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**THE DISINTEGRATION OF NETWORK
EXTERNALITIES INDUSTRIES**

The computer and the telecommunications
equipment industries

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THE ECONOMICS OF TELECOMMUNICATIONS

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Abstract

This paper explains from a transaction cost economics approach disintegration of network industries whose externalities depend on seamless interaction between its constituent components. A simple two-period model is developed that explains why the positive effects of integration in the first phase are turned into negative effects in the second period causing disintegrated firms to replace integrated ones. The model is used to explain the disintegration of the computer industry, the network equipment industry and the cellular handset industry with reference to leading firms such as IBM, AT&T, Ericsson and Nokia.

1. INTRODUCTION

During the last decade we have witnessed a series of radical disintegrations of major enterprises such as IBM in the computer industry, AT&T in the telecom equipment & services industries, and most recently Ericsson in the cellular equipment industry. All these are network externalities industries producing a wide variety of complementary and mutually value-enhancing modular products, bundled into larger systems across standard technical interfaces. All firms have disintegrated by outsourcing production activities, divesting non-core activities, and migrating into downstream service provision, accompanied by dramatic downscaling and downscoping of traditional activities. As a consequence, thousands of employees have been laid off.

Whereas those directly involved tend to view these events as serious corporate failures, viewing these rather as responsive and mainly efficient corporate adaptation to changing conditions may be just as appropriate. The purpose of this paper is accordingly to develop a dynamic explanation for the last decade disintegration of major firm in the computer and the telecom equipment industry based on transaction cost economics (TCE) (Williamson, 1985, 1999a), supplemented with insights from technology management (TM) research (Garud and Kumaraswamy, 1993, 1995; Sanches, 1995; Meyer and Lehnerd, 1997; Worren et.al., 2002; Christensen et. al., 2001).

Both research traditions (TCE and TM) agree that industry-standard modular architecture will cause industries to disintegrate, but they differ in their explanations. Whereas TM refers to rigidities and myopia in integrated firms as explanation for why disintegrated companies in these instances replaced integrated ones, TCE refers to transaction cost efficient/inefficient governance. According to the former explanation, integrated companies failed to develop more attractive modular products because they missed the opportunity. According to the latter, integrated firms failed, not because they missed the opportunity, but because they no longer were the most efficient organizational form. That is, when design interdependencies that initially caused the conflicts that threatened to upset or undo opportunities for obtaining mutual gains, no longer exist, corporate governance that initially were designed to bring order into these relations, are no longer needed (Commons, 1932:4; Williamson, 1999b: 312). As a consequence, the hierarchical safeguards offered by integrated firms will become too

protective, and therefore counterproductive. Instead of facilitating the adoption of disruptive technology and development of more attractive modular products, integrated firms will act to prevent such adoption and development. In the longer run, such attempts are doomed to fail. By implication, *corporations will tend to disintegrate as the standard interfaces that make system components work seamlessly together, change from proprietary and firm-specific in the first phase of industry development to less-proprietary and less-specific in the second phase.*¹

A series of profound changes in organization, market, regulation and technology over the last couple of decades have created natural experiments in the computer and telecom industries that now lend themselves to closer examination and analysis. Moreover, since the two industries also are rapidly converging, lessons from the earlier computer industry will increasingly become relevant for the more recently computerized telecom equipment industry. In particular, voice and data services transmitted over a complex network of digitized switches and transmissions connect not only to telephones and faxes, but also to computers. As telephones, computers and television converge, the need for new interface standards connecting all three will also appear (as alternative to more compact and clumsy integral products).

The larger industry complex consists of five groups of actors, (i) equipment manufacturers supplying network equipments and terminal equipments (customer premises equipment), (ii) content providers supplying various information and entertainment (iii) network operators that own and operate wired and wireless communication systems, and (iv) service providers distributing basic and value-added services over public and private networks, and finally (v) all the business and resident customers that consume the services offered by the respective service providers (Figure 1).

¹ Standard interfaces can be owned by the system-producer (proprietary) and shared only by a smaller group of integrated or closely allied component suppliers (closed), or not owned by anybody in particular (non-proprietary) and thus freely accessible to all (open). Interfaces may vary from simple all-purpose connections to complex and highly specialized information processing connections.

Figure 1. The telecom industry complex

Upstream	Upstream	Midstream	Downstream	Downstream
Equipment manufacturers	Content providers	Network operators	Service providers	End users
<i>switches</i> <i>transmission</i> <i>terminals</i>	<i>information</i> <i>news</i> <i>entertainment</i>	<i>wired</i> <i>wireless</i>	<i>basic</i> <i>enhanced</i> <i>value-added</i>	<i>businesses</i> <i>residents</i>

Each communication network consists of (a) switches which route the audio, text, data or video signals from sender to receiver and (b) transmission lines on which audio, text, data or video signals travel, as integrated or separate services. In this paper, no statistical testing will be applied, only a series of simple observations to substantiate the relevance of our theoretical explanations and propositions. Throughout, our major concern will be how changing alignments of technology and governance may affect economic performance and industrial evolution at large.

