one conference between the people in charge of each component is required in order to determine the priorities and clarify the requirements of the subsystems. All the priorities and requirements are extracted as the *design rule* of the system. Then the product architecture is *modularized.*

This modularity of the architecture led to the division of the value chain. Because the interrelations between each component are reduced and the interfaces are clarified, different

[63] P63 (Chapter 3) of Carliss Y. Baldwin and Kim B. Clark (2000)
[64] P123 (Chapter 5)of Carliss Y. Baldwin and Kim B. Clark (2000)

firms can develop and produce each component. In the LCD TV industry, for instance, production of the LCD panel and assembly of TV sets are often done by different players.

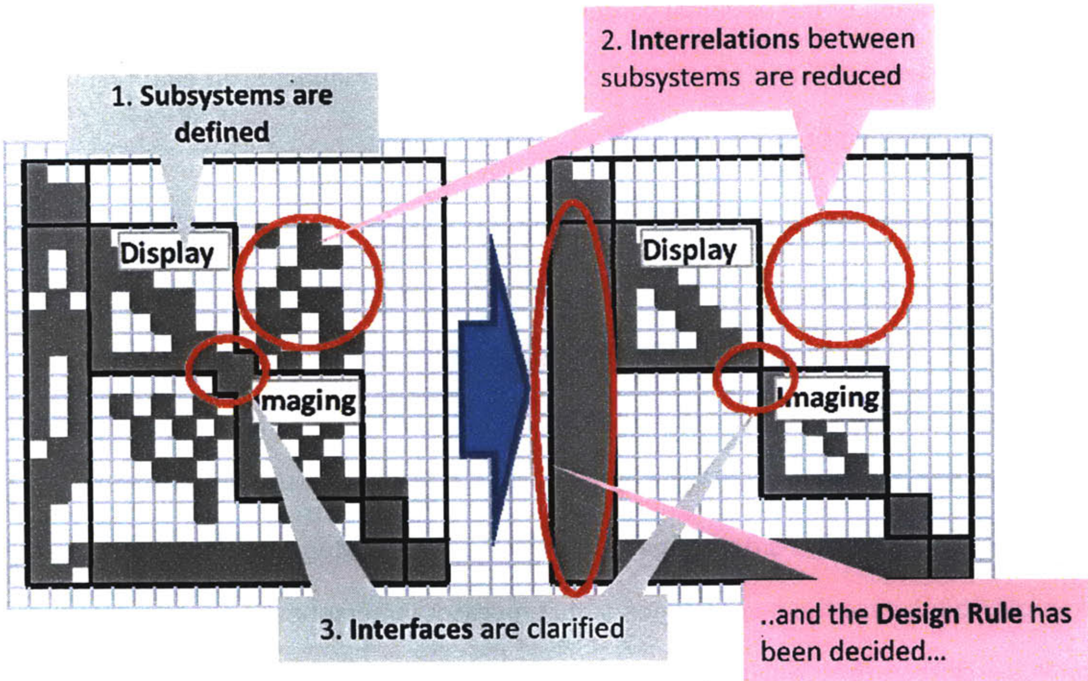

Figure 4.1: Modularization of the LCD TV set architecture

Modularization of product architecture and the accompanying value chain division are often seen in other industries. In the mobile handset industry, for instance, the 1G analog handset industry was highly integrated and mostly owned by Motorola. However the value chain was completely divided in the 2G and 3G technologies, and those subsystems were developed and produced by different players; baseband semiconductor by Qualcomm, Infineon, etc.; multimedia processors by Samsung, etc.; OSs by Nokia-Sony Ericsson (Symbian), Microsoft, and Google etc.; handset assembly by Nokia, Sony Ericsson, Samsung, Apple, and etc.; and the mobile applications by various producers[65]. Modularization of the computer systems is also a famous story. IBM developed the first modular family of computer systems, the System/360 to

[65] Fernando Suarez et al (2009)

achieve a compatible product line[66]. The modularization of the tasks in the System/360 was not followed by the division of the industry, but it led a division of labor within IBM. IBM also led the modularization of the personal computers in order to outsource the development of some components such as OS and micro processors for the faster launch. This event later triggered further division of labor in the industry.

Often times, firms should drive modularization for several reasons. One of the biggest reasons is to evolve the complex system without "writing off "the investment made in old technologies and to utilize the existing assets as much as possible[67]. Modularity enables the firm to evolve the whole system by replacing only one or two obsolete subsystems and utilizing other subsystems. This is what occurred in the LCD TV industry. Also, modularity enables each subsystem to evolve at a different pace because each subsystem does not affect the others. For example, to increase the performance of its processor in personal computers, Intel modularized the PCs architecture through defining interfaces between its processor and other components and hiding its processor from other components[68].

Another major motivation for the incumbent firms to drive modularization is *to increase the value of the total system with the same level of investment.* Using the option value theory, Baldwin and Clark have shown that a certain modularization will bring a bigger pay-off by enabling the industry to select better combination of subsystems[69]. Like a stock portfolio, holding options on a number of different subsystems permits the system to have less risk and higher expected value. With modularization, firms can maximize the system's value by selecting the best option in each component, deleting the components that are no longer valuable, or adding the components which become valuable. There is always an additional associated cost, such as the cost of achieving modularity, experimentation and integration; however, a new

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[66] Carliss Y. Baldwin and Kim B. Clark (2000)
[67] Carliss Y. Baldwin and Kim B. Clark (2000)
[68] Gawer and Cusumano (2002)
[69] Carliss Y. Baldwin and Kim B. Clark (2000)

combination of components generally gives higher value than the additional cost. Historically, many firms have benefited from modularity. Therefore, further modularization of the product architecture is often inevitable for firms.

