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The Semiconductor Industry’s Role in the Net World Order

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Since its beginnings in the 1960s, the semiconductor industry has been characterized by a series of transformations driven by technology advances and changing markets (Tilton, 1971; Braun and Macdonald, 1982; Borrus, 1988). This chapter examines the most recent transformation, which is driven by the emergence of distributive networks as the leading application for the electronics industry. New forms of network communication and information flows are giving rise to what we call the "Net World Order." Our analysis of the industry focuses on how chip makers are creating and capturing value within the emerging Net World Order compared to the 1990s when the personal computer (PC) was the most important destination for semiconductor devices.

Spurred by breakthroughs in the United States, including the development of the integrated circuit (or "chip") and the creation of the microprocessor, the 1960s and 1970s saw the rise of semiconductor producers in the United States, Europe, and Japan. Despite its history of technology leadership, the United States semiconductor industry's market leadership had diminished by the mid-1980s when Japanese firms displaced their U.S. counterparts largely on the strength of their manufacturing prowess applied to memory chips (primarily DRAM), which became commodities. The 1990s saw a "reversal of fortune" as U.S. firms responded with both improved manufacturing capabilities and more sophisticated designs (Macher, Mowery, and Hodges, 1998). The key application for semiconductors during the 1990s was the PC. Intel, who had been selected in 1980 as the supplier of the microprocessor for the initial IBM PC, became the world's largest chip supplier beginning in 1992.[1]

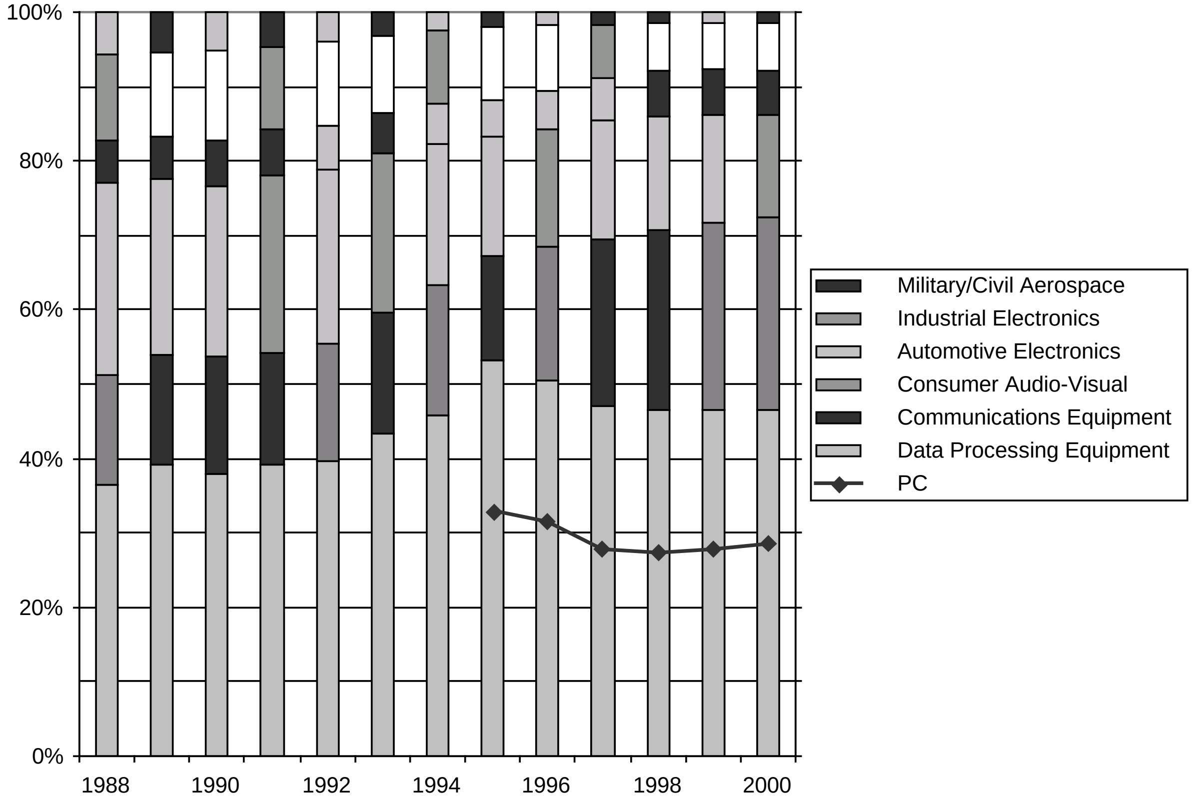
This chapter discusses the implications of a new set of changes that are looming in the semiconductor industry. First and foremost, the PC sector is declining in relative importance as communications applications become a bigger market for chips. This shift in the electronics industry has been widely heralded as the dawn of the "Post-PC era" in which the central application is the Internet, along with the home, office, and wireless networks connected to it, which are collectively known as "distributive networks."[2]

Figure 1 illustrates these changes. During the early 1990s, the share of semiconductor sales to products in the data processing sector climbed steadily to a 1995 peak of more than 50% of all semiconductors sold. Since 1995, data processing's share, about three-fifths of which is accounted for by personal computers alone, has fallen to 47%, while the share of chip sales to the communications sector (both wireline and wireless) has almost doubled to 26%. Much of this chapter is devoted to delineating the differences between the PC and communications markets for semiconductors and noting the corresponding differences in the requirements for competing in these markets.

[1] based on data from Dataquest.

[2] In a telling example, albeit one that was perhaps driven in part by the dot-com bubble, Ziff-Davis changed the name of its venerable "PC Week" magazine to "eWeek" in May 2000.

Figure 1: Sales of Semiconductors by Final Product Market, 1988-1999



SOURCE: DATAQUEST (July 2000)

The second major transformation occurring in the semiconductor industry has to do with the PC semiconductor market itself, which is no longer the one-company story it has been for much of the last decade. Although Intel is still the world's largest chip vendor, its dominant position in microprocessors no longer appears as unassailable as in the past. In 1998, Intel's most serious rival, Advanced Micro Devices (AMD), finally began volume production of a microprocessor aimed at the budget PC market after several years of mis-steps. By the third quarter of 2000, according to one source, AMD's share of PC microprocessor units had reached 17%.[3] Among other Intel rivals, TransMeta, a U.S. start-up, is marketing a low-power design that has attracted attention for portable PCs, particularly in Japan, a large market for notebook computers.[4]

Yet even as Intel faces credible competitors in the PC market, it must divert resources to build a position in the Net World Order where it does not enjoy a standards-based advantage. An understanding of the special case of Intel is essential to understanding the changes in the industry overall.

A third change is that the role of manufacturing in building competitive advantage has declined. Intel's dominance of the semiconductor market has been built in part on its commitment to manufacturing excellence (Appleyard, et al., 2000). Rapid successive

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[3] Mercury Research data reported in"Newly Competitive AMD Prepares To Battle Intel in Corporate Market, *Wall Street Journal Interactive*, December 27, 2000.

[4] "Transmeta 'Crusoe' is in All Major Japanese Vendors' PCs," *Asia Biz Tech*, May 22, 2001.

introductions of new generations of process technology enabled the creation of faster microprocessors. Few companies could match the technology level or volume of Intel's production.