Technology standards are being transformed in both industries from proprietary closed to proprietary open and even to non-proprietary & open standards. Simultaneously, the governance structures for commercializing new technology are also changing from vertically integrated and monopolized structures to disintegrated companies operating on vertically separated market layers coordinated by common interface standards, long term supply contracts and co-operative agreements.

Currently, disintegration takes place in all value-chain directions, vertically, laterally as well as horizontally. Through vertical disintegration system producers increasingly outsource individual components and sub-systems to outside suppliers who specialize in developing, producing and selling these and related components and sub-systems to a larger market of downstream system producers, assembler firms or even final consumers. Extensive outsourcing may subsequently force system producers to move further downstream and specialize on marketing, consulting and customer service, besides total system design and final assembly.

Through horizontal and lateral disintegration major diversified firms increasingly divest themselves of scale and scope assets that no longer need to be organized internally due to comparatively more efficient markets, or due to more

contractible services supplied to a greater variety of downstream customers. Increasingly, also leading technology suppliers choose to release their interface specifications and join forces with complementary and rival firms in developing next generation modular architecture, with subsequent positive effects on both innovation rates and network externalities.²

Whereas standard TCE (Williamson, 1985) assumes that investments in firm-specific technology and corresponding governance structures (e.g.; a unified corporation) have primarily cost economizing effects, our dynamic approach includes both cost and income effects, and these may change and become negative as the industry develops. In particular, we will be searching for factors that may influence the trade-off between the positive effects of vertically integrated and even monopolized firms in the earlier and less standardized phase of the industry and the negative effects of such integration and monopoly in later and more standardized phases.

In section 2 below we outline the theoretical framework for analyzing disintegration in the network industries. Then, section 3 presents the computer industry and the telecom industry cases. In section 4 propositions focusing on the cellular handset industry summarize the relations between governance structure, technology characteristics and performance. Summary and implications close the paper. The study is based on secondary and qualitative data (previous studies, reports, press releases, business magazine articles, simple observations).

² The decision of leading technology suppliers to release the interface part of their technology so that other firms can participate in developing complementary components to their core product is highly strategic. The final outcome depends both on (i) the contractual terms and the conditions for releasing the interface technology, (ii) the firm's ability to release only the interface without also releasing the core technology, (iii) the scale economies in developing and producing individual components, (iv) the transaction hazards associated with outsourcing development and production of components, and on (v) the industrial dynamics released when a larger number of competing firms start producing mutually value-increasing components that also increase the value of the core product.

2. TRANSACTION COST ECONOMICS IN NETWORK INDUSTRIES

In our TCE approach, market, firms and hybrid forms are alternative governance forms affecting transaction costs associated with designing and developing system components (Williamson, 1985). A transaction (our unit of analysis) occurs when information about the functionality and interaction of system components is transferred between technologically separate activities engaged in designing such components. Interface specifications define the technical rules for such interaction. When these are firm-specific and proprietary, integrated firms will be the most transaction cost efficient governance form. As interfaces become less specific and less proprietary, firms also become less efficient compared with markets and hybrid forms (Williamson, 1999a).

Transaction costs are the costs of running the transaction. They include the ex-ante costs of drafting, negotiating, and safeguarding an agreement and, more especially, the ex-post costs of maladaptation and adjustment that arise when contract execution is misaligned as a result of gaps, errors, omissions, and unanticipated disturbances (Williamson, 1996: 377-379). Factors causing transaction hazards and investment disincentives include both attributes of the players such as opportunism and bounded rationality and attributes of the transactions such as incompletely specified contracts, dependency relations and asymmetric information.

To a large extent, transaction costs are caused by people's inclination to behave opportunistically; that is, to mislead, deceive, obfuscate, and otherwise confuse in a calculated and self-interested way. Without such transaction hazards, contracts could have been designed that would have both contributed to more efficient utilization of available system and component technologies (static efficiency) and to more efficient development of new technologies (dynamic efficiency). This would have protected the component makers from exposing its assets to expropriation by the system producer and owner of the operating system technology, and eliminated the system producer's incentives to actually abuse its power. In situations characterized by incomplete contracting between bounded rational and opportunistic actors, interdependency caused by large investment in firm-specific (non-redeployable) assets hinders market transactions. The performance effects of different governance forms, then, such as

vertically integrated system producers, will depend on the way governance-transaction alignments affects transaction costs and investment incentives.³

Vertical integration under common ownership has been the standard solution for protecting both firm-specific and proprietary assets, but decreasingly so in the rapidly progressing network industries, even for the biggest players.⁴ The reason is modular architecture and associated industry-standard interfaces. While internal organization is still important for safeguarding specialized assets and technology, individual system components sharing the same interface standard may be developed more efficiently through markets and alliances. Under such conditions, serving a larger and more diverse group of downstream system producers (assemblers) would simply provide richer opportunities for economies of scale, scope and learning. As a consequence, the respective scale & scope assets as well as the respective core competencies may develop faster and be more fully utilized under the contracting mode than under the corporate mode.