Modularization of the architecture and the resulting division of the value chain is the trigger for value-shift; however, it does not solely entail value-shift. As long as the incumbent assembler firm owns the design rule to control the whole value chain and the development and the production of the strategic (or bottleneck) components, the firm can maintain a certain level of power over the industry and the value-added even when the firm outsources some of the non-strategic components. Apple's iPhone is a good example: the iPhone's product architecture is highly modularized and most of its components are outsourced to outside vendors. The outsourced components include not only commodities such as the display module, cameras and a flash memories, but also components with a smaller number of suppliers, such as an RF transistor and a baseband processor (Figure 4.2). However, the customers' *key buying factors* depend almost entirely on the OS and applications, so the quality of the software development and the management of the third-party application vendors is the *bottleneck* of the total system. Therefore, while controlling the suppliers' power through a strong design rule applied to the product, Apple focuses only on those two factors. As a consequence, Apple has a higher value-added (estimated 40% of the total value-added) than any other components supplier firm in the industry (Figure 4.3). Outsourcing is possible because the product architecture is highly modularized. However, Apple can take the biggest value-added in the industry, being the design rule owner. Modularization itself is not the sole mechanism by which incumbent firms lose the power and the value-added. It is simply a trigger for them to lose the strategic bottleneck components or lose the design rule.

Manufacturer	Multi-Source Probability	Component Description	Cost
Toshiba	High	Flash Memory NAND, 16GB, MLC	$24.00
	High	Display Module 3.5" Diagonal, 16M Color TFT, 320 x 480 Pixels	$19.25
	Medium	Touch Screen Assembly Capacitive, Glass	$16.00
Samsung	Low	Application Processor ARM Core, Package-on-Package	$14.46
Infineon	Low	Baseband HSDPA/WCDMA/EDGE, Dual ARM926 and ARM7Core	$13.00
	Medium	Camera Module 3 Megapixel Auto-Focus	$9.55
Samsung (with Elpida die)	High	SDRAM - Mobile DDR 2Gb Package-on-Package (Mounted on Application Processor, Two Die)	$8.50
Broadcom	Low	Bluetooth/FM/WLAN Single Chip, WLAN IEEE802.11b/g, Bluetooth V2.1+EDR, with FM and RDS/RBDS Receiver	$5.95
Numonyx	High	Memory MCP 128Mb NOR Flash and 512Mb Mobile DDR	$3.65
Infineon	Low	RF Transceiver Quad-Band GSM/EDGE, Tri-Band WCDMA/HSDPA, 130nm RF CMOS	$2.80
Infineon	Low	GPS Receiver Single Chip, 0.13um, with Integrated Front-End RF, PLL, PM, Correlator Engine and Host Control Interface	$2.25
Infineon	Low	Power IC RF Function	$1.25
Murata	Low	FEM Quad-Band GSM, Tri-Band UMTS Antenna Switch and Quad-Band GSM RX RF SAW Filters	$1.35
Dialog	Low	Power IC Application Processor Function	$1.30
Cirrus Logic	Low	Audio Codec Ultra Low Power, Stereo, with Headphone Amplifier	$1.15
		Rest of Bill-of-Materials*	$48.00
		Total Bill-of-Materials	$172.46
		Manufacturing Costs*	$6.50
		Grand Total	$178.96

Figure 4.2: Apple iPhone's List of Outsourced Components[70]

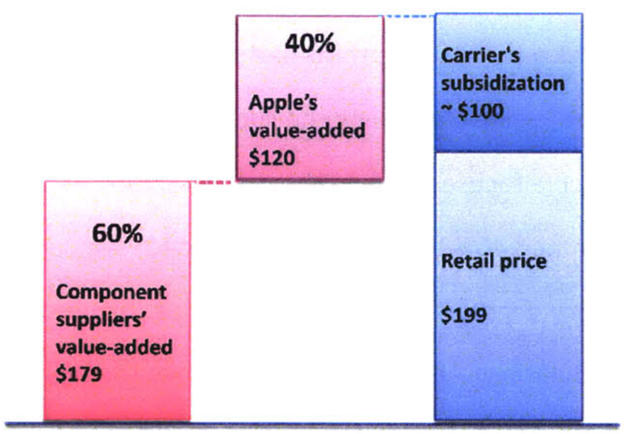

Figure 4.3: Apple's Estimated Value-Added in the Industry

Considering that a high level of modularization can trigger the value-shift, avoiding the modularization is one of the strategies that an incumbent can take. As discussed briefly in the

[70] Source: iSuppli; C-net news (2009/06/24): http://news.cnet.com/8301-13924_3-10272240-64.html

section 3.5.1, Toyota intentionally leaves the interfaces between Toyota and its suppliers unclear even in *supplier proprietary parts* or *black-box parts* to strengthen the control over the suppliers[71]. Toyota then owns and maintains the *design rule* of the total architecture and defines the role of suppliers. Leaving a certain amount of interrelations unclear will help the firm to maintain its power over the industry and therefore the value-added in the whole system.

Avoiding modularization is important not only for owning control over the industry but also for crisis management. Too much modularization makes it difficult for assemblers to find problems because a problem can be *hidden* in one of the many subsystems. For example, Boeing delayed the completion of its Dream Liner because it modularized the product architecture into too many modules with too many suppliers; therefore, it took a long time to find the problem when integrating the total system[72].