Yet manufacturing has become less of a differentiator among semiconductor firms for two reasons. First, many products that used to require specialized manufacturing processes can now be fabricated in the industry's most common process, known as CMOS. Second, providers of chip manufacturing services – foundries that design no chips of their own – have achieved technical levels in CMOS manufacturing that rival those of the leading integrated producers and have built up formidable capacity (Macher, et al., 1998). The availability of high-quality foundry service permits some chip firms to specialize in design and avoid building costly fabrication facilities ("fabs"). For example, the cellular telecom company Qualcomm, whose CDMA technology first appeared in the market in 1995, was able to rapidly expand foundry production of chip sets for its phones and base stations to become the largest "fabless" chip company with sales of roughly $1 billion by 1998. Such fabless companies now account for about 10% of the chip industry's sales, [5] and sell into some of the most profitable markets.

Fourth, chip markets are becoming increasingly globalized. While the manufacturing value-added chain (e.g. fabrication and assembly) has been spread among global regions for quite some time (Henderson, 1989), sales have been concentrated within the home regions of individual chip companies. As the chip industry's product markets become more global, chip firms need to be attuned to the diverse requirements of different regions.

Taken together, these changes pose a considerable competitive challenge to incumbent chip firms. This chapter examines these challenges in detail with the ultimate goal of understanding how chip-level innovation (value creation) translates into revenue and profits (value capture) in the Net World Order. To what extent are the chip makers capturing the value they create? What determines their share? How have the rules of the game changed as the industry expands its focus from personal computers to distributive networks?

To research these questions, we have conducted interviews at over a dozen semiconductor and system firms in the United States and Europe. Our research also incorporates the rich store of publicly available information in trade journals and company reports.

The chapter proceeds as follows. Section 1 provides a brief overview of the semiconductor industry in the PC World. Section 2 discusses the globalization of sales in the semiconductor industry. Section 3 describes the role of semiconductors in the Net World Order and presents a simple framework for analyzing value creation and value capture. Section 4 contrasts the operation of the PC World with the emerging Net World Order using the value creation and capture framework. Section 5 examines the relationships that chip firms build with their customers to capture value in the Net World Order. Section 6 concludes.

1. The Evolution of the PC Market

In order to provide a context for understanding the significance of the changes wrought by the emerging Net World Order on the semiconductor industry, this section provides a brief history of the "PC World," which we date from the 1979 introduction of the Apple II+, the first personal computer to appeal to a broad audience. The personal computer industry as it exists today, with current sales of more than $150 billion per year, began to take shape after the

[5] Based on data from the Fabless Semiconductor Association reported in "Order Up?" *Electronic Business*, November 1999. Chip firms that own fabs are increasingly turning to the foundries for part of their output.

introduction of the first IBM PC in 1981. That PC, for which the operating system could be licensed, became a *de facto* standard on the strength of network effects (Katz and Shapiro, 1994) relating to DOS-, and later Windows-based applications. Because the operating system was tied to Intel's x86 architecture, Intel has had nearly as much bargaining power as Microsoft.

At the chip level, the steady growth of the PC market has been accompanied by a steady rise in the market for microprocessors, which expanded steadily from 3% of all semiconductor revenues in 1987 to 17% in 1999 according to Dataquest.

Another product that boomed along with the PC market is the DRAM (dynamic random-access memory) chip, for which the share of semiconductor revenues expanded from 8% in 1987 to about 14% in 1999. The DRAM market, however, has been much more volatile than that for microprocessors because of the interaction of supplier competition and cyclical demand. During periods of relative shortage, the price of DRAMs has rocketed. In 1995, for example, DRAM sales accounted for just over 28% of total semiconductor revenues.

Because of steady competition in the commodity DRAM market, profit margins moved with market conditions much more so than for microprocessors, where Intel was able to keep its competitors at bay. The harsh market conditions for memory chips have led to the exit of all but one U.S. producer. Notable exits from the market include those of Intel in the mid-1980s (Burgelman, 1994), and, more recently, Texas Instruments, which sold its global DRAM operation in 1998 to concentrate on building a franchise in digital signal processors, a key component in many of the latest electronics products, from cell phones to anti-lock brakes.

Microprocessors thus constitute the single biggest *success* story of the PC World, and Intel, the company whose processor set the standard for the dominant PC design, was the big winner. Intel successfully executed several strategies to defend its monopoly position. One strategy was breakneck innovation enabled by relentless shifts from one generation to the next. The average product life cycle (i.e. the time before a new PC model with the latest microprocessor is introduced) dropped from about five years in the very early years of the industry to less than two years in 1989 (Wesson, 1994). By 1997, the length of time a new PC model commanded the highest price before being superceded by a better model had fallen to three months (Curry and Kenney, 1999).

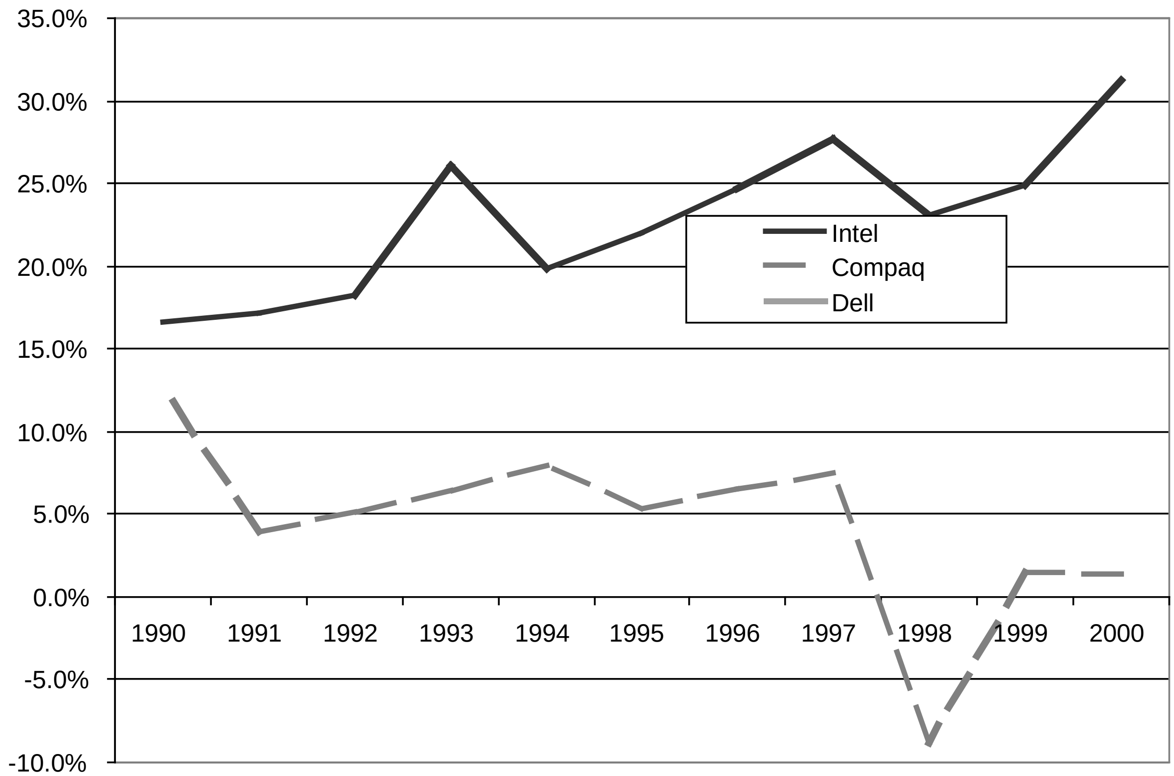
Another successful element of Intel's strategy was the establishment of a brand in the mind of end users. This was a big break from the traditional anonymity of chip suppliers, and successfully increased Intel's bargaining power with its customers. The "Intel Inside" program was introduced in 1991 and continues today.