That is, the disintegration story of transaction cost economics is essentially a story about fundamental transformation *reversed* (Williamson, 1985).⁵ What may have been a small number trading relation in the first innovative phase of the industry is

³ A transaction occurs when a good or a service is transferred across a technologically separable interface such as the one separating design, production and assembly of system components or the ones separating lower-layered basic infrastructure that produces switching and transmission from higher-layered applications that produce value-added services. Being technologically separable indicates that the respective activities also are candidates for being organized in separate firms. Technological inseparability would imply team organization.

⁴ In particular, to survive as component suppliers under open competition, business firms must develop organizations that creates and preserve (i) *specialized resources and capabilities* that are used for making *differentiated or customized* products and (ii) *technically advanced expertise* that are used for developing *technically superior products*.

⁵ The standard TCE argument goes as follows. To survive and stay competitive, private firms must *adapt* to *consequential disturbances* caused by changing prices, demands, and technologies by changing their activities and associated governance mechanisms (control, incentives, conflict resolution mechanisms). In cases where the system-producer is dependent on specialized external component suppliers in the sense that switching between suppliers will cause substantial loss in productive value, adaptation to disturbances should be done by *adjusting* the contractual relation rather than by *switching* suppliers. Potential losses from switching suppliers may arise both from *technology leakage* and from *non-redeployable assets*, and the larger the potential losses, the more consequential the disturbances, especially when combined with contracts that are *incomplete* in the sense that they do not take every conceivable disturbance into explicit account (which normally is the case). Rather than specifying every conceivable detail, the transacting players usually agree on more general guidelines that can be further specified and detailed when needed. As disturbances gradually become more *consequential*, the exchange relations are bilaterally adjusted

transformed into a large number supply relation in the later and more competitive and standardized phases of the industry. Here, interface technology linking complementary products plays the crucial asset specificity role outlined in transaction cost economics. Technical interfaces are the connections that make complementary products work seamlessly together so that network externalities can be realized.⁶ As network industries mature and technical interfaces become more standardized and less firm-specific, the identity of complementary component makers will matter less and continuity will take on less economic importance. Autonomous adaptation supported by market contracting will therefore gradually supplant cooperative adaptation supported by corporate organization.⁷

The disintegration story of technology management is essentially a story about competitive advantage of modular over systemic (non-modular) products, changing from negative in the first period where systemic products have an advantage to positive in the second period where modular products may have an advantage. Modular products are created by decomposing a tightly connected system product into relatively independent components and by specifying standard interfaces that define the inputs and outputs that flow between interacting components (Sanchez, 1999).⁸ Conditions are thereby created that makes it possible to (i) upgrade products both faster and cheaper by

rather than unilaterally terminated. To achieve better adjustment under gradually more consequential circumstances, market is replaced by hybrid, and hybrid by hierarchy.

⁶ Such externalities are created when the user value of a given product such as a mobile phone increases with the number of accessible users (i.e.; direct externalities) and with the number of complementary products and services (i.e.; indirect externalities) such as multimedia service applications and multimedia content (Katz and Shapiro, 1986; Farrell and Saloner, 1986, 1987).

⁷ Whereas corporations (hierarchy) support cooperative adaptation by combining low-powered incentives, extensive administrative control and resolving most disputes within the firm, market contracting supports autonomous adaptation by combining high-powered incentives with little administrative control and a legalistic dispute settling mechanism. Hybrid contracting is located between market and hierarchy in all three respects (Williamson, 1999: 312). Governance structures that feature cooperative adaptation (e.g.; a fully integrated corporation) encourage compliance and a stronger system (or mission) orientation, whereas governance structures that feature autonomous adaptation (e.g.; arm's length market contracting) encourage independence and enterprise.

⁸ Modularity is created in architecture when the interfaces between functional components are standardized (i.e.; not allowed to change over some period of time) and specified to allow the substitution of a range of variations in components into the product architecture without requiring changes in the designs of other components (Sanchez, 1999: 95). Attributes of standard interfaces such as modularity, property rights and asset specificity, are highly strategic. Not only do these attributes affect cost structure and innovation rate of integrated companies. They also affect the cost and benefit of component outsourcing (Sanchez, 1999:109) and thus corporate disintegration.

replacing individual components instead of redesigning the complete products⁹, (ii) differentiate products by mixing and matching components, (iii) achieve competitive advantage by specializing on component functions most critical to main customer groups, and to (iv) outsource remaining components to low-cost suppliers or leading specialists.¹⁰

For example, when technological progress overshoots what mainstream customers can make use of, companies that want to win the business of the overserved customers in less-demanding tiers of the market are forced to change the way they compete: they have to design modular products and start to compete on price, flexibility and convenience, rather than on functionality (Christensen, 2001: 75-76). Alternatively, established companies could have searched for “killer applications” that would have increased the demand for systemic products and thereby eliminated overshooting.