4.2 Stage 2: Values Centralized in a Single Module and Incumbents Lost the Access

The second stage of the value-shift is that only a few subsystems of the entire system become more important than other subsystems. In addition, the incumbent firms that were originally vertically integrated assemblers delegate the development and production of those valuable components, intentionally or unintentionally, to suppliers and lose access to those components. An unintentional example is the CRT- to - LCD technology transition. Most of the CRT TV incumbent assembly firms lost access to LCD because they had bet other technologies such as PDP, SED and OLED, which finally did not come out as the dominant design. An intentional example was IBM's PC case. To launch the product within 15 months, in order to catch up with the rapidly growing Apple II computers, IBM outsourced the design of most of its

[71] Kim B. Clark and Takahiro Fujimoto (1991)
[72] James McNerney lecture in MIT Sloan (April 2010)

major components to non-IBM manufacturers[73] and did not need to wait long to gain expertise[74]. This strategy enabled IBM to be in an industry leadership position (its market share was 50% in 1985) and to control the role of suppliers and maintain strong bargaining power until the late 1980s. Either intentionally or unintentionally, losing access to the source of value weaken incumbent firms' power over the value chain can leads to stage 3 of the value-shift described below.

As illustrated by in the TV industry case, the main reason that only one of components becomes valuable is that the component is the *bottleneck* of the entire system; a firm can improve the value of the whole system by improving the performance of the bottleneck component. Possessing a bottleneck component in-house is the biggest source of the value for a firm. There are other industry examples: in the automobile industry, software and electronic parts become the most valuable components because most of quality problems are now arise from the unreliability of electronic components; according to McKinsey & Company's research, electronic failures are responsible for approximately half of all vehicle breakdowns[75]. Furthermore, it takes a long time to integrate and test the software, delaying the time to market and becoming the critical issues for assemblers. Therefore, the improvements in electronics and software will increase the total performance of the car significantly; they are clearly the bottleneck. However, those bottlenecks are now mostly owned by electronics suppliers (such as Bosch and Denso) and the incumbent OEMs are losing value in the industry.

Here I describe the mechanisms of how only one or two components become bottlenecks using the *"modular operators"* proposed by Baldwin and Clark. Of six modular operators, *splitting* and *excluding* are not related to the creation of a bottleneck; the other four

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[73] Alfred D. Chandler, Jr. (2001)
[74] Peter L. Grant (2000)
[75] P87, McKinsey & Company (2005): McKinsey forecasts the value of the electronic components will increase to 40% of the total vehicle value in 2015 from 19% in 2004

operators *substituting, augmenting, inverting and porting* can be operators to create bottleneck module. (Figure 4.4 and Figure 4.5)

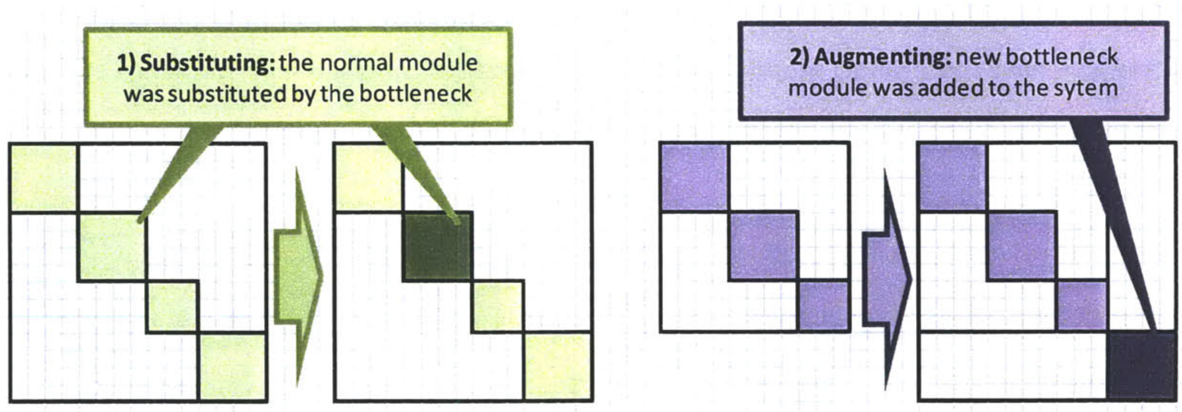

Figure 4.4: Four Modular Operators to Create Bottleneck Module (1 of 2)

1) ***Substituting*** **one module with a new bottleneck module:** The LCD TV case illustrates this mechanism. A subsystem (a display) becomes the bottleneck because the old and saturated technology (CRT) was substituted to the emerging new technology (LCD). Now the performance of the substituted module is very low and the improvement of the module is the key to improving the overall performance of the system. Other modules lose value-added relative to the new bottleneck module. In this mechanism, the incumbent firms easily lose their access to the bottleneck module because supplier firms (Sharp and Samsung) that already have the expertise in the technology (LCD) use their expertise to replace the old components (CRT) with the new bottleneck component (LCD). Therefore, the incumbent firms can lose values.

2) ***Augmenting*** **– adding a new bottleneck module to the system:** The car electronics and software case I described earlier illustrates this mechanism. Mechanical parts and assembly were originally the largest source of value-added and mostly owned by incumbent assemblers (OEMs). However, electronic parts and software, the bottleneck modules, were *added* to the system and mechanical parts and assembly have lost their value relative to the new modules. OEMs do not have the expertise in those new modules; instead 1st tier electronic components suppliers such as Bosch and Denso have the expertise. Supplier firms now have more value-added as well as more power to control the performance of the entire system. Consequently, the incumbent firms' value-added is squeezed.