Intel's strategy, however, could not stop the tides of change. Although many consumers were willing to buy high-powered computers at a high price, a "value" segment of the market was waiting to be served that opened up opportunities for competitors. By late 1996, personal computers selling for less than $1,000 had come to market (Curry and Kenney, 1999), and growing numbers of these low-end machines no longer have Intel inside.

According to Dataquest, the average selling price of all PCs fell from about $2,150 in 1996 to $1,445 in 2000 – a drop of more than 30%. The steady price reductions attracted relatively more non-business buyers, whose share of PC purchases (in units) grew from 24 to 32% over the same period according to the same source. Thanks to the market expansion, the total wholesale value of the PC market rose from $107 billion in 1996 to $158 billion in 2000, and chip revenues amounted to about 42% of this.[6]

What is perhaps surprising, however, is that Intel seems to have suffered far less than its customers from the low-end expansion of the PC market. Figure 2 shows the net profit rates of Intel and two of its key customers.[7] Dell and Compaq saw their profit rates decline or stagnate while Intel's has been tending upward.

Figure 2: Net Profit Rates in the PC World, 1990-1999



SOURCE: Primark Corp. (Global Access Database)

The seeming immunity of Intel from the changes in the PC market can be explained by its delays in addressing the low-price segment,[8] coupled with its success at driving down manufacturing costs. By maintaining its primary focus on the high-end of the PC market, Intel successfully maintained its profitability. This created a low-end opening for Intel's competitors, particularly AMD, whose share of microprocessors in the fast-growing sub-$1,000 PC market reached 51% in June 1998.[9] Intel eventually provided strong competition in all ranges of the market and earns the continued benefit of its brand-awareness premium.

[6] The breakdown of chips in PCs by value is nearly 50% for the microprocessor, about one-third for memory, 4% for core logic, and the balance for miscellaneous semiconductors (estimated from Dataquest data on total semiconductor sales into the PC market for the period 1996 to 1999).

[7] Other income measures yield a similar picture. The two PC companies were chosen for their emphasis on a single product type for most of the period.

[8] "Intel To Attack Low-End PC Mkt, "*Electronic Buyers' News*, November 4, 1997.

[9] estimate from PC Data reported in "Battle of the Budget PC Chip," *Mercury Center*, August 19, 1998.

However, even Intel no longer believes that the PC will maintain its privileged position in the electronics industry. Intel has moved into the infrastructure and consumer markets of the Net World Order. These new efforts include the development of portable devices such as an Internet music player around a non-Intel processor architecture;[10] an aggressive entry in the small but lucrative market for chips in switches and routers;[11] and the pursuit of a proprietary digital signal processor in partnership with Analog Devices with a likely first application in Internet-capable cell phones.[12]

2. Regional Markets and Globalization

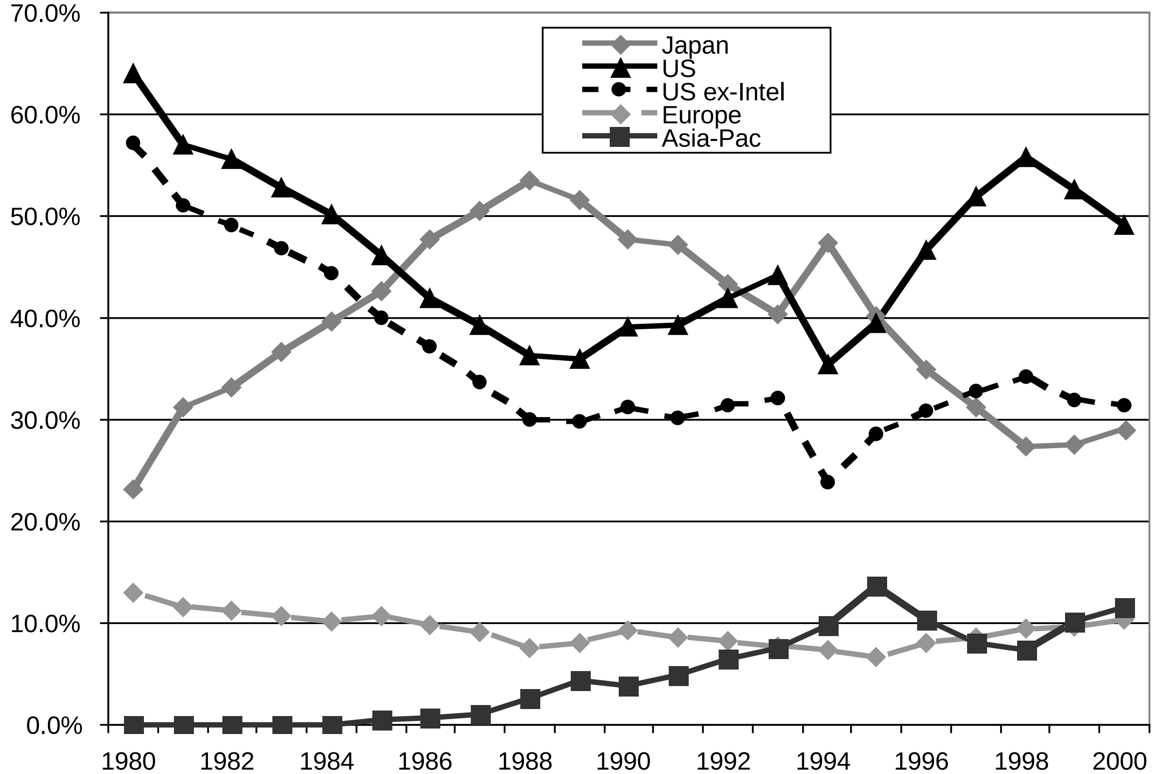
Next we look at the regional distribution of chip sales in order to analyze how markets are changing as we move from the PC World to the Net World Order. As a starting point, Figure 3 shows the respective shares of the global chip market over a 20 year period for the Top-40 suppliers, who are based in the United States, Japan, Europe (France, Germany, Italy, and the Netherlands), and Asia-Pacific (South Korea and Taiwan). The well-known rise and subsequent decline of the Japanese share is shown along with the resurgence of the U.S. beginning in 1990. The growing distance between the U.S. share and the "ex-Intel" (dashed) line beneath it shows the enormous role Intel has played in the U.S. "comeback." Without Intel, the U.S. share has been almost flat since 1990, and Intel's expansion came mostly at the expense of the Japanese share. At the end of the 1990s, U.S. firms held almost one-half of the market, while Japanese firms had about 30% of the market and Europe and Asia-Pacific each had about a tenth.

[10] "Facing Computer Slowdown, Intel Hopes New Consumer Devices Will Boost Growth," *Wall Street Journal Interactive*, January 2, 2001. The StrongARM processor architecture used in the digital audio player is licensed from ARM, a British firm that licenses designs and sells no chips of its own.

[11] "Intel's New Network ICs Target Enterprise-Class Applications," *Electronic Buyers' News*, May 1, 2000. Intel's "IXP" networking chips also use the StrongARM architecture.

[12] "ADI-Intel DSP Core Appears Ready For Prime Time," *Electronic Buyers' News*, December 1, 2000.

Figure 3: Share of Sales By Top 40 Semiconductor Firms By Region, 1980-1999



SOURCE: calculated from Dataquest data; based on location of company headquarters.