But then, innovative application development is exactly what industry-standard interfaces facilitate and stimulate. Such interfaces would enable a growing number of component makers and system producers to specialize and to compete in bringing higher-quality and lower-priced components and systems to market more quickly.¹¹ By releasing only the interface specifications, while still keeping the inner core technology proprietary (e.g. the source code of the Intel chip), not only the core technology owner, but also component makers may earn positive rents from their complementary innovations (usually less than what the core technology owner earns). Due to the coordinating effect of shared industry-standard interfaces, for example in the mobile communication industry, modular components are increasingly developed, produced, and operated by independent specialist firms, rather than by vertically integrated firms.

⁹ As pointed out by Garud and Kumaraswamy (1995: 96): ‘In sum, firms may impart upgradability to technological systems by designing unutilized degrees of freedom into higher-order components. These unutilized degrees of freedom enable designers to enhance system performance by substituting only those lower-order components whose potentials have been exhausted.’

¹⁰ According to Sanchez (1999:92): “When used efficiently, modular architectures make it possible to create greater product variety, introduce technologically improved products more rapidly, bring new products to market more quickly, and undertake these initiatives at lower costs than ever before”.

¹¹ Technology management may therefore easily be subsumed under the transaction cost economics approach, providing a more balanced treatment of technology and organization. As Christensen et.al. (2001: 76) emphasize: “Once a modular architecture and the requisite industry standards have been defined, integration is no longer crucial to a company’s success. In fact, it becomes a competitive disadvantage in terms of speed, flexibility, and price, and the industry tend to dis-integrate as a consequence.”

¹² Although a smaller share of a larger economic rent is thereby appropriated, this may still exceed the value of the larger share of a smaller rent under more restricted network externalities. The benefit of extended network externalities is therefore what motivates incumbents to release their interface standards and entrants to adopt them. Eventually firm-standards coalesce into industry-standards.

Negative incentive effects from the resultant dependency on proprietary technology may, however, prevent speedy conversion of firm-specific interfaces into industry-standard interfaces. Most of the investment that component makers put into developing new components will be specific to the proprietary architecture (or platform), and firms controlling proprietary technology tend to charge monopoly price on their contribution to the joint product.¹³ Being already locked into their chosen proprietary platform provider through their previous platform-specific investment, component developers are forced to accept the resultant price squeeze.¹⁴ Upon realizing that most of the added revenue will flow to the owner of the platform, complementary component makers will gradually cease to invest in component and process innovation until private property rights in interface standards are transferred, shared or fully released (Grossman and Hart, 1986; Hart and Moore, 1990).¹⁵ By operating as separate firms and by granting complementary innovators a larger share of future cash flow, a larger number of innovative and mutually beneficial products and services will probably be developed. Subsequently, this will generate extra revenue for all players.

For many years, however, lock-in was the favorite strategy of the computer industry, the telecommunication equipment industry and the telephone services industry.

¹² GSM (Global System for Mobile Communications) is the most common 2nd generation digital mobile standard. W-CDMA (Wideband Code Division Multiple Access) is one of the 3rd generation mobile technologies. When based on common technology standards, complementary products and services such as mobile handset and mobile networks are also easily adjustable and replaceable. Under these conditions, value is added not only by adding more complementary software and services, but also by adjusting and upgrading the total system as newer and better parts become available (Garud and Kumaraswamy, 1993).

¹³ Although the rules for transmitting signals to an Intel processor, for example, are published openly for all vendors, the underlying design of the processor (the source code) is owned and protected by Intel, just as the design of Sun's operating system, and so on for Microsoft's Windows, Novell's Netware, or Adobe's PostScript (Morris and Ferguson, 1993: 88).

¹⁴ Such supplier lock-in works much the same way as customer lock-in when customers, after having invested in proprietary systems, start considering further investments in upgrades, accessories and supplementary components.

Being less defensible from a welfare economic point of view, dominant system producers and telephone network operators are now increasingly being forced by the regulatory authorities to open up their technology and networks so that competing firms can start developing and supplying complementary products and services.

Besides, expected revenue growth from extended network externalities may motivate voluntary sharing of property rights, especially among new entrants expecting cutthroat competition from dominant incumbents. In particular, sharing of property rights can be used as a competitive weapon to undermine the technical monopoly position of incumbent firms.¹⁵ To avoid being locked into a restricted communication network built on proprietary closed standards, customers also increasingly prefer to buy from suppliers that commit themselves to open technology standards and refrain from vertically integration.

In short, charging monopoly prices on one's contribution to the joint product, or integrating complementary activities under one unified corporation cannot in general be considered the most productive solution in typical network industries such as the computer and the telecommunications industries. The main features of the development of these industries are presented below with reference to representative firms such as IBM, Microsoft, Ericsson and Nokia. My intention is not to provide genuine new information, but to examine these cases through the lens of dynamic transaction cost economics. Finally, this exercise will enable us to draw more general conclusion about disintegration of network externalities industries.

¹⁵ Nor will merging the respective firms solve the problem since most of the resultant profits then will be returned to corporate headquarter rather than to the contributing firms.

