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Wintel and Beyond: Leadership in the Net World Order

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ABSTRACT

The separate vertical product segments of the electronics industry are converging into a Net World Order of multifunctional product categories. We lay out a stylized value chain for analyzing firm performance in the various horizontal segments of the Net World Order. We measure firm performance with ROI data for the 1990s, and find that high-performing companies can emerge in any segment. We then turn our attention to the future and sketch the key elements of value creation and capture in the emerging Net World Order marketplace. Alliances and customer relationships are increasingly important, while standards ownership and vertical integration are less important than in the PC era.

Keywords: competitive advantage, profitability, value chain, semiconductor industry, electronics industry

JEL codes: L1: Market Structure, Firm Strategy, and Market Performance
L63: Microelectronics; Computers; Communications Equipment

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The global electronics industry is traversing a period of technological ferment. An industry that was long dominated by vertically-integrated firms such as RCA, IBM, and AT&T, has steadily disintegrated as most of the old giants have spun off major parts of their operations. The rapid transition of the Internet from academic oddity to everyday resource has opened numerous new opportunities that are far from fully exploited, but which have already led the industry into one of the most intense boom-and-bust cycles it has ever experienced.

As industry players that survived the downturn position themselves for the recovery, we take a broad look at firm performance as the formerly separate PC, consumer electronics, and communications industries converge into a Net World Order (NWO). The framework and data analysis developed below address the following questions:

- How have the industry value chains evolved with the rise of the NWO?
- Does a particular position in the industry value chain determine market power and ability to capture value? Can a firm in any position in the value chain achieve above-average returns?
- What determinants of value capture in Net World Order are revealed in the performance of representative firms?

The focus of our analysis will be the United States, but we will touch on trends and companies in Asia and Europe as well.

In our framework, the value chains of the electronics industry are defined to include three key positions: embedded systems, such as semiconductors; assembled systems, such as cell phones; and distributed systems, such as cable networks.

We begin by measuring market power along four major industry value chains—PC, Cellular Telephony, Network Hardware, and Cable Television. Comparing return-on-investment (ROI) across the companies in each of the value chains from 1990-2001, we ask whether any particular link in the value chain has inherently more power (profit potential) than the others. We find that a firm in any link in the value chain has the potential both to earn above-normal rates of return and to perform poorly.

Next, building on these findings, we analyze value creation and value capture in the emerging Net World Order. The global deployment of communications networks is ushering in new competitive dynamics. The period before the spread of the Internet and other telecommunications networks could be considered the “PC era”, since it was dominated by the personal computer (PC). The linking of the consumer, computing, and communications value chains with network services into the Net World Order has redefined the technologies that people rely on at work and at home. The comfortable predictability of “Moore’s Law” in setting the pace and direction of technological change in the PC era has given way to greater uncertainties as PC sales stagnate, wireless device sales grow, and new hybrid products proliferate.

Our framework for value capture suggests that the relative importance for profitability of network effects, brand building, and intellectual property is shifting as the industry moves from the PC era to the NWO. In particular, the network effects that underpin the dominant positions of Microsoft and, especially Intel, will be much less decisive in future rounds of competition. At the same time, the balance of bargaining power in the NWO may be shifting toward the carriers, who can act as gatekeepers between manufacturers and their customers. This means that the business models and managerial attention of component and system suppliers also will need to shift to ensure success in the new competitive environment. Brand building and management of customer relationships are critical to capturing value and growing the market as end users of

networks assess and compare the complete bundle of features and services offered by an array of competing yet overlapping value chains.

The next section presents a simple framework and uses it to discuss ROI in four electronics markets. Then we present our concept of the Net World Order, or a complex value chain encompassing the four markets discussed earlier. The next section describes the rules for value creation and value capture in the Net World Order, and discusses the medium-term outlook for the four electronics markets. The final section summarizes our findings and their implications for industry leadership.

Looking back: competitive performance in the 1990s

In this section we look at firm performance during the 1990s in four markets that represent the major branches of the electronics industry: personal computers (PCs), cellular telephony, network infrastructure, and cable television. Before proceeding to the data, we present a framework for understanding the markets of the electronics industry.

From electronics sectors to the Net World Order

The electronics industry is currently in transition from a segmented to a more integrated structure. We dub the older, segmented structure the “PC era” because of the singular importance of the personal computer during the 1990s (Linden, et al, 2003).

In our framework, we focus on three key positions in the value chains of the electronics industry:

- *embedded* systems are the fundamental enabling technologies like semiconductors and operating systems;
- *assembled* systems combine one or more embedded systems with hardware and application software to make an end-product such as a PC or a router;
- *distributed* systems link together assembled systems, for example a cellular telephony network made up of handsets, base stations, and switches.

Embedded systems impart the underlying intelligence to the assembled systems. System assemblers choose feature sets, industrial designs, and interfaces to make that intelligence user-accessible. The assembled systems are then linked together by network infrastructure to give rise to distributed systems.

Some firms are vertically-integrated across these boundaries, especially across assembled and embedded systems. This type of integration is, however, becoming ever more rare. IBM is a notable holdout in the U.S. computer industry. Motorola and Philips are vertically-integrated in cellular handsets and cable set-top boxes. The Japanese electronics giants such as Hitachi and NEC also remain vertically- (as well as horizontally-) integrated, although they have recently spun off a number of divisions in quasi-independent companies or joint ventures. We assess the performance of these integrated firms apart from those that are more specialized.

The PC era can be presented as a simple grid that encompasses multiple industries and their more-or-less separate value chains. Table 1 shows four electronics sectors of the PC era with their value chains. Each sector of the grid shows representative firms, and until recently there has been relatively little overlap from one vertical industry to the others.

[TABLE 1 ABOUT HERE]

The emergence of the Internet as a market phenomenon in the late 1990s began the process by which these sectors have converged around a common set of network-based technologies that makes it increasingly difficult to consider them in isolation. Current examples of this convergence include the competition between cell phones and hand-held computers for the mobile business market and the competition between personal computers and digital set-top boxes for the home entertainment market.

We call the new converged structure the “Net World Order” (NWO), which constitutes a single complex value chain. Table 2 uses an expanded value chain to show how networks and end-users are all using intersecting technologies. A related aggregate value chain, the “multimedia” value chain constructed by Collis, Bane, and Bradley, emphasizes the role of content generators, but for our purposes, we will concentrate on the infrastructure and devices employed by businesses and consumers.¹

The emergence of the NWO has made life considerably more complex for participating firms than the PC era of separate value chains. To take the simplest example, consumer electronics producers such as Philips Electronics have been forced to develop linkages to, and expertise in, communications realms such as cellular telephony and wireless networking that were previously restricted to the communications and computing industries, respectively. Even market leader Intel, which can no longer rely upon the PC for dominance in the chip world, has been forced to develop communications expertise to field products such as its “Centrino” brand of wireless-ready notebook computer chip sets.

The network operators (transmission carriers and/or service providers) manage connectivity across the NWO by packaging services and access for distributed systems. Network operators link the end-user to content via the transmission infrastructure, and they provide critical support infrastructure such as account management and billing.

[TABLE 2 ABOUT HERE]

Markets in the Electronics industry

The relative importance of the three system types (embedded, assembled, distributed) varies across the four product markets that we consider here. We first briefly characterize the interaction between systems within each market.

In the PC market, the embedded systems dominate because of Microsoft and Intel’s successful promulgation of their de facto “Wintel” standard of the Windows operating system coupled with Intel’s x86 microprocessors. In fact, one analysis of the changing terms of competition in electronics and other industries (Borrus and Zysman, 1997) adopted the term “Wintelism” to describe how market power could arise anywhere in the value chain through the control of such standards. The fortunes of PC assemblers have fluctuated over time, with the mantle of success passing from IBM to Compaq to Dell, but for 20 years Wintel has profitably fueled all of the rivals. Carriers are relatively weak in this market because the PC, which can function as a stand-alone product, is network-agnostic and can use traditional landline, cable, or even wireless networks.