A possible interpretation of the relative strength of the U.S. semiconductor industry is that Japan and Europe were slower to embrace both the personal computing revolution and the subsequent networking phenomenon. U.S.-based chip firms reaped a considerable advantage because of the rapid adoption of PCs in the U.S. by both businesses and households. However the underlying forces are not clear. The empirical relationship between domestic adoption and company performance presents us with a chicken-and-egg problem, as well as the accompanying task of identifying important institutional forces that may be driving both adoption and performance. For example, did rapid adoption of computers by the business community give a competitive advantage to U.S. chip firms, or did rapid adoption occur because the U.S. firms were instrumental in convincing the business community by example and advertising of the value of using computers? In addition, we must ask what was the role of the U.S. university system in the adoption process, both in terms of creating educated users, semiconductor engineers, and the technology itself? What was the role of the Federal government (and the National Science Foundation in particular) in disseminating Web use throughout the public educational system? The answers to these important questions, which we do not address in this paper, would contribute to an understanding of the relationship between the regional markets and local companies that we only describe here.

To begin to understand the forces behind the global dynamics of the semiconductor industry depicted in Figure 3, we need to assess two basic interactions of markets and location. First, to what extent does the location of producer headquarters correspond to the location of sales? And, second, how do regional markets differ?

In order to document headquarters' location and the distribution of sales, we obtained data from Dataquest detailing the geographic distribution of semiconductor sales for firms grouped by the location of their headquarters for the years 1992 to 2000. In every year, each group of firms had the biggest share of sales in its home (i.e. headquarters) region. This might occur because it is easier to sell to customers in one's own region and/or because one's own region represents a large share of the global market.

To screen out the second factor, we converted the data into an index, called the Home Substitution Index (HSI) where:

$$HSI = \frac{\text{\% of Sales in "Home" Region} - \text{"Home" Market as \% of World Market}}{\text{Foreign Markets as \% of World Market}} \times 100.$$

The HSI shows to what extent the "excess" sales to the home market (i.e. sales above the average market share) replace sales to foreign markets. The index ranges from zero when sales to the home market match the market's relative size to 100 when sales to the home market replace 100% of sales to foreign markets. The lower the HSI, the more global the sales distribution of home-based firms.

Table 1 reports the HSI for semiconductor firms headquartered in four major regions (the Americas; Japan; Europe, Middle East & Africa; or Asia ex-Japan). For example, in 1992 U.S. companies replaced 30% of the foreign sales that would have been predicted if the industry were perfectly globalized with sales in the Americas. In other words, in 1992 U.S. companies' sales to foreign markets were 70% of what would be expected based upon the relative size of the four markets

Companies in all regions except Japan show a decline in reliance on home market sales during the 1990s. European, Korean, and Taiwanese firms rapidly became more global in sales as their HSI converged toward the U.S.'s low value of 20 in 2000.

To look at product markets in more detail, we break out memory chips because such chips are interchangeable (within a given specification) regardless of producer. Sales for chips of this type presumably face low barriers to overseas sales because of the limited need for sales support. Non-memory chips, on the other hand, are more design-intensive and likely to be linked to specific applications and even specific customers (Linden, 2000). As this difference suggests, the HSI for memory chips is lower than that for non-memory semiconductors within each region.

U.S. companies decreased their reliance on their home market for non-memory chip sales during this period, and Asia-Pacific companies posted a similar decline, although to a much higher end point. The declining HSI of European firms for non-memory chips found them at the level of home substitution (31) at which U.S. firms began the period.

Perhaps the most interesting entries are those of Japan, which, at the end of the period, has the highest HSI overall. Japan's HSI for memory chips declined through 1995 then rose sharply to finish higher than it started, which reflects a relative loss of competitiveness to lower-cost producers. Meanwhile, Japan's HSI for non-memory semiconductors stagnated at about 50 for most of the period.

In the underlying data, the share of Japanese firms' sales staying in Japan rose only for memory chips, but declined for non-memory and overall. On the other hand, this un-indexed share is either the first or second highest in each category. Furthermore, the relative size of Japan to the world market for semiconductors, declined from 31% in 1992 to 23% in 2000. Japanese firms as a group therefore are relying heavily on a market whose global importance has declined.

This apparent loss of competitiveness in overseas markets is a major force driving the retreating global market of Japanese chip firms.

Table 1: Home Substitution Index For Global Semiconductor Sales, 1992-2000

ALL SEMICONDUCTORS									
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
US Firms	30	27	26	24	22	22	21	19	20
Japan Firms	46	41	37	34	40	42	44	44	46
Euro Firms.	53	47	43	45	40	40	40	34	27
A/P Firms.	42	38	27	25	26	30	32	24	23
MEMORY									
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
US Firms	24	18	20	18	24	24	26	22	19
Japan Firms	21	19	15	14	18	22	25	24	32
Euro Firms.	49	44	41	43	44	34	35	19	13
A/P Firms.	27	24	14	16	15	14	16	13	11
NON-MEMORY									
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
US Firms	31	30	28	27	23	22	21	20	21
Japan Firms	57	53	51	50	51	49	50	50	51
Euro Firms.	54	47	44	45	39	40	41	37	31
A/P Firms.	80	83	79	80	76	79	80	69	70

SOURCE: Authors' calculations based on Dataquest data

A similar analysis (not shown) looks at the same data from the perspective of markets and shows that the Japanese market is also the least penetrated by foreign chip vendors. Europe, by contrast, is as open to foreign vendors as the U.S. – in contradiction of its reputation as a protected market. Japan, for better or worse, is clearly an exceptional case in the global semiconductor industry. Or as one chip executive put it: "Japan is Japan."

What happens to these trends in the future depends in part on regional demand patterns, to which we now turn. Just as the PC World contributed to a realignment of global market shares toward U.S. producers and away from their Japanese counterparts, the Net World Order may also realign global regional markets. The PC World has been U.S.-centric, and the U.S. also looms large in the Internet. If we look, however, at wireless devices, many parts of the world have been quicker than the U.S. to adopt cell phones. Depending upon which devices become the preferred vehicles for voice, video, and data transmission, this next phase of the electronics industry may be less dominated by U.S. firms.

The World Competitiveness Yearbook provides country-by-country comparisons for a number of products (IMD, 2000). In the case of computers per 1,000 population in 1999, the U.S. (539) ranks much higher than Japan (325) or the large countries of Europe such as the United Kingdom (379), France (319), Germany (317), and Italy (245). In sharp contrast, the U.S. ranks only 24th globally for cellular subscribers per 1,000 population, at 315, behind Japan (383), Italy (521), the United Kingdom (409), and France (350).

The world of the Internet is, however, still largely U.S.-centric. For the number of Web host computers per 1,000 population, the U.S. is again ranked first at 137, far ahead of Japan (17) and the large European countries (28 in the UK, 18 in Germany, 11 in France, 7 in Italy). However as wireless Web appliances become available at attractive prices, the Internet will likely become less U.S.-centered as it is embraced in countries with low PC penetration but high penetration of hand-held communication devices.

The disproportionate lead of the U.S. in Internet adoption does not necessarily mean that U.S. firms, including chip suppliers, will have the same advantages that helped them excel in the PC World. The absence of network effects in many Net World Order applications may prevent the U.S. from benefiting from its large market, i.e. *de facto* standards (should any arise) in the U.S. will not necessarily displace those in other countries, just as incompatible television standards have long co-existed in the U.S. (NTSC) and Europe (PAL/SECAM).