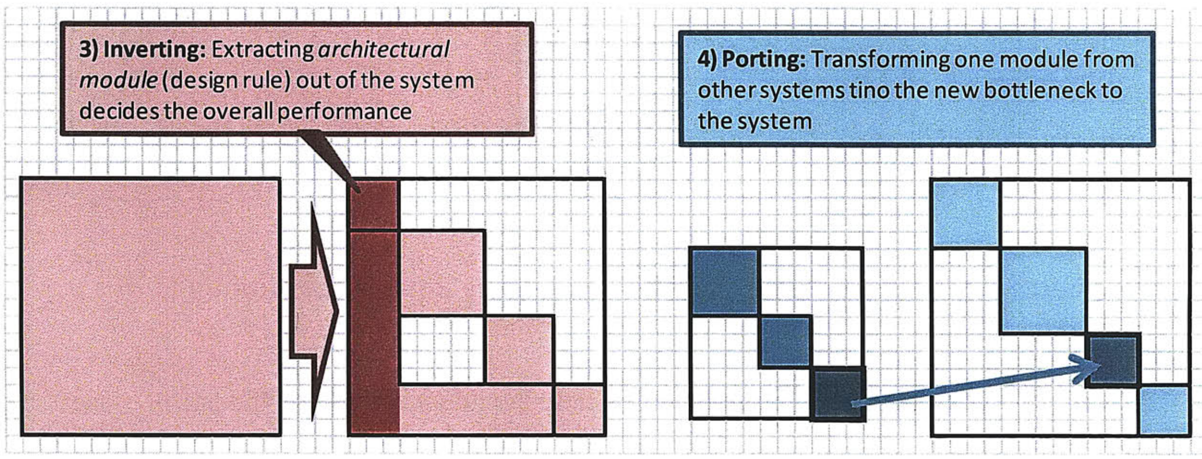

Figure 4.5: Four Modular Operators to Create Bottleneck Module (2 of 2)

3) ***Inverting* new bottleneck module:** *Inverting* means extracting core functions from the system and creating a *design rule*. A *design rule* is the set of tasks or modules that are at the top of the hierarchical orders of the system, *visible* to the entire system and interrelated to other hidden modules. A change in the design rule will affect all the modules in the system. The modules that function as design rules are called *architectural modules* by Baldwin and Clark[76]. (Figure 4.6)

Creation of operating systems is one example of an *inverting* new bottleneck module. Once the operating system is extracted as the set of functions that rule the functions of other components, it becomes the b*ottleneck* component of the system and its focused development

[76] P333 Carliss Y. Baldwin and Kim B. Clark (2000)

becomes the competitive advantage. By *inverting* a set of bottleneck functions into a bottleneck module and focusing investments on its development, a firm can make investments more efficient. When this module is separated from the entire development process and is acquired by supplier firms, those firms have more value-added in the industry. This took place when IBM *inverted* operating systems and microprocessors of personal computers and outsourced them to Microsoft and Intel.

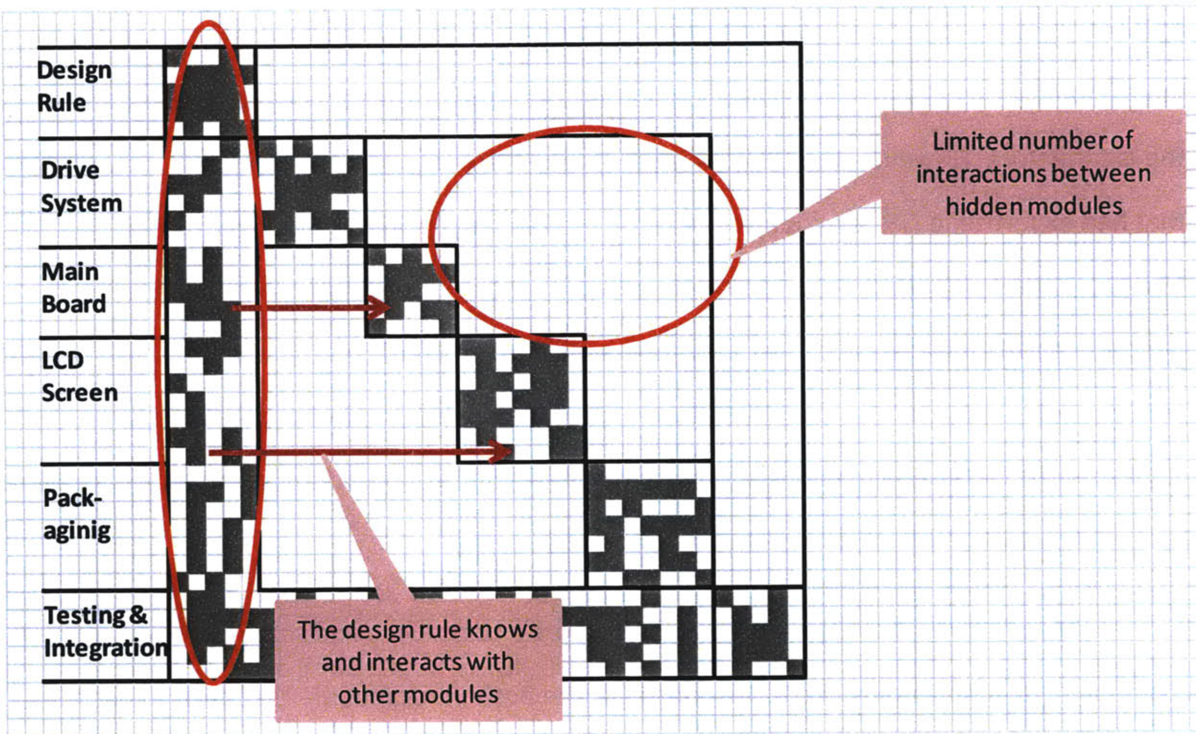

Figure 4.6: Design rule knows and interact with other modules

Note that *inverting* is an important module operator for suppliers wanting to take over the design rule from the incumbent assemblers and assume industry leadership, as I will discuss in section 4.4, the fourth stage of the value-shift mechanism.

4) ***Porting* a module into a new bottleneck module in other system:** *Porting* means taking out a module developed for one system and making it work in another system. This operator is a combination of *splitting* and creating an interface (called a *translator module*) between the ported module and the new system. *Porting* often works to create a new bottleneck module in other systems.