In the Cellular Telephony market, the carriers (e.g. Vodafone, Sprint PCS, and NTT DoCoMo) largely control the relationship with the end customer and make the key decisions about which equipment will be used in and with their networks. Assembled systems companies like Nokia and Ericsson compete to attract carriers directly, by the inclusion of unique revenue-

generating features, and indirectly, by adopting distinctive handset styling or interfaces that are attractive to end-users. Embedded systems companies, such as Qualcomm and Texas Instruments, have tried to obtain market power by providing proprietary “platforms” of software and hardware comparable to the Wintel combination in the PC market.

In the Network Infrastructure market, the carriers are the end customers and wield bargaining power more or less proportional to the size of their networks. Assembled systems companies like Cisco, Alcatel, and Lucent, drive the evolution of this product segment. The carriers invest in and construct the distributed systems for voice and data transmission. Embedded systems suppliers, such as LSI Logic and Broadcom, generally have limited power beyond the medium term because assemblers can shift suppliers from one product generation to the next at relatively small cost. In this product market, IBM spans the embedded and assembled realms. Lucent used to span both realms prior to spinning off its semiconductor arm in 2002 under the name Agere.

Finally, in the Cable TV product market, the value chain links together embedded systems suppliers like STMicroelectronics with the assembled systems manufacturers such as Scientific-Atlanta and the distributed systems companies like AT&T Broadband, Comcast, and TW Cable. Because of their proprietary architectures, Scientific-Atlanta and General Instrument (acquired by Motorola in 1999) had strong bargaining power over the cable companies that deployed their *analog* set-top boxes in subscribers’ homes. As described below, the cable companies are attempting to dismantle this power with the current generation of *digital* set-top boxes by promoting open standards.

Return on Investment in the electronics industry

We now examine the economic performance of companies in the three positions of the four industry value chains. Our three-part value chain framework allows us to ask whether any position in the value chain, such as the carrier, has an advantage, on average, in capturing value or, if not, whether high-earning firms can arise in *any* of the three value chain positions.

In order to compare earnings across firms, we need to adopt a metric for their rates of return. The metric would give the ratio of earnings to some measure of the capital employed by the firm, but there is no standard treatment for a host of relevant items including depreciation, minority interest, short-term liabilities, taxes, extraordinary items, and more.

The measurement we report here is “Return on Investment” (ROI) as reported in Standard & Poor’s Compustat (<http://www.compustat.com>) North America database. The precise definition of ROI used here is income – after taxes and earnings attributable to minority shareholders in subsidiary companies but before extraordinary items – divided by “Total invested Capital,” the sum of long-term debt, preferred and common equity, and the share of subsidiaries belonging to minority shareholders (which is equivalent to total assets plus short-term liabilities).

We have evaluated one other measurement, Return On Assets (same as ROI but including short-term liabilities in the denominator), in detail. The results, not reported here, are qualitatively similar to those we report, but lower in levels.

In the absence of clear theoretical guidance as to which measure to prefer, we are unable to make definitive statements about the absolute level of returns with respect to some relatively safe, long-term investment (i.e. the opportunity cost of capital), such as a 5-year treasury bond. This potentially prevents us from recognizing “excess returns” (profits greater than those earned by firms in a normally competitive market) unless they are so high as to be unmistakable. Persistent excess returns are an indication that a company has some advantage that is neither

easily reproduced by its competitors nor drained by the market power of its supply chain partners.

In perfectly competitive industries, trend ROI should be no more than some economy-wide normal rate of return such as the 6% average yield on the five-year U.S. Treasury bill during the 1990s. By comparison, the ROI of companies in the Standard & Poor's 500 Index was about 7% for the period 1994 to 2001, and we will refer to this below as the "prevailing" rate of return.

Since we have doubts about the correct level of our measure, we will be cautious about identifying returns as excess or inadequate but these values give us some idea of what "normal" low-risk returns were during this period. Firms that successfully create a competitive advantage will have ROI consistently greater than the normal rate of return. Trend ROI of less than 6% suggests that, at least in hindsight, these assets would have been better used elsewhere.

We gathered data for a group of 57 chip, assembler, and carrier companies with combined 1999 sales of more than \$1 trillion and calculated average ROI and standard deviation for 1990-2001 (or as available, see Table 3 for details). The average ROI for the full sample (weighted by 1999 revenues) is 7%, with a standard deviation (also weighted) of 10.2. If we look at average weighted ROI of companies broken down by the three parts of the value chain, we see that the assemblers have the highest ROI of 10% (S.D. 19.4). The carriers are next with weighted average ROI of 6.9% (S.D. 7.1). Since this group is dominated (in terms of sales) by traditional voice carriers that are only partially deregulated, we would expect their ROI to be close to the prevailing rate of return, and it is.

The semiconductor companies are presented in two groups – integrated companies (those who are also assemblers) and pure-play chip suppliers, since the former companies' ROI includes revenues from a wide array of products other than chips. The vertical and horizontal diversification should reduce the standard deviations of the returns. This is true for the Japanese companies in our sample, with standard deviations ranging from 2.4 to 5.7. The other integrated firms—Philips, Motorola, and IBM—displayed much higher volatility, with standard deviations between 9 and 15.

For returns, the story is reversed. The Japanese integrated firms in our sample had noticeably lower average returns (from 1.3 to 2.6) than their US and European rivals (from 5.3 to 8.9). The lower Japanese returns may be reflecting the weakness of the Japanese economy during the period under study, the desire of Japanese managers to avoid risk, or the lack of pressure from key stockholders.

The pure-play semiconductor companies have a high weighted ROI of 12.6% (S.D. 11.98), until we note that a large part of the profit goes to one company – Intel. The ROI of the chip companies excluding Intel falls to 5.5% (S.D. 15.1), which is the lowest weighted average ROI among the three pure-play segments (carriers, assemblers, and chips). The integrated companies have a weighted ROI of 4.3% (S.D. 7.9), which is less than the return to chips-only suppliers and below the prevailing rate of return.

Taiwan Semiconductor Manufacturing Corporation (TSMC), a provider of semiconductor manufacturing services that sells no chips of its own, doesn't fit exactly into any of our categories but is worthy of mention as a standout performer (but is not shown in the table). From the first year data are available, 1995, to 2001, TSMC's average ROI was 20.8% (S.D. 11.1), which would place it in the upper reaches of our sample. The phenomenon is company-specific and the performance of TSMC's rivals (e.g., SMC) was average or worse based on the limited data available.

It is worth noting that the large standard deviations make the average returns reported here statistically indistinguishable from each other (and from a zero rate of return), but in practical terms, it means only that returns have been volatile over the period studied and that the period itself is relatively short for statistical purposes (which inflates the standard deviation). The outsized standard deviations remain even if the sizable downturn in 2001 is eliminated from the data (results not shown). Yet, small differences in these averages matter a lot to the firms involved and their investors, so they are well worth studying with the tools available.

These results show that, on average, the companies in all three positions of the value chain (embedded, assembled, and distributed systems) earn little or no excess return, and many companies earned below-prevailing rates of return during the 1990s (see Table 3). In particular, carriers, who hold entrenched “gatekeeper” positions, do not appear to be earning profits at the expense of other players in the value chain as we expect them to be able to do in the future.

Next we look more closely at the ROI within four PC era value chains to see if position in the value chain makes a difference, or if other patterns emerge. The industries were chosen primarily for their relevance to the emerging NWO, but a secondary consideration was the availability of corporate information in Compustat. Graphs of returns for the companies discussed are presented.