The data on cellular penetration, combined with the earlier evidence that chip firms still rely disproportionately on home-market sales, provide the first indication that the Net World Order may lead to different outcomes in the semiconductor industry than those of the 1990s. In many Net World Order applications, Japan, Europe, and the United States are pursuing somewhat different technology trajectories that reflect a combination of differences in regulation, legacy infrastructure, and consumer preferences. In Japan, for example, the leading cellular carrier, NTT DoCoMo, adopted a relatively low-tech interactive cellular standard ("i-mode") that became a huge success. Most other providers have waited for more technically advanced systems before rolling out cellular Internet access. This has given DoCoMo a lead in terms of developing services and a business model, which it is now trying to export by investing in cellular companies in Europe and the U.S. The Japanese phone and chip companies that are DoCoMo's primary suppliers are hoping to piggyback on their customer's global expansion.[13]

The widespread adoption of cellular telephony by European consumers was stimulated by Europe's uniform adoption of GSM cellular technology and the relatively high cost of wireline telephone service. This high adoption rate has been credited with providing the well-known European handset producers, Ericsson and Nokia, an advantage in world markets, where they command a combined share of more than one-third. European dominance at the system level has not translated to a similar dominance at the chip level, but market leadership is considerably more balanced than is the case for PC chips. The leading vendors of non-memory chips in the cellular market as of 1999, according to Dataquest, are Motorola (itself the second-largest handset producer) and Texas Instruments (on the strength of its early commitment to digital signal processor technology). But the list of leading vendors includes the three main European chip makers – STMicroelectronics, Infineon, and Philips (through its acquisition of U.S. company VLSI Technology) – as well as three Japanese producers – NEC, Fujitsu, and Hitachi. The share of European firms is noticeably larger in the wireless market (21%) than for non-memory chip sales overall (10%). As noted above, the acquisition of U.S.-based VLSI by Philips boosted Europe's share in the wireless semiconductor market, and the fact that this acquisition was essentially a hostile takeover signaled Europe's new readiness to aggressively pursue market share.

To summarize, strong local markets for cell phones may have helped European and, to a lesser extent, Japanese chip firms compete globally. The reverse proposition, however, does not appear to hold, i.e. U.S. chip firms were not hindered by a relatively slow domestic adoption rate of cellular technology. Time will tell if continuing differences across regional markets will undermine the current global dominance of the U.S. chip industry.

[13] "Panasonic Looks to Expand Its International Cell Phone Reach," *Electronic News*, November 6, 2000.

3. Chips In The Net World Order

This section begins the examination of new markets for chips in the Net World Order. We first examine this emerging Net World Order by characterizing four segments of Internet-related applications: fixed computing (PCs, servers, mainframes, LAN equipment), wireless applications (digital cell phones and infrastructure), consumer multimedia (video game consoles, digital set-top boxes), and wired infrastructure (central office equipment, routers). Although some products in these categories, such as cell phones and game consoles, are not yet universally capable of transmitting data, it is expected that they will be in the near future.

Table 2 provides a rough quantitative characterization of these four markets, which amounted to approximately 54% of all chip sales in 1999. The computer market for chips is projected to grow at a rate less than the industry average for the next few years, while the opposite is true for chip sales into the other Net World Order categories. These projections pre-date the severe downturn in the semiconductor industry at the beginning of 2001, but they should still be useful for indicating the relative expected size of these markets if not their true magnitude in 2004.

Possibly many products that we excluded from our categories, such as cars, household appliances, and industrial robots, will be connected to networks by 2004, which would raise the share of the Net World Order chip sales.[14] Communications-related chip sales into these new markets could eventually resemble the historical growth of chip sales to the digital (but not yet Internet-enabled) cellular handset market, which grew at a 60% annual rate from $2 billion in 1995 to $20 billion in 2000, to become 10% of all chip revenues.[15]

Integrated circuits are at the heart of all Internet-related devices, but their importance in terms of value-added varies widely across (as well as within) these segments. PCs are relatively high (32%) in the value of the chips they contain, as are new consumer products such as the video game consoles and digital set-top boxes, which contain few other parts. At the other extreme, cell phones and telecom infrastructure are relatively low (under 20%) in the value of the chips they contain, since software adds a larger share of value in these products.

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[14] The Net World Order is also worthy of study because it includes the applications, such as network infrastructure and computers, for which chip companies generate significant process and product innovations that diffuse to the rest of the chip industry and to the economy as a whole (Jorgenson, 2001).

[15] Dataquest data – the 2000 number is from a Fall 2000 forecast.

Table 2: The Chip Markets Of The Net World Order

	FIXED COMPUTING	WIRELESS APPLICA-TIONS	CONSUMER MULTIMEDIA	WIRED INFRA-STRUCTURE	ALL ELEC-TRONICS
LARGEST PRODUCT CATEGORY	personal computer	digital cell phones	video game consoles	central office equipment	personal computer
SHARE OF CHIP MARKET REVENUE IN 1999	37%	10%	3%	4%	100%
FORECAST CAGR* TO 2004	11%	20%	23%	25%	14%
AVERAGE RATIO OF ICs TO SYSTEM WHOLESALE PRICE	32%	20%	51%	10%	17%

*CAGR: compound annual growth rate
SOURCE: calculated from Dataquest reports issued in Spring 2000

Another important observation is that the newer markets of the Net World Order (wireless, multimedia, and infrastructure) are relatively fragmented and diverse compared to the more homogeneous computing sector. Even DRAM, one of the most commoditized products of the PC World, is becoming a more fragmented market in which multiple standards (particularly Rambus and Double-Data Rate) are competing for market share. Growth markets for memory chips in mobile consumer products have very different technology requirements, such as low power consumption.

Our analysis of the diverse markets of the Net World Order begins with a simple framework that incorporates the major determinants of the competitive position of chip companies based upon their innovation activities (value creation) and their marketing and distribution strategies (value capture). The following lists are not comprehensive, but rather focus on those elements that our research suggests are the primary factors that distinguish the emerging Net World Order from the competitive situation of the past 20 years.

Semiconductor product innovation involves three types of competencies that are difficult for competitors to imitate.[16] Successful firms usually do not excel in all three but rather focus on one or two:

- Process Skills: Does the firm use specialized or “bleeding-edge” (best-in-class) fabrication processes?
- Integration Skills: Does the firm command system-level knowledge necessary to the design of integrated hardware-software platforms?
- Intellectual Property (IP): Does the firm own specialized design (as opposed to process-related) IP?

[16] Rumelt (1987) provides a general discussion of such “isolating mechanisms,” defined as “impediments to the immediate ex post imitative dissipation of entrepreneurial rents” (p.145).

Five primary characteristics of the marketing and distribution channels of semiconductors are:

- Standards: Do products need to meet critical standards set by regulatory or industry bodies?
- Market size: Is the market unusually large (or unusually small)?
- Adoption: Is the market subject to network effects?
- Infrastructure: Does the product require that a network be in place for the product to operate?
- Branding: Are the final customers likely to be swayed by brand image at the chip level?

The combination of innovation competencies, marketing and distribution channels, and firm-level strategy produces a particular configuration of the value-added chain in which a chip firm participates, which in turn determines the distribution of rents. In the PC World, semiconductor companies dealt with system firms (e.g. Compaq), usually in an arms-length fashion. Intel, through its process skills coupled with its ownership of the dominant architectural standard, has commanded consistently high margins.

In the Net World Order, however, carriers who own or rent infrastructure are also an important part of the value-added chain. These carriers may interact directly with chip suppliers to develop, sponsor, or test new products and services. The distribution of rents in this more complex value-added chain differs from one case to the next based on the relative bargaining power of participants, which we will examine below. We first turn to a more detailed exploration of the value-added chain.

4. Value Creation in the Net World Order: Firm Competencies and Market Attributes

This section examines how innovation in the semiconductor industry occurs in the major product markets of the Net World Order and compares it with innovation in the PC market. The analysis will focus on the highest-value chips in each of these markets, e.g. baseband controllers for wireless applications.