¹⁶ One of the earliest and most successful firms that initially pursued such a non-proprietary & open strategy was Sun Microsystems (Garud and Kumaraswamy, 1993). In particular, Sun's strategy of selecting open standards and leasing out own proprietary technology, proved more successful than IBM's simultaneous attempts at developing proprietary and closed standards (Garud and Kumaraswamy, 1993: 357-358). The reason for this is the growth in network externalities and demand that may be achieved with open standards compared to closed standards.

3. LESSONS FROM THE COMPUTER AND TELECOM EQUIPMENT INDUSTRY

*The computer industry*¹⁷

Until the late 1970s nearly all computers were large machines used for mind-numbing calculations and bookkeeping, mostly bought by larger organizations that could afford their price and service costs. Computers such as mainframes and minicomputers were the most complicated machines ever produced. They were sold in a relatively small number, and mostly produced by large companies that were vertically integrated from basic circuitry, computer platforms and operating system software to application software and distribution. Newcomers had a hard time breaking into the business for several reasons. First, few had the resources necessary to enter at all levels simultaneously. Second, for those who entered at one or two levels, the small number of independent suppliers and distributors made it immensely costly to operate. Third, due to the machines' complexity and service needs, most customers were reluctant to buy from anyone but large, established suppliers.

So far vertical integration had served two purposes. First, by internalizing the development process, computer makers controlled technology leakage so that proprietary and mutually incompatible systems could be developed and sold to increasingly captive customers. Second, by internalizing the process, the computer makers could also develop and deploy firm-specific assets more efficiently for the production of differentiated products. Since each chain of production was vertically chained together by closed interface technology, bilateral monopolies arose between component suppliers and assemblers that apparently were more efficiently managed by hierarchy than by market contracting (Williamson, 1985). Competing production systems remained therefore vertically integrated until challenged by a more flexible and less expensive technology, the personal computer (PC) technology.¹⁸

¹⁷ The account of the computer industry draws heavily on The Economist, February 27th, 1993.

¹⁸ According to Christensen et.al. (2001: 76), PC disrupted the industry: "During the early decades, the dominant companies were integrated across most value-chain links because competitive conditions mandated integration. As the personal computer disrupted the industry, however, it was as if the industry

With this technology installed, distributed computing and networking soon became a more flexible and efficient alternative to the mainframe system for ever-more complex and power-consuming tasks. Since the new computers could be assembled from hardware pieces and software components supplied by independent firms in the market, the new computer industry was never vertically integrated as the old computer industry. Coordinated by open interface standards, interchangeable components were outsourced to achieve economies of scale without the risk of excessive transaction costs. The need for vertical integration to control technology leakage and to manage firm-specific assets along the value chain decreased.

From its inception, the personal-computer market assumed a different pattern from the established industry, mainly because of rapid diffusion of new technology. The chip manufacturers were now able to cram a simple version of a computer's central processing unit, the circuits that did most of the actual computing, on to a single chip, a so-called microprocessor. Around this, a small cheap machine could be assembled from readily available parts used to supply the consumer-electronics industry. The most successful of all personal computers, the IBM-PC, based on Intel's microprocessor and Microsoft's operating system, became the industry standard for which a large number of application software firms wrote their programs. Fortunately for both firms, full property rights to the basic technology were retained in the initial contracts with IBM, and due to this, a large number of chips and software copies could be sold at a premium price to a booming computer industry. A parallel rapid growth in compatible application software, developed by innovative third parties, created the "network externalities" that substantially improved the value of the underlying technologies. Since Intel and Microsoft through incremental innovations succeeded in keeping their technologies both proprietary and in strong demand, huge monopoly profits ensued. As IBM's losses kept skyrocketing, it became gradually clear to everybody that Intel and Microsoft had profited substantially more from the success of the PC than any PC-maker, including the largest of them all till then, IBM.

got pushed through a bologna slicer. The dominant, integrated companies were displaced by specialists that competed in horizontal strata within the value chain.”

As additional software, equipment and network products were developed, the value of possessing an IBM-compatible computer continued to grow, and so did the sales and use of such computers. Spawned by a constant stream of technical innovations and improvements, mainframes and minicomputers lost out to PC-network and stand-alone PC for steadily more complex tasks. As distributed computing and networking continued to replace the old mainframe system, the demand for open interface standards and intersystem compatibility continued to rise, stimulated by a more open system strategy. This was most strongly demonstrated by Sun Microsystems. Soon open product standards and open network systems were demanded by most customers and supported by most computer makers. When open technology standards were supplemented with conversion programs and internetworking technology, the level of interoperability increased even more. Consequently, most personal-computer makers were never vertically integrated. Separate groups of firms supplied parts, fully assembled machines (platforms), operating-system software and application software.