Value Chain: Personal Computers

As expected, embedded systems suppliers Intel and Microsoft (based on data prior to a restatement of earnings to reflect expensed stock options) clearly earned excess returns from their respective monopolies. Intel’s average ROI from 1990 to 2001 was 22.4%, with a standard deviation of only 7.8. For the same period, Microsoft (which, like other software firms, is excluded from our sample) had an average ROI of 28%, with a standard deviation of 4.9. These are among the highest average returns (and lowest standard deviations) of any of the firms we examined.

[FIGURE 1 ABOUT HERE]

Figure 1 shows the ROI for Intel and several other companies in the PC value chain for the period 1990 to 2001. The other chip company in the figure besides Intel is Micron Technology, a supplier of memory chips, which are competitively supplied by other producers in Asia and Europe. Micron’s earnings (average ROI of 10.6) are very volatile (SD of 15.7) because periods of low demand are marked by damaging price wars that can drive memory prices below their manufacturing cost. Other chip suppliers to the PC industry, such as graphics chip maker ATI Technologies (average ROI 15.6, SD 23.2), not shown, experience similarly vertiginous swings in their returns.

The biggest surprise in this value chain was the strong performance of Dell, with an average ROI of 28%, albeit with a relatively large standard deviation of 21, for the 11-year period. In sharp contrast, the ROI of Compaq, not shown, once one of the leaders in the PC field, trended noticeably downward during the period and averaged 9.7% (SD of 13.6) in the decade prior to its sale to Hewlett-Packard. Dell’s ability to have Microsoft-like ROI has been traced to its well-documented business strategy.² Dell’s successful direct-selling business model is supported by a heavy emphasis on their customer and supplier relationship management that help it to keep costs and prices favorably aligned.

Since the launch of their Internet strategy in 1994, Dell's embrace of "virtual integration" across its supply chain and to its customer base has reduced its supply of inventory from 32 days in 1994 to five days in 2000. Dell's inventory reductions were not uniformly experienced across the industry. For example, at Compaq the corresponding inventory supplies ran 67 days in 1994 and 36 days in 2000 (Fields, 2002, p.230). Dell's ability to cultivate Internet-mediated relationships with their customers and suppliers has been a primary driver of the company's success, where the company's sales in 2001 (roughly \$32 billion) reached nearly ten times their 1994 level (ibid, pp.224, 226). Dell's relationship with the end user is direct whereas Compaq is buffeted by distributors.

Value Chain: Cellular Telephony

Figure 2 shows the value chain for cellular telephony. Embedded system providers are considerably weaker than in the PC chain. Texas Instruments, one of the leading chip suppliers for handsets, averaged 7.3% (S.D. of 11.4), no better than the prevailing rate of return. Qualcomm, which commands a virtual monopoly in cellular chips for the standard known as CDMA, averaged -2.6% (SD of 19.3). Even if the large negative return of the first year of reported data is excluded, Qualcomm's 10-year ROI of 2.9% is less than the prevailing rate.

As did computers, the cellular value chain has a stand-out assembler, Nokia, with average ROI of 24.5 (S.D. 8.1) for the period 1993 to 2001. Similar to Dell's success in the PC value chain, Nokia's rise to the top was built on strong brand marketing and customer relations. Nokia's closest competitors in the global handset market, Motorola, is vertically-integrated and horizontally-diversified, which makes comparison difficult, but Motorola's average ROI (5.9%) is much lower than Nokia's.

We expected carriers in this value chain to be relatively strong because the sector is less regulated and firms are more entrepreneurial than is the case for wireline telecom and cable. The global leader in wireless, Britain's Vodafone, fulfilled this expectation with an average ROI of 24% (S.D. 16). Two U.S.-based carriers, AT&T Wireless and Sprint PCS (not shown), only reported data beginning in 1998, and their four-year averages (0.1 and -11.5, respectively) are heavily weighted by the industry downturn that began in 2000 and by the sizable debt loads assumed when acquiring spectrum in government auctions.

[FIGURE 2 ABOUT HERE]

Value Chain: Network Hardware

Figure 3 shows the ROI of selected firms in the network hardware value chain.

No chip supplier to this infrastructure industry has been able to develop a sustainable advantage. LSI Logic, an important supplier of chips to the network and other markets, has a below-normal average rate of return of 1% (S.D. 13.5). Smaller companies more exclusively focused on networking chips, such as Broadcom (-6.6%, S.D. 42) and PMC-Sierra (-6%, S.D.44.5), had even lower and very volatile returns, even if one ignores the disastrous year 2001. This supports the notion that any advantage procured by a networking chip company from being first to market and/or having the fastest chip is fleeting.

Like the PC and cellular value chains, the network hardware market has a stand-out assembler, Cisco. Cisco's advantage, based on a mixture of integration skills, sales support, and early presence in the router market, does not appear to have been sustainable through its

ambitious expansion via acquisition after 1994. Its ROI began to sag after 1996 (**Figure 3**), which is well ahead of the high-tech sector's downturn, because the price tag of acquisition targets was inflated by the stock market bubble. Even so, Cisco's ROI levels exceeded others in the network hardware value chain with an average of 24% (S.D. of 12.3).

Cisco was able to succeed in the high-growth environment of the 1990s by pursuing a fast-follower strategy anchored by the pervasiveness of its quasi-standard Internet Operating System (IOS) software in the router market. The company essentially outsourced its R&D through acquisition, especially in new product markets, as indicated by its careful attention to retaining the engineers in the acquired firm. Then Cisco would rapidly grow the market of the acquired technology by bringing to bear its extensive sales and product support networks (Mayer and Kenney, 2002). It remains to be seen if this strategy will prove viable as the industry resumes normal growth following the current severe downturn.

Carriers in the network hardware market are a mix of entrepreneurial firms, many of whom have failed during the downturn, and more traditional telecommunications carriers. In **Figure 3**, we show Sprint, one of the major owners of the Internet "backbone," whose near-prevailing returns (average 7.6%, S.D. 3.7) are typical of the large, established carriers.

[FIGURE 3 ABOUT HERE]

Value Chain: Cable TV Set-Top Boxes

Figure 4 shows selected firms in the Cable TV set-top box value chain. It is immediately apparent that the general level and variability of the returns to firms in this market are both lower than in the three markets already discussed. The explanation resides in the somewhat unusual business model of the cable companies at the heart of this market.

Until recent efforts at consolidation, U.S. cable firms were typically family-controlled enterprises that pursued revenue growth while tax-sheltering profits by building out infrastructure or acquiring other cable systems. The low returns of Comcast (-0.5%, S.D. 5.6), the cable carrier whose returns are shown in the figure, are representative of those reported by other companies in the sector, such as Cablevision (-15.8%) and Cox Communications (3.9%).

Most set-top boxes deployed before 2000 used analog technology that was proprietary to the assembled systems firm. As shown in the figure, Scientific-Atlanta, one of two primary set-top box suppliers in the U.S., has a higher ROI (10.4%, S.D. 6.2) than Comcast because of the returns earned by its proprietary embedded technology.

The cable industry is changing. As the market for infrastructure became saturated, which undermined the tax-shelter business model, leadership at the largest cable companies shifted to teams of professional managers. The upward trend in Comcast's ROI is representative of what is happening with several other cable companies, including Cablevision and Cox.

Another change is that cable companies are working together to develop open standards that will introduce competition among set-top box suppliers. Over time, the competition should erode the box suppliers' returns from proprietary technologies as consumer electronics firms are able to offer competing products. Scientific-Atlanta's upward-trending ROI is a tribute to its ability to build on its past relations with the cable industry as the major shift from analog to digital gets underway.