Competencies. First, we ask which innovation competencies are most relevant to a given application market. Table 3, which summarizes our assessment, shows that the competencies needed by chip firms in the nascent markets of the Net World Order differ markedly from those that have been relevant to the PC World.

Table 3: The Relevance of Competencies in the Net World Order

	Personal computers	Wireless applications	Consumer multimedia	Networking infrastructure
Process skills	Yes	No	No	No
Integration skills	No	Yes	Yes	No
Intellectual property	Yes	Varies by application		

When we interviewed representatives at semiconductor and systems firms, a competency that was often mentioned as an attribute of successful chip companies was speed, or “time-to-market.” This cuts across both the PC World and the Net World Order because the steady improvement of chip technology leaves products relatively short market windows before something better, faster, and/or cheaper comes along. This competency is not included in the table because it is so pervasive in the electronics industry, but it is worth noting that a reputation for delivering working chips in a timely manner is the basic requirement for chip firms to create and capture value. With that, we turn to the competencies that distinguish, to differing degrees, the PC World from the Net World Order.

Process skills have played a critical role in differentiating chip producers in the PC World, but, at least at this stage, fabrication skills are less important to the Net World Order. To create a competitive wedge between itself and its rivals, Intel has remained in the forefront of process technology and has maintained its own manufacturing capability for microprocessors rather than using contract manufacturing services. Process skills are also vital to competitiveness in the manufacturing of DRAM, and DRAM companies also do their own manufacturing.

Process skills are relatively less important in the other three markets. In wireless, for example, Qualcomm was able to grow rapidly to account for more than 7% of the market for digital cellular chips while owning no fab of its own. Qualcomm’s strength is the intellectual property that it owns, along with the system-level knowledge needed to successfully design a highly integrated chip set. Many successful companies in the consumer broadband and network infrastructure markets, such as Broadcom and PMC-Sierra, are also fabless and compete on the strength of their intellectual property and fast time-to-market.

Integration of functions on a chip, which requires system-level engineering skills, has become a critical skill in the Net World Order for several reasons (Linden and Somaya, 1999). A reduction in the number of chips in a system brings many benefits including increased reliability, greater speed, lower unit manufacturing cost, lower power consumption, and smaller size. Lower cost is very attractive for consumer markets, where high price is often the biggest barrier to the adoption of new technologies such as digital set-top boxes and personal digital assistants (PDAs). Small size and low power are particularly important for mobile wireless applications, but also for uses where space is at a premium such as Web hosting data centers and telecommunications infrastructure.

Integration also provides the means for chip companies to offer their customers faster time to market by providing a ready-made system. A system-level chip will contain at least the central processor and most of the main memory, plus any of a range of additional functions, including protocol converters, signal processors, and various input and output controllers.

This requires complete integration of both software and hardware, with the system firm able to customize and differentiate the final product by choosing from a menu of optional functions that are already part of the package. Some functions, such as power management for portable devices, typically remain separate for technical reasons, such as optimization in a non-CMOS process.

For the chip company, a high level of integration on one or a few chips means that all the necessary technologies must be brought together at one time either through internal efforts, licensing, or acquisition. Horizontally-diversified firms that already own a broad range of intellectual property tend to have an advantage in these markets because they do not need to negotiate agreements for outside IP, which may slow product release, or pay royalties to third parties. For example, the firms that had announced system-on-a-chip solutions for digital set-top boxes by 1999 were Motorola, IBM, LSI Logic, STMicroelectronics, and Matsushita Electric Industrial. Each of these firms carries an extensive product portfolio and has sufficient system engineering expertise in-house to design system-level semiconductors.

Even large, diversified chip firms may, however, be missing pieces of the system. This need has given rise to a growing market for the exchange of "intellectual property (IP) blocks," which are partial chip designs that can be integrated in a single system-level design. Intellectual property can also be acquired rather than licensed. An example on a large scale was the $800 million purchase in 1999 by Philips of VLSI Technology, mentioned above for its strong portfolio of communications-related intellectual property that Philips needed to pursue new applications such as home networking.[17]

Integration is also increasingly important in the PC market as it confronts the Net World Order although, historically, system-level integration skills were not a required competency of PC-oriented chip companies. Specialized niches in the PC, such as graphics chips, are being absorbed by the ever larger microprocessor or its closely connected logic chip set. In the case of graphics, Intel chose to acquire the necessary know-how by purchasing a graphics chip supplier called Chips & Technologies in 1997 and incorporated the technology in an integrated chip set beginning in 1999.[18]

The importance of the third competence, design-related intellectual property (IP), has already been touched on with regards to both the PC and the emergent applications of the Net World Order. Intel owned, refined, and defended the x86 architecture, which forced rivals to invent around this architecture while complementary component makers had to guarantee compatibility with it. In the Net World Order, chip firms still develop or acquire unique IP as a means of earning higher rents. Philips, for example, developed the TriMedia processor for consumer multimedia applications including set-top boxes. Ultimately, Philips decided to spin-off the TriMedia business to make it more attractive to outside customers.[19] Companies specializing in network infrastructure, such as PMC-Sierra, also boast a large portfolio of patented technologies.[20] As discussed above, Qualcomm provides an example of the importance of intellectual property in wireless applications.

However our interviews also revealed some negative aspects of IP development and ownership. One executive from a large chip maker warned that IP ownership can lead to technological "lock-in" that might prevent the company from pursuing more successful alternatives – a problem that can result from any major investment in capital or technology. Another pointed out that development of elaborate IP, such as a potential proprietary standard, can be so costly that it is not necessarily more profitable unless the actual size of the eventual market meets expectations.

Market attributes. Table 4 summarizes by application market the five attributes of marketing and distribution channels that affect the ability of semiconductor firms to capture value commensurate with their innovative contributions.

[17] "Philips' Bulging Portfolio Poses Integration Problem," *Electronic Buyers' News*, November 1, 1999.
[18] "Intel Quits Discrete Graphics-IC Market For Integrated Approach," *Electronic Buyers' News*, August 19, 1999.
[19] "Philips Spins Off TriMedia Processor Technology As Separate Company," *Semiconductor Business News*, March 29, 2000.
[20] "CEO of the Year: PMC-Sierra's Bob Bailey," *Electronic Business*, December 2000.

Table 4: Market Attributes in the Net World Order

	Personal computers	Wireless (mobile) applications	Consumer (fixed) multimedia	Networking infrastructure
Standards	Stable/Owned	Stable/Shared	Unstable	Stable/Public
Market Size	Very large	Large	Potentially large	Small
Adoption	Network Effects	Network Effects	Individual	Individual
Infrastructure	Independent	Dependent	Dependent	Not applicable
Branding	Important	Important	Important	Not important

Standards for PCs have been relatively stable. Although the underlying technology for PCs has evolved dramatically over time, the market's dominance by a duopoly – Intel and Microsoft – has kept the development path predictable. As discussed above, Intel's control of a *de facto* standard has given it tremendous bargaining power with its customers.

Standards for wireless applications and network infrastructure are also fairly stable, but for a very different reason, namely that they are determined by negotiation within international committees. The underlying intellectual property may still be owned by firms, as in the case of Qualcomm's CDMA, but they must be available for licensing to become *de jure* standards. A public standard, in sharp contrast to proprietary standards such as Intel's, reduces the bargaining power of chip firms because the public standard provides a level technological playing field and increases the likelihood that systems firms will be able to purchase their components from multiple sources.