By attracting a larger number of potential innovators, open standards contributed to the growth of network externalities, and thereby to the profitability of the firms that controlled these standards, such as Intel, Microsoft and Novel. Companies that did not control technology standards, including most computer makers, benefited less. In other words, when open and dominant standards are owned, patented or difficult to imitate, the owner of the standards will also tend to get rich. The assembler, however, will not tend to get rich unless some additional proprietary technology is added to the system. While earning extra profit became constantly harder for computer makers, the owners of the original and incrementally improved standards got constantly richer. The emergence of open, but still proprietary standards, thus fundamentally redistributed competitive advantages and economic profits, from computer makers such as IBM (and Norsk Data) to chip producers such as Intel, and software firms such as Microsoft, Novel, Word Perfect and Lotus. Also the system-users benefited immensely. As long as they stayed within the dominant IBM-standard, customers could freely choose between a growing number of high-performing low-priced computer systems, and no longer needed to be exploited by their chosen computer maker.

However, proprietary standards will still exist, and as more companies start outsourcing a larger share of their component production, leading component technology may even develop into world standards. To the degree these are owned by one supplier, considerably higher profits can be earned after the production systems have disintegrated than before (which was and still is the case for Intel in microprocessors and Microsoft in operating-system software). Although positions as profitable as those of Intel and Microsoft are extremely rare, many firms regularly develop proprietary technology with significant profit potential. Even if future technology standards should be less proprietary than before, technological innovations within these standards can still be kept proprietary.

Successes as impressive and positions as dominant as those of Intel and Microsoft can seldom be attained without the active use of some kind of monopoly power. Clever tricks and ploys that may pass when performed by non-dominant firms, may not pass, however, when carried out by dominant businesses. Gradually, this was also realized by Intel who wisely moderated its practice when the US Federal Trade Commission requested them to do so. Microsoft, however, did not moderate its business practice when asked to, but continued to punish companies that developed competing products (e.g., Netscape, Sun Microsystems) or customers that sold competing products (e.g., IBM, Gateway). The findings of the subsequent antitrust case of *U.S. v. Microsoft* thus unambiguously showed that Microsoft routinely used its monopoly power to crush competitors, even leading the judge to portray the company “as nothing less than a social menace” (Business Week, 1999, Nov. 22: 45).

After the judge had officially declared Microsoft a monopolist, regulators started to discuss remedies of which there were two major types: one behavioral type and several structural ones. The behavior remedy would require close supervision over issues such as pricing and contracts with other companies, eventually making the government the permanent overseer of Microsoft. Being very difficult to monitor, supervision of such behavior might become overly costly and stifle innovation, or unreliable if not fully implemented. Structural remedies contained several dramatic measures such as breaking up the company into three horizontally separate companies (operating systems, application software, and Microsoft Internet business) or three

vertically integrated and competing Mini Microsofts (“Baby Bills”), or forcing Microsoft to auction or license out proprietary technology to competing companies.

The question was how to punish Microsoft and stop its abusive conduct while encouraging innovations and protecting the consumers. Although the different remedies could help to restrict monopoly pricing and power abuse they were not without costs and limits. Disintegration would not create competition in the market for operating systems; partitioning into competing Baby Bills and auctioning Windows might fracture the Windows standard; open-source code licensing might facilitate illegal copying. In any case, remedies should only be recommended if significant net benefit could be expected. Benefit could have been gained from structural remedies both in terms of making the core technology more accessible and less costly for downstream customers, and in terms of making innovations in complementary products easier to develop and more profitable to commercialize for related businesses. Significant investment disincentives were, however, also involved since structural remedies would make investments in operating systems less profitable for the main firm.

Two years later, an appeal court overturned the antitrust punishment, but not the guilty verdict of abusing its monopoly power. Rather than breaking up the company, the court ordered a bundle of sanctions on its conduct, which Microsoft finally accepted. Although Mr. Microsoft himself, Bill Gates, complained that Microsoft was being penalized for innovating, it is actually striking how little innovation there has been in the parts of the market where Microsoft has dominated compared with other parts of the markets. Operating systems, web browsers and word-processing software all look much as they did five years ago, but not mobile phones, handheld computers and music-sharing software.

The evolving computer industry illustrates perhaps better than any other industry how the dynamic efficiencies of alternative governance forms change as the underlying technologies change from non-redeployable and proprietary to redeployable and non-proprietary standards. Most important, the evolving alignment of technology and governance are fully consistent with our dynamic transaction cost economics approach presented earlier in the paper, including escalating transaction costs caused by conflicting relations between complementary and competing component suppliers when

one of these is also the owner of the enabling system technology that determines the future compatibility of these components.

Let us now examine more closely how similar forces affected the less-famous telecom equipment industry before we start examining the mobile handset industry.

The Telecom Equipment Industry

For a long time, local production and proprietary architectures characterized switching and transmission equipment much like in the computer industry.¹⁹ Economies of scale were under-exploited and equipment over-priced. To improve conditions, telephone companies started in the early 80s to invite the world's leading vendors to compete for the development and production of digital and more standardized switching and transmission equipments.²⁰ By the early 90s, digitization had advanced well into telecom networks and telephone terminals in most western countries. With increasing standardization of system architectures, similar disintegration that a decade earlier had started to affect the development of the computer industry, started now to affect the development of the telecom equipment industry, including leading firms such as AT&T (of the US) and Ericsson (of Sweden).