In the mobile handset industry, for instance, porting operating systems from PC architecture to mobile handset architecture created a new bottleneck in this industry. The mobile handset was originally vertically integrated and the bottlenecks were spread out over the architecture. However, the OS became the competitive advantage after it was *ported*. Firms that had expertise in OS development became the key players in this industry, such as Microsoft and Apple. *Porting* an idea of an independent microprocessor into the mobile handset created a bottleneck as well. When handset assembler firms outsourced those *ported* bottlenecks to supplier firms, supplier firms gained larger value-added in the industry. Qualcomm in 3G baseband processor and Samsung and Intel in multimedia processors came to take a large portion of value-added in the handset industry.

These four modular operators work to create a bottleneck and shift it from incumbent assemblers to suppliers. By losing the control of the bottleneck module that determines the overall performance of the system, an incumbent firm also loses the biggest portion of its value-added. This process is one of the mechanisms by which value shifts from incumbent assemblers to suppliers.

4.3 Stage 3: Incumbent firms "Lost" the Design Rule

After the incumbent firms lose the most valuable bottleneck component, they also tend to lose the overarching rule that control the entire architecture: *the design rule*.

Losing the bottleneck module (stage 2) and losing the design rule (stage 3) is different. Losing a bottleneck module solely drives the value-shift, as discussed in section 4.2, but losing the design rule entails a further value-shift. For example, in the PC industry, when IBM lost bottleneck components by outsourcing the development of OS and microprocessors when it launched the PC business in 1981, it lost more of its value-added (stage 2) than when it did not outsource at all. Although there are many IBM PC-compatible businesses and the PC market was very competitive, IBM remained *the most powerful player and set the directions that others followed*[77] by maintaining and updating the design rule that determined the entire PC architecture. For instance, in 1984, it was IBM who introduced the more advanced PC-AT architecture and the rest of the industry. Not only the suppliers and complementary goods suppliers but also PC clone makers followed IBM's movement. In this architecture, the ISA (Industry Standard Architecture), the bus that connected all the components in the PC, such as the hard disk, the graphics chips and the CPUs, played the role of design rule through being visible to and interrelating with all those components. However, the design rule again became obsolete, especially because the slow speed of the ISA became a bottleneck in the PC architecture. A new design rule to replace ISA was suggested by both IBM (Micro Channel Architecture, or MCA) and Compaq (Extended ISA); this battle over the bus leadership caused a big confusion in the PC industry[78] because *the leaders weren't there*[79]. In the late 1980s, IBM clearly lost further value-added because its bargaining power against the suppliers became smaller.

Incumbent assemblers thus lose the value-added when they lost the control of the design rule. This situation also took place in the LCD TV set industry, as discussed in chapter 3.

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[77] Albert Y. Yu (1998)
[78] Albert Y. Yu (1998); Robert A. Burgelman (2002)
[79] This expression is from A. Gawer and M. A. Cusumano (2002)

4.4 Stage 4: Component Supplier Strategically Takes, Re-organizes and Reinforces the Design Rule

The final stage of the value-shift is induced by the suppliers' strategic move to take over industry leadership. When a supplier takes over the design rule that was originally owned by an incumbent assembler, the supplier has more bargaining power over the assembler, and finally the value of the assemblers is completely squeezed. Note the value-shift in the TV industry included only from stage 1 to stage 3. Stage 4 is discussed here for the first time.

One notable example of this stage is Intel's development of the PCI bus in the PC architecture. As introduced in section 4.3, IBM owned the design rule of the PC industry (ISA bus and I/O bus) in the early 1980s but failed to maintain its quality up to date in the late 1980s. ISA was very slow and limited the performance of the other components in the PC; ISA had reached the technological plateau and had to be replaced. Intel was very frustrated by this speed[80]; even though Intel introduced faster microprocessors, the overall speed of the PC did not increase due to this slow bus. Moreover, an I/O (input/output) bus that determined the speed at which data arrived at and exited the microprocessors also killed the processing speed of the microprocessors[81]. In 1991, Intel established the new laboratory called the Intel Architecture Lab (IAL), developed the Peripheral component Interconnect (PCI), and drove the industry to replace ISA and adopt this new bus[82]. With this Intel's strategic move, PCI became the *global design rule* of the entire PC architecture because now it was the PCI bus that was *visible* to and interconnected to the all the components of the PCs. In other words, Intel *moved up* the value chain upstream and took over the *architectural module* (design rule module), becoming the industry leader that determined the all the interfaces and relations among other

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[80] Robert A. Burgelman (2002)
[81] Annabelle Gawer and Michael A. Cusumano (2002)
[82] Robert A. Burgelman (2002)

components (Figure 4.6). Note that Microsoft took part of the design rule to control the part of the PC architecture.