[FIGURE 4 ABOUT HERE]

The industry is also changing for semiconductor suppliers. Chips containing proprietary technology were generally designed in-house by system assemblers, which left more standard chips for outside suppliers. STMicroelectronics (**Figure 4**) is one of the more profitable suppliers of set-top box (and many other kinds of) chips, with average ROI of 12.7% (S.D. 5.5) since 1993. Its competitors in this market include LSI Logic, IBM, and Matsushita.

With digital technology, the chip content of the newer generation of set-top boxes has been reduced to two or three “system-level” chips, which are part of a “platform solution” (including software and a reference design) provided by the chip company that will enable manufacture by many assemblers. This shift will tend to favor the chip suppliers over the assemblers. On the other hand, lively competition in this chip market will likely put steady pressure on prices.

Lessons learned

The major lesson of these ROI charts is that the ability to earn excess returns is not confined to any particular position in the value chain. In theory, a firm’s position in the value chain can confer market power. Sawhney and Parikh (2001), for example, claimed that only the core of the network (infrastructure ownership) and its extremities (personal services) hold out the hope of excess returns: “The middle of the network gets hollowed out; it becomes a dumb conduit, with little potential for value creation” (p.81). Similarly, Borrus and Zysman (1997) claimed that market power in the disaggregated value chain would be wielded primarily by companies that control product market standards.

Yet that is not what we found in the recent past. The dominance of Intel and Microsoft in the PC value chain did not preclude a profitable strategy from Dell. The privileged position of carriers in the cellular value chain did not prevent Nokia from establishing a valuable brand.

Another clear lesson is that semiconductor suppliers, with the notable exception of Intel, are in the least advantageous position. Within our sample, their ROI is just below carriers and well below assemblers. However the ROI data for individual chip companies show that there is a wide variation in the performance of competing chip makers within each industry value chain. Yet any excess returns earned are short-lived as competitive pressures from rivals and from customers drive down margins until the next big design win. This relative weakness may come from their distance from end-users, which diminishes their ability to capture value through branding and customer relations. This situation is the flip side Sawhney and Parikh’s claim about the relatively high profit potential of services delivered through the network.

Looking forward: Value creation and capture in the Net World Order

Having looked at the recent historical record, we now turn our focus to the future of the electronics industry. This section examines more explicitly how the primary players of the NWO create value and, more importantly, capture it.

Value creation

In terms of their expertise, the typical value creation proposition of embedded, assembled and distributed systems companies is divided between technology, on the one hand, and business practices, on the other, as shown in **Figure 5**. Embedded systems suppliers create value primarily

by developing technology. At the other extreme, carriers invest in technology but add most of their value by developing business methods, such as efficient monitoring and billing procedures.

Suppliers of assembled systems can build their value proposition around either or both of these activities. Nokia, for example, derives its advantage from innovations in wireless communication technology as well as from the creation of stylish handset designs. Dell Computer, on the other hand, built its success on a direct marketing model and a build-to-order production system that pushes inventory costs upstream in the supply chain while at the same time allowing for customer choice (Fields, p.242).

[FIGURE 5 ABOUT HERE]

From the vantage point of the end-user, value creation arises from the interplay among the embedded, assembled, and distributed systems that constitute the NWO. **Figure 6** illustrates this interplay, where key features of embedded systems, such as features and software, give rise to distinguishing characteristics of assembled systems, such as personalization. The assembled systems are then combined into distributed systems, which differentiate themselves by their ability to integrate complex technologies, assure quality of service, and provide network coverage.

Although the figure presents this relationship as linear, the choices at the embedded and assembled system levels are made in consultation with actors at the other levels. For example Qualcomm develops new features in, and applications for, its CDMA products in part through working with wireless carriers. Chip companies in the consumer electronics market work with suppliers of DVD players and set-top boxes to learn what features are most demanded by customers.

[FIGURE 6 ABOUT HERE]

Other aspects of Figure 6 are more linear. The reliability of embedded components and software is at the root of the reliability of assembled systems, which in turn is an important element of the quality of service in a distributed system.

An aspect of value capture worthy of specific mention is compatibility among systems, because of its central importance in the PC era. Compatibility must be omnipresent at the embedded, assembled, and distributed levels to be available to end users. Compatibility usually requires a conscious decision on the part of the embedded, assembled, and distributed systems companies in a particular product market. Companies often seek an advantage by creating closed, proprietary systems. With the build-out of the Internet globally, however, users have developed a strong desire for interconnectivity. As a result, economic network effects like those creating the Wintel standard have become harder for firms to create. Some network effects persist, however, such as the long-running incompatibility of various instant messaging systems. Other network effects are national, especially in the highly-regulated communications sector, where standards may be chosen, for example, to favor local equipment producers.

An increasingly important source of value creation in the NWO is the personalization of products and services, which are developed as embedded technologies in hardware features or software interfaces, then made available to end users by the assembled and/or distributed systems. For example, assembled systems companies like Dell permit end users to configure the assembled systems to their individual specifications. Similarly, the application software on an

assembled system like a cellular handset can be used to construct a personalized experience on a distributed network.

Many companies are capable of creating value in the ways shown in Figure 6, yet some companies have been consistently more profitable than their competitors despite offering similar bundles of technologies. We now turn to a closer examination of how the players in the NWO value chain position themselves to capture the value they help to create.

Value capture

What determines which firms dominate the product markets of the Net World Order?

Firms supplying the Net World Order are not immune to conventional economic forces, and most NWO markets are fiercely competitive. Some firms, however, carve out a competitive advantage that can lead to product market dominance and the rise of bargaining power across the value chain.

We look at three traditional sources of market power and discuss how each operates in the NWO:

- Economic network effects: de facto standards, dominant designs, preponderant networks
- Branding: differentiation through non-technological means such as customer relations
- Intellectual property: trade secrets or patents or other government-sanctioned protection of a stream of returns grants

The PC era was dominated by the network effects of the Wintel standard. Microsoft's position, in particular, has remained virtually unassailable in light of the desire for users to have effortless compatibility.

Although NWO markets are generally not dominated by network effects and de facto standards, authorship of a standard still can provide some measure of market power through associated first-mover advantages or intellectual property ownership. Companies lobby to have their design or technology adopted by carriers, industry, or official agencies. Failing formal adoption, coalitions of firms backing incompatible standards may compete in the marketplace, with the attendant loss of business due to customer hesitation or confusion.

Widespread adoption of an embedded architecture, an assembled system configuration complemented by a library of application software, or wide-spread subscription to a distributed network based on particular protocols, can produce barriers to entry. Across our the three types of systems—embedded, assembled, and distributed—the barriers would manifest themselves as de facto standards, dominant designs, and dominant networks, respectively.

Where network effects are not possible or not present, branding and other forms of non-technological differentiation can contribute to user loyalty, and therefore market power. As demonstrated by the “Intel Inside” campaign, even embedded systems companies can wield market power through brand building by reaching the end-user.

Firms can build their brand through customer relations. Systems firms like Dell that stay in touch with customers after the sale and provide expert help create loyal customers. Since reliability is an important attribute of products in the NWO, provision of services when a product fails becomes important.

Finally, market power can be conferred through an outright grant of monopoly power. Such grants include a government's allocation of spectrum rights to a telecommunications company or a geographic territory to a cable franchise. Similarly, when a company secures an enforceable intellectual property right like a patent, the company can wield monopoly power

according to the provisions of the intellectual property rights regime, e.g., the length and breadth of patent protection.

With these sources of market power in mind, we return to our four product markets and try to project our findings about their recent past into the future, while bearing in mind that distinctions between them are blurring.