Consider first AT&T and how regulation and technology affected its development over the last couple of decades. After the regulatory enforced 1984-breakup, where the local exchange business was spun-off into seven local exchange companies (LEC)²¹, AT&T continued as a combined equipment supplier and long-distance operator. It subsequently diversified into related computing and information businesses by buying the computer firm NCR, and by expanding into a full range of

¹⁹ After AT&T's breakthrough innovation in digital switching based on integrated circuits, a continuous stream of incremental innovations followed. Smaller and more compact electronic parts replaced mechanical parts, which greatly reduced the space, weight and cost of telecom equipment. The demand for telecommunications services kept growing, and switching and transmission were digitized to exploit the high-volume capacity of the new transmission media such as fiber optics and microwave. Gradually, high-capacity switching and transmission based on digital high-frequency techniques replaced low-capacity switching and transmission based on analog low-frequency techniques.

²⁰ At the end of the 1980s, the number of switch makers had halved to seven vertically organized global enterprises. Central office digital switches required some \$1 billion to develop and \$14 billion in sales to break even. Huge investments and uncertain demand had also delayed the development of next generation's ATM- switches.

²¹ These are also called Baby Bells, or Regional Bell Operating Companies (RBOCs).

communication and information services including wireless calling, credit cards, online services, consulting and electronic commerce.

To prepare for maximum use of its long distance telephone network, AT&T tried to be a player in every conceivable type of communications terminal.²² This was done through an enormous network of alliances and joint ventures. Officially the objective was to coordinate increasingly complicated and advanced communication networks. Capturing a larger share of potential profit from complementary products was obviously another, but apparently less official objective.

In most of these ventures, AT&T's new partners were mainly responsible for developing and producing terminals and equipment that promised to increase the use of AT&T's networks and the company's income from these networks, especially if the interface standards could be kept proprietary and closed. Enforcing closed standards and restricting their partners' ownership rights to their own technologies, however, could once again arouse anti-trust reactions. Besides, emerging lessons from the computer industry suggested that proprietary closed standards will be difficult to maintain, and if maintained, would become increasingly unprofitable, as it did to Apple Computers.

²² As reported by Gary Slutsker (in Forbes, Feb., 1993), these included the following: A "*neighborhood*" phone that extends the range of a cordless phone fourfold, to a mile; a *converter box* for the top of the television set, to access and decompress up to a possible 540 cable channels (through a joint venture with TeleCommunications and General Instrument); a combination home computer/videogame/TV for *interactive multimedia* (through a deal with 3DO, Time Warner and Matsushita); and a *portable computer* that communicate without wires (through an investment in Silicon Valley startup EO). The AT&T Business Products outfit, selling office phone system and AT&T voice mail, strengthened its sales potentials considerably through its recent *interconnection deal* with the computer network software king Novel, enabling AT&T switchboards to connect to Novel's local area networks (i.e., making proprietary Novel network "open" to AT&T switches). AT&T internal *chip* division, called AT&T Microelectronics, that previous manufactured solely for AT&T, now sells to external buyers 40% of what it makes, including a customized chip to Hewlett Packard's 21 megabyte PC card (a miniature hard disk that connects compact palmtop and notebook computers to peripherals such as faxes and local networks). Through its acquisition of NCR Corp. AT&T moved into the global business of selling *computers* designed to be connected to networks such as those of bank teller machines and retail cash registers. By acquiring control over U.S. largest *cellular* company, McCaw Cellular Communications, AT&T may eventually be able to bypass the local Bell companies and thereby save billions of dollars in access fees (today AT&T pays \$ 14 billion a year). From cellular AT&T moves further into next generation of *personal communications* and *wireless communication*, into making *computer* that links into wireless networks, and into high-capacity, low-power and low-heat *microprocessor* suitable for personal communication (such as its recently designed Hobbit), and into *video phone* production and *videoconferencing*. At the same time, *legal restrictions* put on AT&T due to its huge size are removed, and the *outsourcing* of communication network services from giant corporate customers to carriers such as AT&T, British Telecom and MCI, is increasing.

With open standards, however, partners' chips and software could also be used in competing terminals and networks, benefiting competitors as well as AT&T. Small innovative firms that developed proprietary technology that ran on compatible AT&T equipment and networks might actually become more profitable than the operation of AT&T itself (similar to the relation between Microsoft and IBM in the computer industry). Without being owner of the proprietary technology and production facilities, AT&T would only profit from the widespread use of traffic-generating intelligent terminals to the degree previous monopoly positions in service provision were regained.