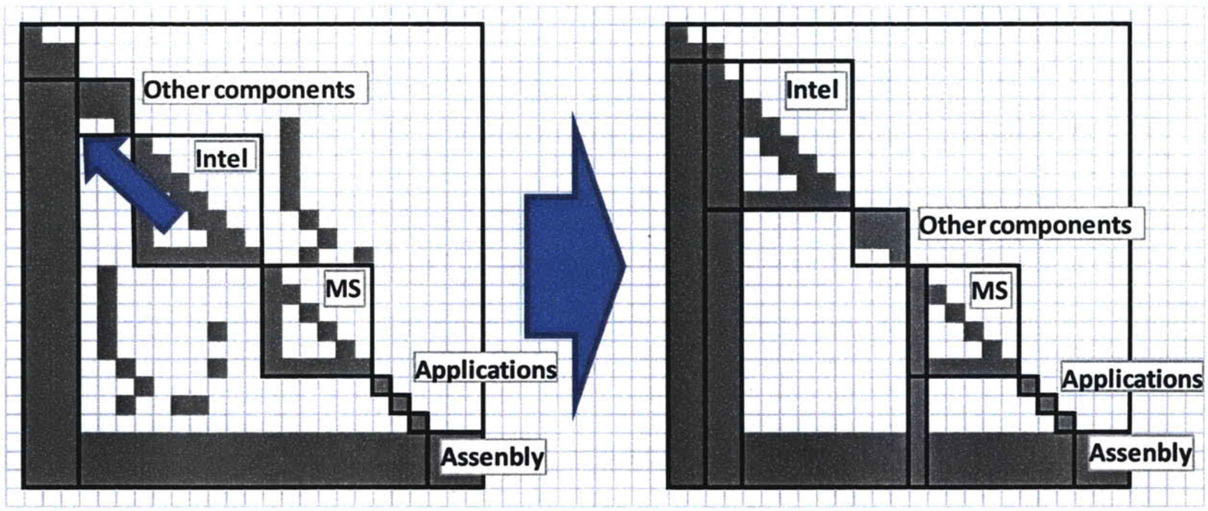

Figure 4.7: Intel's Strategic Move to PCI and USB Bus to Take Control of the Entire Architecture

Under this new design rule, Intel engineers removed the interrelations between Intel processors and the other components so that future versions of the microprocessors would not require a redesign of anything else in the PC architecture[83], and allowed Intel to accelerate the further evolution of processors no matter how slow the rest of the industry developed the components. In other words, Intel made the design rule more obvious and *hid* the processors' information, and *decoupled Intel's zone of innovation from the rest of the computer*[84].

Creating effective design rule at the architecture level is one of the success factors that Intel adopted; in addition, there were other business strategies that Intel employed to drive the whole industry to adopt a new design rule. The following four strategies were critical in Intel's becoming the industry leader.

[83] Annabelle Gawer and Michael A. Cusumano (2002)
[84] Annabelle Gawer and Michael A. Cusumano (2002)

1) **Demonstrate strong commitment to the new design rule**: To convince IBM, Compaq and other OEMs to adopt PCI, Intel had to demonstrate its strong commitment by making a large investment in the mass production of PCI chip sets and renaming the company division "PCI component division"[85].
2) **Gain strong customers' pull through "Intel Inside" marketing campaign**: Intel increased its customers' recognition and reputation and made customers select PCs based on the performance of microprocessors. By doing this, Intel could increase bargaining power against other players and make them adopt the new design rule.
3) **Build some peripheral components that support the new design rule:** In 1993, Intel created a motherboard that had a chip, a bus, and a chip sets so that other suppliers and complementary suppliers could easily see what they had to do.
4) **Create and support new complementary suppliers in the ecosystem**: Intel developed a set of programmable instructions to make it easier for complementary suppliers to adopt the PCI hub. Intel also developed tools for smaller PC makers to make it easier for them easier to produce higher quality PCs at a lower cost and compete against IBM and Compaq.

Clearly, not only a product architecture strategy but also a business strategy such as gaining more bargaining power is important for suppliers to take over the industry leadership. After a supplier takes the control over the design rule, incumbent assemblers usually lose most of their value-added and it becomes very difficult to maintain previous organizational structure. Therefore, most PC makers withdraw from the assembly and outsourced it to Taiwanese or Chinese assemblers with low-cost labor, utilizing the brand value that they developed.

[85] Annabelle Gawer and Michael A. Cusumano (2002)

In the next section, I propose what strategies for both parties: strategies that incumbent assembly firms can use to defy value-shift and that supplier firms can adopt to take more value-added.

4.5 Possible Strategies for Incumbent Firms

In this section, I discuss generalized strategies for incumbent firms to defy value-shift and how they can evaluate the strategy according to the industry situation. As discussed in detail for the TV industry in chapter 3, there are four generalized strategic measurements that incumbent assembler firms can use to defy value-shift and one last resort survival strategy.

4.5.1 Strategy 1: Decelerating too much modularization works in some industry

As discussed in section 4.1, modularization is often inevitable because it gives positive value to a firm by allowing the firm to choose the best combination of modules and by increasing the value of a product with less investment. It is also beneficial for the whole industry because it increase the innovation ratio. Therefore, decelerating the speed of modularization is *not* the best strategic option for most incumbent firms. In fact, accelerating modularization is more beneficial for firms in most cases.

However, as discussed in section 4.1, in some complex assembly industries such as the automobile and aerospace industries, too much modularization lead significant cost increase of integrating modules and risks of quality problems, thereby cancelling its benefit. In this case, maintaining a certain level of integration between modules and controlling all the interrelations among modules is not only beneficial for incumbent assembly firms in terms of increasing quality, lowering costs and accelerating delivery. (See section 3.5 for Toyota's strategy) Defying a possible value-shift is a sub product of this strategy.

4.5.2 Strategy 2: Disperse the value of the product to several components

The main purpose of this strategy is avoiding the centralization of the product values in the supplier firms' component. By dispersing the source of overall performance improvement to several other components that the incumbent assembly firms control, they can lower the relative value of the supplier firms' *bottleneck* components. In other words, this creates new *bottleneck* in the system that is controllable by the assembly firms.

The four modular operators discussed in section 4.2 are useful in creating new bottleneck modules. By *substituting* the old and saturated module with a bottleneck module or by *augmenting (adding)* a new bottleneck module to the system and continuously developing the performance of the modules, the incumbent firms can disperse the value of the products to those new bottlenecks. *Inverting* the architectural module not only works to create new bottlenecks but also intensifies the incumbent firm's control over some suppliers related to the module. *Porting* modules from other products is suitable for incumbent firms that have several different product businesses. The examples in section 4.2 will be helpful in building realistic actions for incumbent assembly firms.