Value capture: Personal Computers

In the PC value chain, the main embedded systems – Microsoft’s operating system and Intel’s microprocessors – captured most of the market because of network effects, technological prowess, and branding. Companies selling assembled PCs have had a hard time maintaining market leadership, since brand name did not seem as important to consumers as price when all machines offered the same embedded functionality. Dell’s combination of mass customization and efficient supply chain management has created an impressive record of leadership from the mid-1990s through the early 2000s, but it remains to be seen if it can leverage this success into other NWO products like personal digital assistants as the PC market matures worldwide and/or blends into various “convergence” markets.

Value capture: Cellular Telephony

In the Cellular Telephony value chain, the source of bargaining power for suppliers of chips, the primary embedded system, is to meet the performance requirements of handset companies ahead of their rivals. This means that the chip company must be in close communication with leading handset companies in order to have the required chip ready as soon as the desired specification has been set. Chip companies also gain leverage by offering “platforms” – complete packages of programmable chips and software that greatly reduce the amount of time needed to complete the design of a new handset. For example the current market leader, Texas Instrument, offers the Open Multimedia Application Platform (OMAP) which supports all the major third-party operating systems for cell phones.

The (assembled systems) cell phone market of the 2000s seems likely to develop along the lines of the PC market of the 1990s, with a handful of embedded systems providers like Motorola, Qualcomm, and Texas Instruments enabling a large number of handset assemblers who compete mainly on price.

Handset companies must create competitive advantage through ease of use of the features chosen from the underlying embedded systems and through appearance and size. Branding can become important, especially for the upper end of the market where phones become as much a personal statement as a useful accessory, but the assembler’s brand potentially conflicts with the branding programs of carriers (distributed systems), who are increasingly placing their own logos prominently on consumer handsets.

The provider of the distributed system relies on customer relations and branding for power in a market where entry is limited. By controlling the protocols and the interface with the end user, we expect the carriers to exercise market power vis-à-vis their suppliers. Each network operator, for example, decides which handset providers will be allowed to test their phones on their network, which is a precondition of selling to the network’s users. Customers care primarily about service reliability and price, but this will likely shift over time toward a preference for differentiated services as a greater variety of web-connected services become available.

Value capture: Network Hardware

In the Network Hardware value chain, the (embedded system) chip companies must have the required chip ready for the router maker ahead of competitors. With limited after-sales lock-in, chip prices eventually trend to commodity pricing.

Manufacturers of the primary assembled systems in the network – routers and switches – can gain a first-to-market advantage with carriers, but this each technology generation is short (less than two years) and the competition begins anew. Cisco was able to sustain and extend its advantage during the Internet boom thanks to its large and experienced sales force applied to a series of strategic acquisitions.

As in the cell phone market, the distributed system provider in the network equipment market has a strong bargaining position. The service coverage and market penetration of the larger carriers flows from government licensing. Their ability to attract and retain valuable large users depends on the quality of their technology choices, deployment, and management. The entrenched carriers exercise considerable market power vis-à-vis their suppliers particularly in the low-demand, post-bubble economy.

Value capture: Cable TV

In the Cable TV value chain, we are witnessing a major shift in the bargaining power between the cable company (distributed system) and the set-top box makers (assembled system) as the cable companies are forcing open standards on digital box manufacturers. The analog boxes used proprietary systems, which gave the systems companies after-sales lock-in with the cable company. Once again, the chip makers' bargaining power with the set-top box maker depends on providing the required performance at the right time. Without lock-in or branding, chip prices tend to fall to competitive levels.

In summary, carriers appear to be strengthening their bargaining position with their value chain partners as multiple markets converge into the Net World Order. Suppliers of embedded and assembled systems do what they can – often with considerable success – by seeking market power through authorship of standards, branding programs, and continuous product improvement.

Implications and conclusions

The emerging Net World Order is shaking up the competitive landscape for all firms that participate in any of its markets. The creation of new markets and the convergence of existing ones require a broader strategy and expanded expertise across technologies compared to the PC era. Intel and Microsoft, for example are doing their best to leverage their dominant position in computing into related markets in networking (Intel), interactive television (Microsoft), and cellular telephony (both).

In addition, the Net World Order brings greater complexity to industry value chains by introducing network operators as key players into markets such as consumer electronics where they were largely absent during the PC era. These companies have the most direct access to users and in many cases determine the quality of the user experience for many NWO products. This, combined with the local monopolies of many carriers, raises the prospect that they can exert bargaining power in excess of the value they add to the value chain.

Some of the highest returns among the firms in our sample were, in fact, achieved by two carriers, British Sky Broadcasting and Vodafone. Both of these are based outside the US and in a country (the United Kingdom) where deregulation is more advanced. The low returns of US carriers in our sample may well be an artifact of historical regulatory and management systems that will not apply in the future. As their debt burden abates and management practices evolve, we expect U.S. carriers to generate much higher returns.

The data on returns, however, show that companies anywhere in the value chain can earn excess returns. The paths taken by the standout firms in our sample are many: technology management (STMicroelectronics), business methods (Dell), branding (Nokia), or a combination (Cisco).

If these companies have anything in common, it is a tight relationship with customers. STMicro is known for its long-term alliances with customers such as Nokia and Western Digital, which permit greater sharing of plans and information than arm's-length contracting. Dell is similarly well known for its customer relationship management with consumers and businesses. Nokia conducts extensive marketing research among phone users in all of its markets to learn what they most value and what is considered "hip." Cisco offers extensive engineering support to networks deploying its equipment. It is the mastery of these key relationships that appears to distinguish the high performers.

What of the Intel-Microsoft strategy, i.e. control of a key standard? Will they or some other company develop new standards that will lead to value extraction from the rest of the value chain on such a scale? We believe the answer is "no." Assembled and distributed systems companies have learned the lessons of the past and are pushing open standards wherever possible to avoid lock-in to the suppliers of a single proprietary technology. In the Cable TV value chain, for example, cable companies are trying to impose open standards for next-generation digital boxes so that they can be sold at retail by multiple suppliers. Standards competitions will continue to be hard-fought in all venues as firms search for an advantage, as predicted by Borrus and Zysman (1997), but the lopsided outcome of the PC market seems unlikely to be repeated.

While the rules of leadership may be changing as life after Wintel unfolds, optimal firm structure also may be evolving. Noticeably absent from our list of high performers are integrated firms (Table 3). In theory, the combination of embedded and assembled systems should reduce the variance of returns (at least to the extent that shocks to the two sets of returns are not correlated). Motorola had above-average ROI in the 1990s and also below-average standard deviation. But IBM had a very large standard deviation, as did Philips. Integrated Japanese firms Toshiba, NEC, and Hitachi, had low standard deviations, but also well-below-average ROI. Samsung Electronics, a firm that has received recent attention as a high performer, does not appear in our sample because of lack of comparable data, but the available data would place it in the middle of this group.

In light of the relatively weak performance of integrated firms, the recent spate of spin-offs of chip operations by Lucent, Siemens, and others, makes perfect sense. Vertical integration, if it ever offered an advantage, has become a burden in the fast-moving Net World Order. Even a vertical holdout like IBM has slimmed down by shedding product divisions such as hard disk drives.

Competitive advantage increasingly derives from successfully managing a complex network of external relationships rather than a hierarchically-controlled grouping of internal divisions. Each player in these market-based value chains maximizes its value with a combination of technology and customer knowledge. Ideally this increases the total profitability of the chain rather than pulling profits away from the company's partners, as demonstrated by the ability of both Intel and Dell to be high performers in the PC value chain.

NOTES

¹ See the "multimedia" value chain described in Collis, et al, (1997).

²For an overview of Dell's strategy, see Curry and Kenney, 1999.