The equipment comprising the Internet infrastructure must meet strict requirements for interoperability set by official bodies like the International Telecommunications Union and industry organizations, such as the Internet Engineering Task Force. Because of this predictability in technical standards, the primary challenge for chip companies serving the markets of the Internet infrastructure is to be first to market with the newest generation, such as a faster Ethernet chip. This has led some chip producers to launch their designs ahead of the completion of the bureaucratic standard-setting process. This strategy entails risk, however, because the chip may need an expensive redesign to be compatible with the ultimate official standard.

In sharp contrast, standards in the emerging market for Internet-related consumer products are quite fragmented. First, there is wide variety of machine types that consumers can potentially adopt to access the Internet. In addition to PCs, which are still by far the largest means of access, consumers may also choose from among a box connected to the television set, a cell phone or PDA, and a host of "Internet appliances" such as a dedicated e-mail device. The set-top box could be designed to handle cable, satellite, or broadcast transmission. Each type of application requires mastery of a different type of technology (e.g. radio transmission and power management for cell phones, or video processing in the case of set-top boxes). In each instance, the relevant standards are likely to be some combination of public, proprietary, or even undetermined, as in the case of high-definition television in the United States.

The second attribute, market size, has played a greater role for the PC market than it will likely play for Net World Order (and most electronics) products. At the other extreme, the market for Internet infrastructure products is relatively small because the total number of routers and switches that can be sold in any one year is necessarily limited by demand for capacity. As the recent downturn in communications spending shows, this demand can be highly volatile.

Wireless and consumer multimedia applications are an intermediate case. No high-volume market has yet emerged, but the industry is in the early stage of product development and acceptance. Internet-enabled devices have already demonstrated the potential for tremendous growth. NTT DoCoMo's "i-mode" Web-enabled cell phone mentioned above expanded its subscriber base from zero at its introduction in February 1999 to more than 5 million by March 2000.[21]

The third attribute is whether adoption relies upon individual choices made in isolation or if the technology exhibits network effects. The IBM-standard (sometimes known as "Wintel") PC is a classic case of network effects because software development and the ability to share files depended upon other people using the same platform, i.e. the attractiveness of adoption to one individual increases with the total number of users.

Net World Order products are unlikely to exhibit network effects at the hardware level, with the possible exception of cellular telephony, where at least two incompatible standards are likely to remain in use. Even in cell phones, handset manufacturers are potentially able to use chips from multiple suppliers within any given standard. Chip customers are very wary of allowing another Intel-style standard to emerge that gives a single supplier undue market power. Cable companies, for example, are promulgating an open standard (DOCSIS) that will ensure the availability of multiple, interchangeable suppliers in the interactive set-top box market.[22] Public standards, such as the W-CDMA wireless data specification, are also designed through protracted negotiation to avoid giving individual companies an inordinate amount of leverage. More fundamentally, the Internet's success is built on the notions of interconnectivity and interoperability at the hardware level, which will likely prevent the cumulative phenomena of the PC World from recurring.

What is true for hardware and software need not be true for services, however. The tremendous growth of DoCoMo's i-mode service reflects network effects because DoCoMo's strict veto power over which services have access to its proprietary portal can keep some functions out of the hands of its rivals.[23] Issues of access by non-AOL portals to Warner-owned cable systems were also addressed in the anti-trust negotiations over the AOL-Warner merger.

Service provider strategies may thus ultimately lead to fragmentation of the Internet in a way that would make network effects more common. The prolonged co-existence of multiple, incompatible Instant Messaging programs may be a harbinger. But unless a successful software or service option is tied to a particular hardware platform, which has so far not been the case, the network effects at the software level will be irrelevant for semiconductor suppliers.

The fourth market attribute is the importance of infrastructure. Infrastructure dependency can have a major impact on the ability of chip companies to innovate and earn rents. All Web access devices, whether fixed or wireless, require an extensive and specific infrastructure (e.g. cable, DSL, satellite) before the device can be used by customers, and many devices (e.g. a DirecTV satellite receiver) are network-specific. Network dependence tends to increase the bargaining power of the network operator, particularly since the number of networks is usually limited in any given location for economic or regulatory reasons. On the other hand, the next section will discuss how the presence of network operators in the value-added chain presents

[21] "NTT DoCoMo's i-mode Subscribers Exceed 5 Million," *Asia Biz Tech*, March 21, 2000.

[22] For pre-digital equipment, most U.S. cable companies are locked in to proprietary end-to-end deals with either General Instrument (now part of Motorola) or Scientific-Atlanta.

[23] "NTT DoCoMo-Style Business Model Includes a Few Pitfalls," *Asia Biz Tech*, December 11, 2000.

chip firms with the possibility of developing and marketing new services for a specific network, which will increase the chip company's leverage with system firms.

The fifth attribute – branding – can increase bargaining power, usually in favor of a systems firm. Corporate and private buyers distinguish between brands based on perceived quality or fashion. A network might have some brand cachet as well if it is believed to be, for example, more reliable than its competitors. It is much more difficult for component suppliers to compete by establishing a brand. The Intel case is an anomaly in this regard. The infrastructure market is probably the least susceptible to the influence of branding because of the importance of technical issues such as speed and the technical focus of those making purchasing decisions.

5. Value Capture in the Net World Order: Configuring the value-added chain

Our framework can also be used to analyze linkages in the value-added chain. The creation of value involves not just the harnessing of technology, but also the production of goods for which there will be sufficient demand to provide a return on the fixed costs of product development. To this end, chip firms in the Net World Order benefit from working closely with their customers, who are primarily systems companies and network operators. Here we consider the ways a chip firm can interact with its customers and designate the most likely relationships as primary and secondary pathways, which are summarized in Table 5 by product market. The arrows in the table represent the source of control (e.g. who is placing an order), and a double-headed arrow indicates a strategic partnership. The structure of a pathway has implications for the bargaining power of the chip maker.

Table 5: Value-added chain Configurations of the Net World Order

	Personal computers	Wireless applications	Consumer multimedia	Networking infrastructure
Primary Pathways	IC → S	IC ← S ↔ C	IC ← S ↔ C	IC ↔ S ↔ C
Secondary Pathway (if any)		IC S ← C	IC ↔ S → C	

KEY: IC = chip company; S = system company; C = carrier (network operator)

↔ = strategic partnership

→ = arm's length supply relationship

(arrow's origin indicates source of authority)

The PC World has a simple configuration because of the absence of carriers from the value-added chain. Although PCs are used to access the Internet, they have important stand-alone uses independent of any infrastructure. As shown earlier, Intel has commanded enormous bargaining power with systems (i.e. PC) manufacturers, which translated into high profits.

As we learned in our interviews, carriers, for the most part, do not care what chips are used in the systems they buy, provided the system meets the necessary functional specifications. Chip companies, however, told us that contact with carriers could be beneficial for several reasons. A chip company executive reported that contact with carriers sometimes revealed special needs that could be addressed at the chip level. We also learned of at least one instance where carriers provided support for a chip-level standard that systems firms had rejected. Finally, a consumer chip firm explained that if they understand the carrier's cost structure, they can structure their own costs to match. In contrast, if the chip firm deals exclusively with a systems firm, the systems firm will have already set a price for its deal with a carrier, and will be focused on driving down the chip price to raise its own profit.

We now consider each product market of the Net World Order in turn.

Wireless devices are infrastructure-dependent and must be compatible with an available network. The compatibility can be limited to the interface, as in the case of a handheld computer with an interchangeable modem, or network features can be tightly integrated, as in upcoming third-generation cell phones that will exploit network-specific features such as music downloading or global positioning services. The common arrangement is for the carrier to work with a system firm to design a new handset, and then to let the system firm decide which chips to use. This primary pathway minimizes the bargaining position of chip suppliers.