4.5.3 Strategy 3: Re-build the Design Rule that control the entire architecture

To rebuild the design rule of the product and recover control over the value chain, incumbent firms have to create a new design rule module by setting new and more efficient standards that will bring more values to other players in the industry. The firms need to acquire architectural knowledge and expertise in each component to build such efficient design rule acceptable for other firms[86]. Investment in R&D should focus on creating an efficient design rule rather than developing each component technology.

Then incumbent firms should diffuse the new design rule throughout the industry. To drive other assemblers, suppliers and complementary provider to use the design rule, the firm can utilize Intel's strategic actions described in section 4.4.

- **Demonstrate strong commitment to the new design rule**: Because no one knows whether a new design rule will become the industry standard, other firms generally hesitate to invest in such a design rule. Therefore, incumbent firms should show a strong commitment to use the standard in order to gain their buy-ins.
- **Gain a strong customer pull**: If incumbent firms already have the strong customer demand for a product, suppliers and complementary providers can follow the standard without worrying.
- **Create an ecosystem of new complementary suppliers and support them**: Increasing the number of small players that can profit from a new design rule is also useful in convincing other me-too players to follow the new design rule.
- **Build peripheral components to support new design rule to support other players**: Enabling target firms to follow the design rule by building their skills and providing support tools to lower their cost of transition is also a key in persuading them to follow the design rule.

By taking these actions, incumbent firms can create an effective ecosystem around their new design rule and regain control over the industry.

[86] Carliss Y. Baldwin (2010)

4.5.4 Strategy 4: Maintain or Reenter the components with the biggest value

If the incumbent assembly firm can maintain the key *bottleneck* component in-house, obviously it should do so. However, when the value shifts to the components that supplier firms own, the incumbent assembly firm has to take a bold move to acquire the component knowledge through cross-licensing, collaborative product developing, creation of joint venture or M&A. The level of the knowledge that the firm can acquire is smallest in cross-licensing and largest in M&A because, in the latter case, the firm can acquire the tacit knowledge that is not licensed nor clearly defined but embodied within the organization.

Toyota's acquisition of hybrid car battery technology discussed in section 3.5.4 is a good example of how an incumbent assembler can acquire knowledge through joint venture. However, the risk of entering into joint venture with supplier firms that have only component knowledge is the tacit or undefined knowledge of the incumbent firm can shift to the supplier firm. The firm has to undertake careful knowledge management when it forms joint venture.

4.5.5 Strategy 5: Take thin operation

For an incumbent assembly firm that has lost both the *bottleneck* components and the *design rule* of the entire product architecture, continuing assembly operations with a high level of overhead is just costly because the value-added the firm can take is now very small. Motorola case described in section 1.2.3 is an example that the firm failed because of this.

The last resort for this firm is to withdraw from the assembly operations and to shift most of the corporate resources to a new business. IBM took this approach in the PC industry; it sold its PC production to a Chinese PC assembler, Lenovo, in 2005 but it kept trademark licensing for 5 years. Philips is also taking a similar approach in the TV set industry; it has outsourced more than 70% of its TV productions to outside vendors but has kept the Philips brand name on its TVs. This strategy is the last resort for the firms and it often requires large scale lay-off of engineers; however, the firm at least can avoid losing money from the large overhead cost, despite losing value-added in the industry.

4.6 Possible strategies for supplier firms

From the supplier firms' perspective, modularization of product architecture, division of the value chain, and shifting of value to *bottleneck* components are opportunities to take over industry leadership from incumbent assembly firms. The following three strategies are the key for supplier firms.

4.6.1 Enter the bottleneck components in the early stage

To gain the design rule of a product in the later phase, it is important for supplier firms to own the key bottleneck component. The supplier firms have to find the next generation bottleneck technology long before the dominant design[87] is determined, and possess a significant level of knowledge about the bottleneck components; whether through in-house development or M&A. Baldwin[88] suggested that owning the *architectural knowledge*, the knowledge of the entire product architecture, is important in finding the bottleneck part. Other strategies that supplier firms can take to gain next-generation technology dominance are discussed in detail in Suarez (2004)[89] and Suarez and Lanzolla (2007)[90].

[87] James M. Utterback (1994)
[88] Carliss Y. Baldwin (2000)
[89] Fernando F. Suarez (2004)
[90] Fernando F. Suarez and Gianvito Lanzolla (2007)

4.6.2 Take over the design-rule of the product from the incumbent assembly firms

Utilizing the detailed knowledge of the *bottleneck* components, the supplier firms have to create a new design rule module and diffuse it as the industry standard. This strategy is essentially the same as the incumbent firms' strategy to re-build a design rule, discussed in section 4.5.3.

4.6.3 Continue developing the design-rule to keep control

Finally, maintaining the latest design rule to fit the current structure of the industry and to match the key players' needs is very important for keeping control over the value chain. Otherwise, supplier firms will face the same fate as the incumbent company: losing design rule.

4.7 Conclusion

In this section, I have discussed the generalized but detailed mechanism of value-shift in four stages using Baldwin and Clark's modularity theory and the idea of a *design rule*. The four stages: 1) the product architecture is modularized and the value chain is further divided; 2) the source of value is centralized only in the *bottleneck* components and the incumbent assembly firms lose access to the components; 3) the incumbent firms gradually lose the *design rule* and control over the industry; 4) the value of the incumbent firms is much more squeezed when supplier firms take over the *design rule* and start controlling the whole industry.

Then I suggested strategic options that incumbent firms can take. Modularization of a product is often inevitable for incumbent assembly firms wanting to make use of the best technologies and increase product value with less investment; however, there are several other strategies for defying value-shift depending on which stage the current industry occupies. On the other hand, for supplier firms, the value-shift is the opportunity to take over industry leadership from incumbent assembly firms.