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Table 1: Representative Industries of the PC Era

	Personal computers	Telecom equipment	Cable set-top boxes	Cellular phones
Embedded Systems	Intel, Microsoft	Lucent/Agere, National Semiconductor	LSI Logic	Texas Instruments, Motorola
Assembled Systems	Compaq, Dell	AT&T/Lucent, NorTel	General Instrument, Scientific-Atlanta	Nokia, Motorola
Distributed Systems	not applicable	Sprint, Atlantic Bell	Comcast, TCI	Sprint PCS, Vodafone

Table 2: Net World Order Value Chain

	Business	Carriers	Households
Distributed Systems	Network Owner/Service Provider (cable, landline, satellite, wireless) and its subscribers		
Assembled Systems (User Level)	Business Terminal Devices (PCs, PDAs, 3G phone) and Web Browsers, E-mail, Etc.		Consumer Terminal Devices (STB, PC, 3G phone) and Web Browsers, E-mail, Program Guides, etc.
Assembled Systems (Infrastructure)	Business Equipment (mainframes, servers) and LAN, E-commerce applications	Network Equipment (routers, switches, basestations)	
Embedded Systems	Semiconductors and Operating Systems		

Table 3. Average Return on Investment, 1990-2001 as available

CARRIERS	AVG. ROI	STD. DEVN.		PURE-PLAY ASSEMBLERS	AVG. ROI	STD. DEVN.
BRITISH SKY BRDCSTG GP -ADR (1994)	78.52	223.78		DELL COMPUTER	28.51	21.24
VODAFONE GROUP PLC -ADR	29.10	16.69		NOKIA CORP -ADR (1993)	24.49	8.10
SBC COMMUNICATIONS INC	12.37	3.92		CISCO SYSTEMS INC	24.21	12.30
BELLSOUTH CORP	10.23	3.45		HEWLETT-PACKARD CO	13.93	4.52
AT&T CORP	9.64	8.30		SCIENTIFIC-ATLANTA INC	10.43	6.16
VERIZON COMMUNICATIONS	9.56	3.39		ERICSSON (L M) TEL -ADR	9.94	9.96
QWEST COMMUNICATION INTL INC	7.88	6.82		COMPAQ COMPUTER	9.70	13.56
SPRINT FON GROUP	7.62	3.71		3COM CORP	4.06	17.78
FRANCE TELECOM -ADR (1996)*	6.57	3.24		ALCATEL -ADS	0.64	17.22
LIBERTY MEDIA CORP -SER A (1995)	5.64	19.72		NORTEL NETWORKS CORP	-20.68	82.72
COX COMMUNICATIONS -CL A	3.90	5.35		JUNIPER NETWORKS INC (1997)	-31.13	61.45
NIPPON TELEGRPH & TELE -ADR	2.95	2.04		JDS UNIPHASE CORP (1993)	-64.24	172.77
DEUTSCHE TELEKOM-SP ADR (1995)	2.93	3.05		WEIGHTED AVERAGE	9.97	19.44
AT&T WIRELESS SERVICES (1998)	0.12	1.96				
COMCAST CORP -CL A SPL	-0.46	5.62		PURE-PLAY SEMICONDUCTOR FIRMS	AVG. ROI	STD. DEVN.
SPRINT PCS GROUP (1998)	-11.53	4.04		INTEL CORP	22.41	7.76
ECHOSTAR COMMUN CORP -CL A (1994)	-12.22	8.98		XILINX INC	19.27	8.23
CABLEVISION SYS CORP -CL A	-15.83	15.01		ALTERA CORP	17.52	9.97
AOL TIME WARNER INC (1991)	-19.06	85.90		ATI TECHNOLOGIES INC (1997)	15.57	23.18
COVAD COMMUNICATIONS GROUP (1998)	-101.70	92.64		STMICROELECTRONICS N V (1993)	12.73	5.46
AT HOME CORP (1996)*	-114.47	172.12		MICRON TECHNOLOGY INC	10.64	15.66
WEIGHTED AVERAGE	6.92	7.06		ANALOG DEVICES	9.30	6.14
				TEXAS INSTRUMENTS INC	7.32	11.43
INTEGRATED FIRMS	AVG. ROI	STD. DEVN.		ADVANCED MICRO DEVICES	7.25	11.36
INTL BUSINESS MACHINES CORP	8.88	14.98		ATMEL CORP (1991)	6.60	10.80
MOTOROLA INC	5.92	9.26		LSI LOGIC CORP	0.85	13.50
KONINKLIJKE PHILIPS ELEC - ADR	5.33	14.04		NATIONAL SEMICONDUCTOR CORP	-1.58	29.44
SONY CORP - AMER SHARES	2.59	5.73		QUALCOMM INC (1991)	-2.60	19.34
TOSHIBA CORP	2.28	2.44		CIRRUS LOGIC INC	-4.59	52.94
HITACHI LTD - ADR	1.59	3.06		INFINEON TECHNOLOGIES AG - ADR (1998)	-5.60	19.97
NEC CORP - ADR	1.35	3.19		PMC-SIERRA INC	-5.99	44.53
WEIGHTED AVERAGE	4.30	7.85		BROADCOM CORP -CL A (1996)	-6.62	41.90
				ABOVE SEMICONDUCTOR COS - WEIGHTED AVERAGE	12.60	11.98
				SEMICONDUCTORS EX-INTEL - WEIGHTED AVERAGE	5.46	15.05

NOTES FOR TABLES A1 to A4

- Values calculated by the authors from COMPUSTAT data for 1990 to 2001 as available.
- First year of data in parentheses if other than 1990.
- * data for 2001 not available at the time of data collection.
- Weighted averages calculated using 1999 Net Sales.
- COMPUSTAT defines "Return on Investment" as " Income Before Extraordinary Items - Available for Common, divided by Total Invested Capital, which is the sum of the following items: Total Long-Term Debt; Preferred Stock; Minority Interest; and Total Common Equity."
- Risk-Free Benchmark: 5-Year Treasury Bond (6.16 average ROI, 1.03 standard deviation)