In cases where they can enable new network services, chip companies may work directly with carriers (secondary pathway). For example, Qualcomm developed a multimedia software suite known as Wireless Internet Launchpad to run on its CDMA chip set. In order to enable adoption in Japan, Qualcomm had to first work with the local CDMA network providers to run complementary software on their systems before striking deals with individual handset manufacturers.[24] The strategic partnership between Qualcomm and the carriers greatly increased the chip company's bargaining power vis-à-vis the system (i.e. handset) manufacturers. Although the chip company must maintain good relationships with the system manufacturers to avoid being shut out of future business opportunities, the chip company may exert some leverage over the system house if, for example, the chip company designs the only chip that meets specific functionality required by a carrier.

The primary path in the consumer multimedia market is the same as in wireless--a design to be agreed on between a system firm and a network operator. Thus a set-top box specification might be promulgated by a cable company to several potential suppliers. These system companies, in turn, work with potential semiconductor suppliers to develop the proposed product. The carrier then selects one or more system suppliers, only indirectly selecting the chip suppliers at the same time. America On-Line, for example, chose Philips to assemble its initial cable set-top box, and Philips in turn tapped Boca Research, a communications company, for a reference design that was based on a processor from National Semiconductor.[25]

Strategic partnerships between chip and systems firms (secondary pathway) are one coping mechanism for chip makers in the face of the unstable standards of the consumer market, and one of the major exponents of this approach is STMicroelectronics, a Franco-Italian joint venture created in 1986. In the words of Jean-Phillipe Dauvin, the company's chief economist: "System-on-chip means the silicon must be developed in a very tight linkage to the final users. . . The winning companies will be the companies that form strategic alliances with customers."[26] In the words of a stock analyst that follows the company, STMicro "works with leading manufacturers in principal sectors on the next-generation products so they get locked into the design cycle."[27] STMicro's strategic partners include Nokia, Ericsson and Alcatel.

[24] "Qualcomm CDMA Technologies Announces Widespread Adoption of Compact Media Extension Software in the Japanese CDMA Market," Qualcomm Press Release, July 17, 2000.
[25] "Boca Research's Design Chosen for Philips' Co-Branded AOL TV Set-Top Box," Boca Research Press Release, May 11, 1999.
[26] "ST Micro execs see chip market driven by 'e-society,'" *Electronic Buyers' News*, December 12, 2000.
[27] "It's Europe's Turn," *Electronic Business Asia*, March 1999.

In the rare cases where the chip company initiates a product development pathway, the chip firm can structure its relationships to leave it with maximum leverage in future price negotiations. In an extreme example of chip maker initiative, National Semiconductor created a coalition around a design for a "Webpad" to be based on a specialized processor for which it saw a need to jump-start the market. National worked with Taiwan's Acer for manufacturing, a company called Merinta for software and integration, and Internet Appliance Network for marketing and a link to the Prodigy network.[28] The initial customer was Virgin, a retail company interested in exploring a new business model. In this scenario, the carrier was probably in the weakest bargaining position.

The network infrastructure market is characterized by a two-way strategic partnership with systems companies at the center. The system firm works closely with network operators to develop a network architecture and also with chip suppliers to coordinate technology roadmaps. The bargaining power of the semiconductor companies is enhanced because of the small volumes involved and the need of the system houses to ensure that they have a steady and reliable supply. Interestingly, two major producers of telecommunications equipment – Siemens and Lucent – have opted to spin off their semiconductor operations (as Infineon and Agere, respectively), which suggests that the benefits of coordination across this interface have definite limits relative to the need for both parties to be able to work with others outside the relationship.

The distribution of rents between a chip firm and its customer is ultimately determined through negotiation. In most cases, the chip company is dealing directly with a system manufacturer, and its bargaining power depends on the uniqueness and timeliness of its contribution. Its power may increase once it is "designed in" a particular product because of the potential cost and delay for the system firm to redesign the product around a competitor's chip.

Price negotiation is an ongoing process because of the constant improvements in manufacturing. One executive, interviewed after the latest industry downturn had begun in 2001, described these negotiations as follows: "Most customers expect a steady reduction in price of x% per year or over the course of a year (in good times). In bad times they use the increased competition between suppliers who are more desperate for revenue to renegotiate." A chip buyer at a system firm preferred to characterize these negotiations as the search for a "win-win" balance.

Some aspects of bargaining power are beyond the control of the chip company, such as whether the customer has its own intellectual property and software engineering capability or is dependent on the chip firm. The price (and profit) that the chip company can command from the system house is also conditional on the system house's relationship with the carrier and its success in the marketplace.

System manufacturers have several strategies to retain rents for themselves. Even where system companies have a close relationship with their chip suppliers, negotiations are likely to take place at regular intervals (e.g. quarterly) to demand that the supplier drop prices in line with the regularly productivity improvements that take place in the semiconductor industry. Systems firms frequently employ former employees of chip firms to assure that they have intimate knowledge of how low they are likely to be able to drive the price. Sharing of rents is more likely to occur if the system house wants a long-term relationship with the chip maker.

Another way system companies capture rents is by competing with their suppliers. The development of the fabless model has lowered the barrier for systems companies to design some of their own chips, which many of them are starting to do with simpler, high-volume chips that

[28] "Virgin Territory," *Electronic Business*, September 2000.

can justify the fixed cost of internal engineering to displace an externally sourced product. Executives at systems firms stated that this allowed them to capture profit margins that were previously paid to chip suppliers. Chip companies must then either retreat to more R&D-intensive products or to try to underbid the in-house design program.

6. Summary and Conclusions

Our research examines the transformation of the semiconductor industry that began in the mid-1990s with the consumerization of the personal computer industry. The relative shift toward sales into the market for networking and communications products, which we call the Net World Order, will likely leave its stamp on the global chip market for the next 20 years much as the emergence of the PC industry did. Since the transformation we are studying is on-going, we present our findings with the realization that the world may be a very different place at the end of the decade.

As the electronics industry moves from the PC World to the Net World Order, we find the following important differences:

- Technological innovation shifts from being focused on process and architecture to being focused on integration and specialized design IP. Software and system engineering have become central to the company.
- Manufacturing is a much less important determinant of competitive advantage. Successful semiconductor companies can be fabless and focus on design activities.
- The product market in the Net World Order is much more diversified and fragmented than in the PC World.
- Net World Order markets are characterized by more open standards and often require an infrastructure. Because of its central requirement for product compatibility, the network operator plays an important role in the Net World Order.
- In high-volume markets, chip companies may benefit from being able to sell specialized system-level designs to multiple system houses. In this case, a chip company would be hurt by being part of a vertically-diversified company that is a competitor to other customers for the chip.

One competency of a successful company that has not changed is speed to market, as the rate of innovation has not slowed down.

Value creation and value capture in the New World Order will depend to a large extent on consumer acceptance for the various products being offered and how standards are set across regions. These issues are still very much up in the air. One of the conclusions that emerges forcefully from our analysis is the low probability that the chip industry will ever be dominated by a single company in the way that Intel has done for nearly a decade. System firms and network operators are wary of permitting any supplier to own a standard in the same way that IBM empowered Intel.

At the regional level, U.S. producers are likely to face global competition in the Net World Order from European producers, since they have improved their ability to make acquisitions, form alliances, and sell in foreign markets along with their own large, integrated market. If we were to extend the graph of the regional shares of the Top 40 firms (Figure 3) into the near future, we would expect Japan's share to remain steady or decline slightly, while Europe and the rest of Asia grow their shares as the Intel wedge shrinks back to a more normal size.

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