Chapter 5: Conclusion – Impact of the Thesis and Next step

In this thesis, I have offered a new perspective on the industry dynamics named *value-shift* and investigated its detailed mechanism through an analysis of the TV set industry supplemented by several examples from other industries. As a conclusion, I extract the key impact of this work and discuss the possible future applications of the theory.

5.1 Impact of the Thesis

In Chapter 1, I reviewed major studies done by business scholars in an attempt to answer the question of why incumbent firms lose their leadership. I argued that not many studies have looked closely at specific case that incumbent firms' value is taken over by supplier firms. Below I delineate other key impacts that this thesis may bring to the business strategy research and on the industry.

1) **Extract instances of the phenomenon as observed in many different assembly industries and synthesize them as a new concept called *Value-Shift***: Many people have discussed intuitively that the phenomenon of incumbent assembly firms losing their power and supplier firms taking over leadership; however, there was no theory connecting this phenomenon across different industries and no single term to describe this phenomenon. This thesis extracts instances of the phenomenon seen in various industries and synthesizes them into the concept of *value*-shift. Creating a term for the concept increases people's awareness of it and makes it easier to collect more industry

data points to verify.

2) **Show how to calculate the impact of value-shift in number which people recognize intuitively and calculate the impact using one industry example**: This thesis also intends to show the *fact* that value-shift is occurring in some industries, using real numbers. This calculation also urges people to go beyond intuitive discussions of value-shift and engage in fact-based discussions.

3) **Propose the mechanism of the value-shift in four stages**: This thesis shows that value-shift does not occur at only one time; value-shift actually *evolves* when incumbent firms make the wrong strategic decisions (including doing nothing) or supplier firms take aggressive actions to take over leadership. Showing the mechanism of value-shift is very important to understand the phenomenon and to nail down the real problems that firms face.

4) **Show that incumbent assemblers lose value not because of modularization alone but because of the poor strategic decision-making** : When I was working as a consultant in McKinsey, I heard many business consultants and business leaders from the incumbent firms argue incumbent firms are losing values due to modularization. However, as shown in the thesis, modularization will give positive value for both of the incumbent firms and the industry if the firms utilize it correctly. Also, the thesis showed there are two or more decision making points for incumbent firms may be able to regain their values.

5) **Connect organically the independent ideas of several famous studies from the 1990s and 2000s**: By establishing the value-shift concept, I connect several scholars' works

that have not previously been connected, namely Cusumano[91]'s *Platform Leadership,* Baldwin and Clark[92]'s *Design Rule*, Baldwin[93]'s *Bottleneck Components,* and Henderson and Clark[94]'s *Architectural Innovation* and *Modular Innovation.*

6) **Provide a new tool to forecast the industry's future and possible actions that firms can take**: the mechanism of value-shift in four stages and the set of strategic options will serve as a new tool to investigate other industries and to forecast the future of those industries. It also offers clues for firms involved in those changing industries. I show possible areas of application in the next section.

5.2 Possible Application Area

In my future work, I will continue doing research on the TV industry, where some of my hypotheses are not yet fully verified with supporting facts. In addition to this, I propose some other industry areas that I apply the mechanism of value-shift to forecast the future of these industries and discuss what actions the firms involved should take. Along with the application to other industries, I also can revise and expand my theory to make it applicable to industries in general.

5.2.1 Hybrid Car and Electric Vehicles Industry

The automotive industry is currently facing two major technological transitions: from the gasoline-powered cars to hybrid cars and to electric vehicles (EV). In the transition to hybrid cars, although the overall architecture of the car has not experienced major changes, the

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91 Annabelle Gawer and Michael A. Cusumano (2002); Michael A. Cusumano (2010)
92 Carliss Y. Baldwin and Kim B. Clark (1997); Carliss Y. Baldwin and Kim B. Clark (2000)
93 Carliss Y. Baldwin (2010)
94 Rebecca Henderson and Kim B. Clark (1990)

electrical components, such as battery and electric inverters, are becoming more powerful within the entire architecture. I assume this transition will be consistent with the value-shift mechanism.

In the transition to EVs, the dominant design of EVs is not determined yet, so it is difficult to say whether the transition will require large architectural changes or whether the transition is more modular in nature and will not require major architectural change. The former type of transition is suggested by university researchers and some EV venture firms in the US; the latter transition is suggested by venture firms dealing with electric components and incumbent OEM firms. I intend to formulate two scenarios to forecast the transition of the industry and apply the value-shift mechanism to the latter scenario.

5.2.2 Mobile Handset industry

The mobile handset industry is also facing major changes. The *bottleneck* component of this industry is now clearly the OS and the application software; two business strategies, the horizontal and open strategy and the vertical and closed strategy, are crashing in the same industry. Google represents the former strategy, developing an open source OS called Android. Microsoft is also shifting its strategy to this side by releasing Windows Azure. These two firms are trying to gain only *bottleneck* components horizontally. On the other hand, Apple opts for more vertical and closed strategy by building their proprietary software and the ecosystem of its application software that work only with Apple products. Therefore, the industry change is not that simple as in the TV industry – it is not always the case that value shifts from incumbent assemblers to suppliers. As a result, I have to make some changes to the proposed value-shit mechanism. However, for some incumbent handset assemblers, such as Sony Ericsson, that are shifting from in-house OS development to using Android, I can apply the value-shift mechanism for those firms to maintain their power over the industry.

5.2.3 Non-Assembly industries, such as e-book readers

I also suggest applying the theory in a non-assembly industry that has a clear value chain. For example, the publishing industry is now facing the major transition to e-book readers; publishers, the original orchestrators of the a book's value chain, are losing their value, which is being taken over by e-book readers devices and market places such as Amazon. There is no *architecture* as within the assembly products, but by mapping the activities and tasks of the industry, I believe I can expand the value-shift mechanism to non-assembly industries.

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