Figure 1. ROI in the PC Value Chain

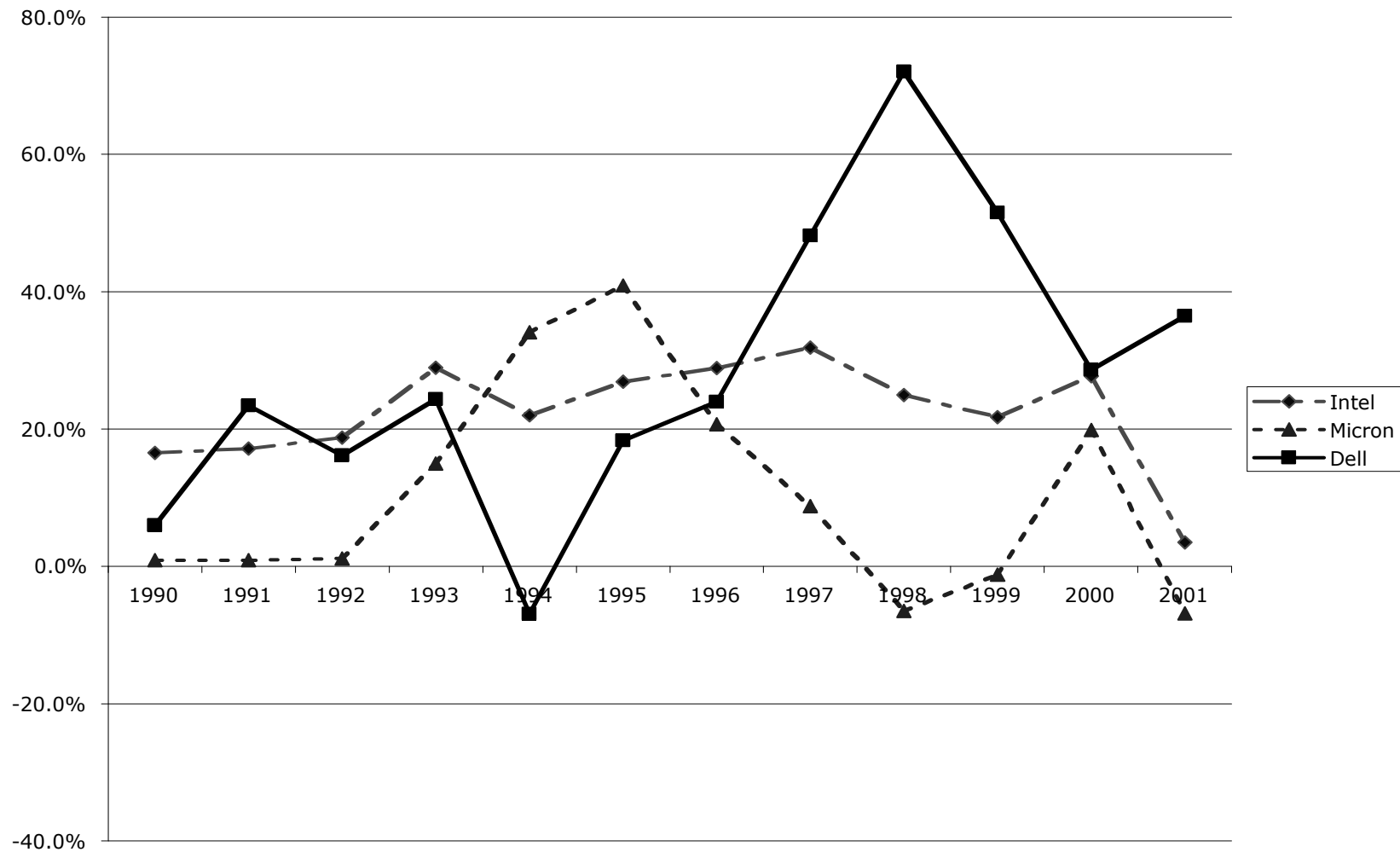


Figure 2. ROI in the Cellular Telephony Value Chain

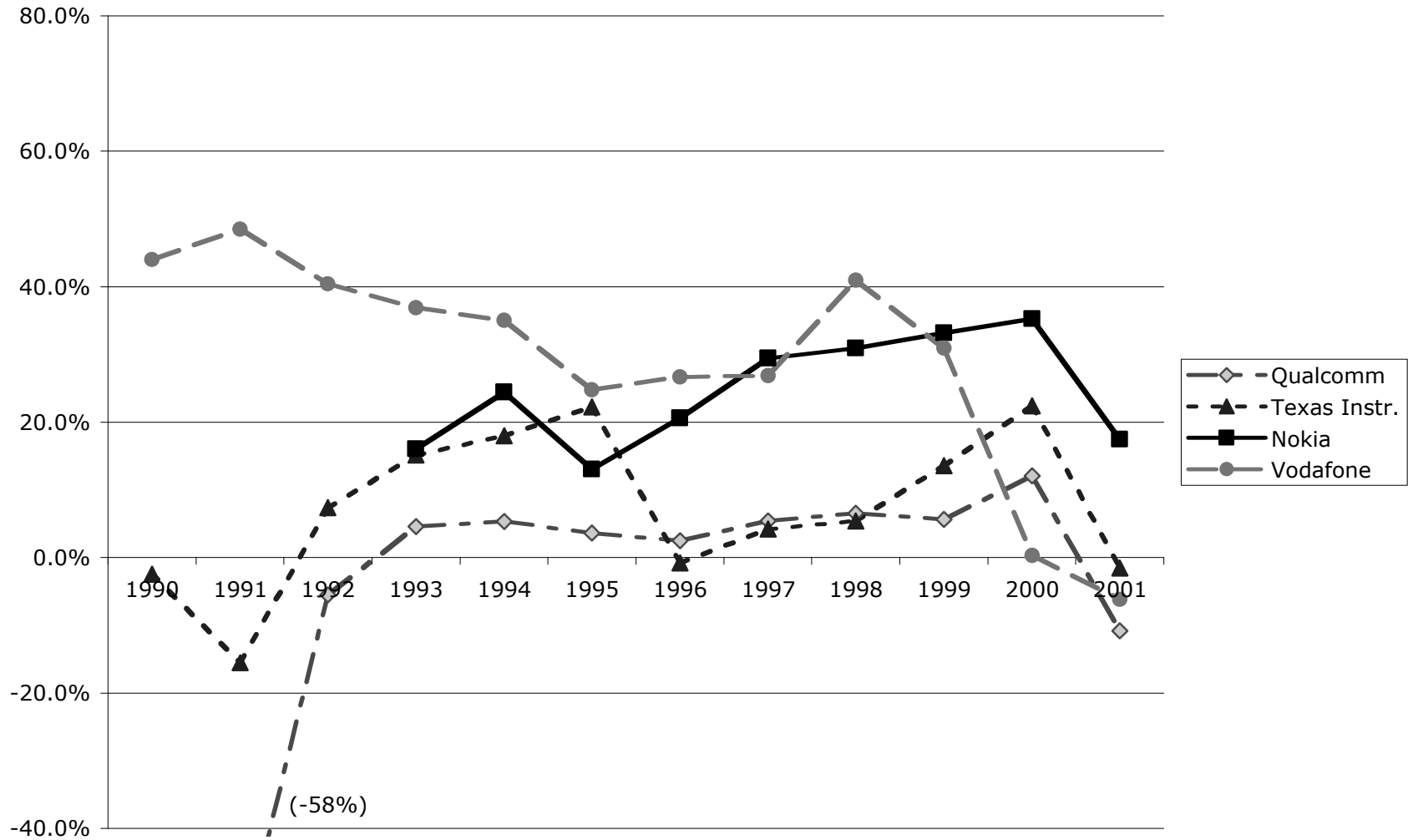


Figure 3. ROI in the Network Hardware Value Chain

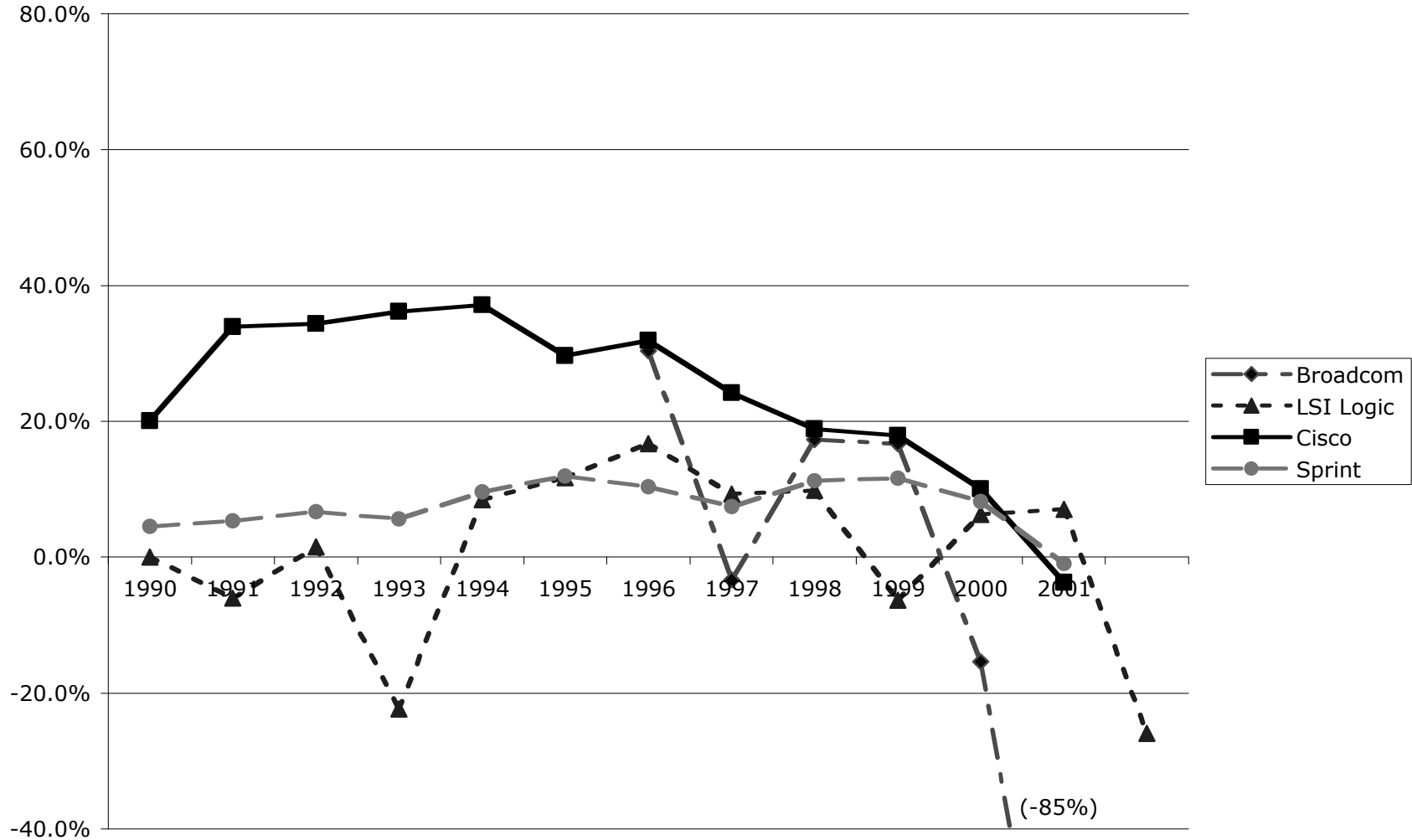


Figure 4. ROI in the Set-Top Box Value Chain

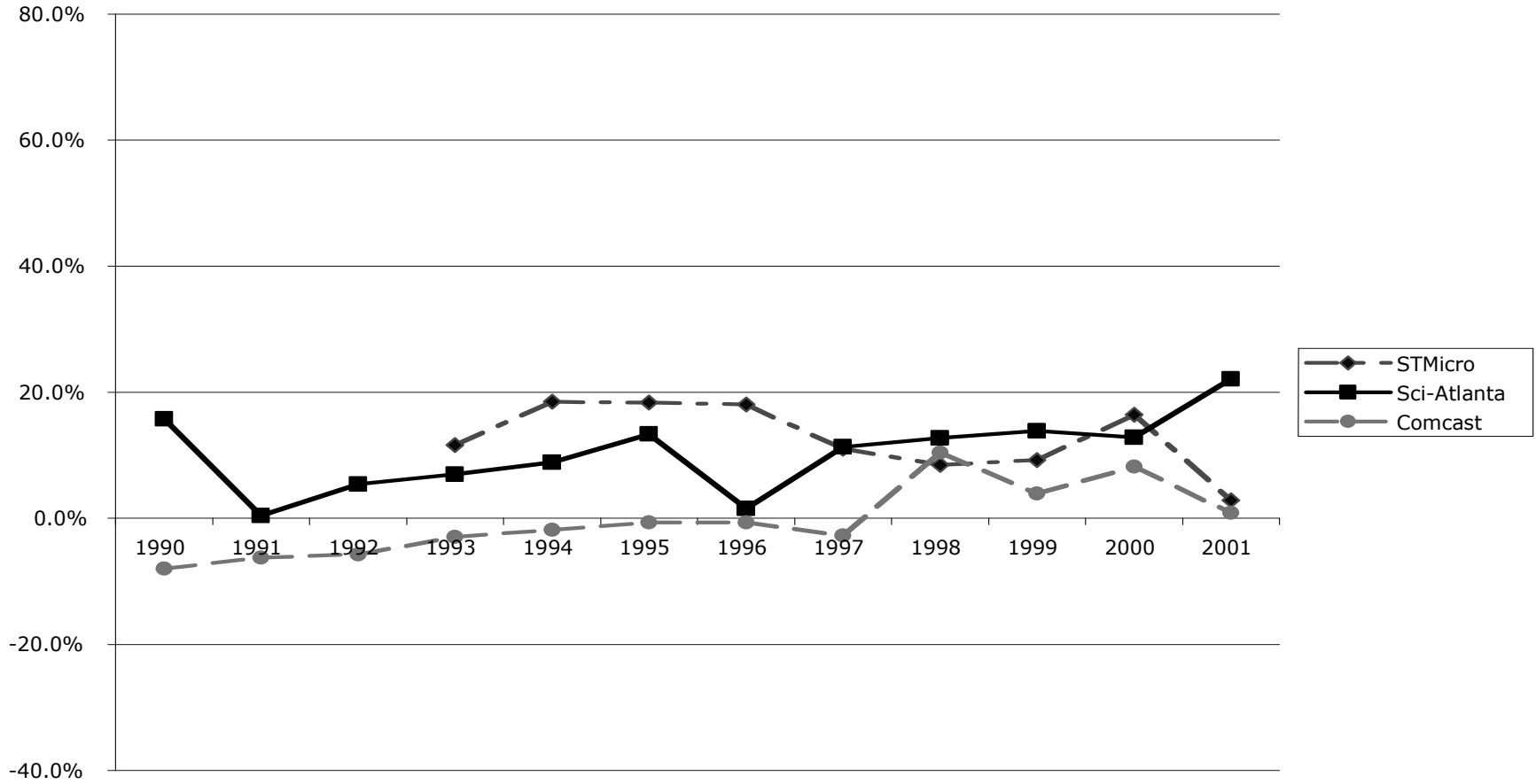


Figure 5. Sources of Value Creation in the Net World Order

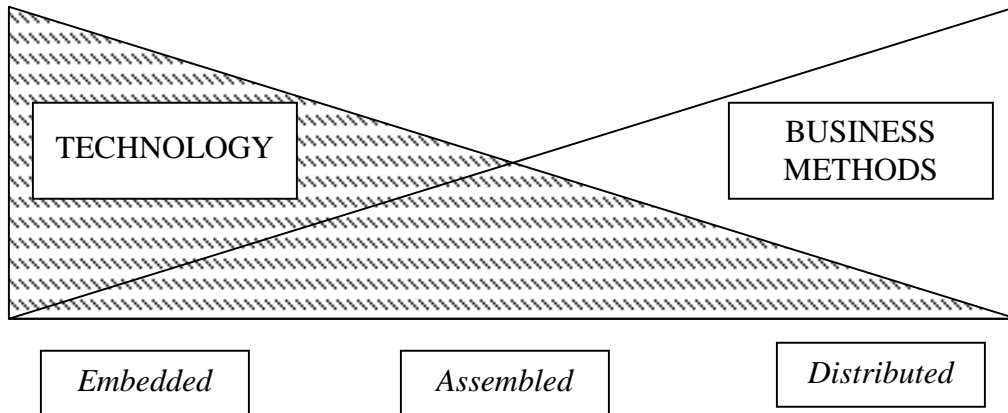


Figure 6. Sources of Value in the Net World Order