The chances of regaining such a monopoly positions vanished rapidly during the 90s, however, as the number of competing long distance operators kept growing and prices and market share kept falling. Despite of impressive growth in stock value after the 1984-breakup (19% per year over 10 years), AT&T failed miserably in computing, and NCR was sold at great losses.²³ It then also decided to withdraw from the equipment business, probably for several reasons, partly to avoid accusation of favoring their own service operations, partly to benefit from international competition in equipment production. The spin-offs of NCR and Lucent were later combined with heavy investment into cable TV assets (TCI and MediaOne) and into wireless, all this to counter increasing competition and falling prices and profit margins in long distance voice traffic. With these assets AT&T intended to offer a raft of consumer services, from mobile services and local telephony to high-speed Internet access and digital television, made possible by the acquisition and modernization of a large chunk of America's cable system. At this time, no other rival was in a position to offer such a rich bundle of services to US residents and companies.

With a rapidly increasing number of long-distance competitors (increasing to 500 towards the end of the 90s), prices started to tumble. AT&T failed once again in turning the group into a profitable enterprise, and decided to split the company into four tracking stock businesses. The wireless and the cable units were later sold, leaving

²³ This supports the prediction put forward by Michael Jensen (1991) about the likely effect of the legal shut-down of the US corporate control market: *"As a result, takeover today are likely to revert to the pattern of the 60s and the 70s, when large companies used takeovers of other companies to build corporate "empires". The recent AT&T acquisition of NCR is an example. And if the past is a reliable guide, many such acquisitions are likely to end up destroying value and reducing corporate efficiency."*

AT&T only with the business and consumer businesses. With the AT&T break-up, a new industry trend had emerged. The vertically integrated model of telecoms that had dominated the past decade was about to be scrapped and replaced by a model in which specialist companies, from Vodafone and Global Crossing to Cable & Wireless, competed horizontally, within their own fields of expertise. Other big telecoms companies also chose to go the way of AT&T such as BT, WorldCom (now bankrupt) along with others facing similar financial pressures.

More recently, disintegration forces have also started to affect less diversified equipment firms. Proprietary products are increasingly being superseded by cheaper open systems built from off-the-shelf parts. Newcomers such as Cisco Systems and Asian low-cost producers such as Huawei of China are undercutting vertically integrated giants such as Ericsson, Lucent and Nortel Networks, just as IBM and Digital Equipment were battered by low-cost PCs from Dell Computer. To compensate for the loss of business, Ericsson and some of its rivals are moving into network operations (so-called managed services) outsourced to them by telephony companies such as Telia, AT&T and Brazil Telecom (*BusinessWeek*, November 4, 2002).²⁴

In fact, Ericsson's strategy of selling services and basic technologies bears a remarkable similarity to the model pursued by IBM during its turnaround in the 1990s. The new Wintel strategy of proprietary and open standards had replaced the previous proprietary and closed IBM strategy. Like then, the "value" in telecom systems is now about to shift from hardware to software and services. A majority of Ericsson's manufacturing and more than 5,000 of its employees are therefore being passed on to contracting outfits like Flextronics International and Solectron. Almost 70% of its operating units will be eliminated, consolidating back-office functions into regional centers. Three-quarters of Ericsson's labs have been closed and work on antiquated mobile technologies is being phased out. Part of its R&D is outsourced to more cost-effective contractors such as Indian software powerhouse Wipro running Ericsson's software labs in New Delhi, Hyderabad, and Bangalore. At the same time, new units to license the company's technology to rival companies worldwide has been opened, and

²⁴ The main sources of information about the disintegration of Ericsson are *BusinessWeek* (November 4, 2002). 'Saving Ericsson', pp 48-52, and various press releases from Ericsson.

its entire mobile handset business is now handed over to a joint venture with former rival Sony Corp.

In short, strikingly similar forces and responses that characterized the turnaround of the computer giant IBM, now characterize the turnaround of the equipment giant Ericsson. Like IBM once realized, Ericsson now also realizes that an increasing number of upstream suppliers and services firms have become more efficient and creative than their own integrated units. Open interface standards that eliminate transaction costs and enable independent specialist to supply their customers with products of higher quality and lower price, is probably the main cause. Consequences for previously integrated equipment firms are outsourcing, downscaling, downscoping and migration into downstream service activities.

That is, as computer technology continue to converge with communication technology, and as open interface standards continue to migrate into switching, transmission and terminal systems, similar transformations may happen in the telecom equipment industry as happened in the computer industry. In particular, as telephone systems become more modular (due to open interface standards) and equipment innovations more autonomous, the need for software and hardware suppliers to merge with final system assembly and network operation to capture a larger share of profit from new technology will vanish. Simpler contracting and partnering will suffice, as it did in the computer industry. If so, less proprietary and open interfaces will increasingly replace proprietary and closed interfaces, technology systems will increasingly become unbundled and modularized, and sharing and licensing strategies will increasingly replace proprietary lock-in strategies. Finally, disintegrated firms will replace integrated enterprises.

4. PROPOSITIONS

To further clarify the underlying micro-analytics associated with the above disintegration tendencies, a set of refutable outsourcing propositions will now be developed, focusing on the cellular handset industry. Rather than dealing with disintegration of the larger enterprise, these will be dealing with outsourcing of hardware and software components by major handset makers, such as Nokia and Ericsson. Also other conditions and attributes than purely technical ones will be included, along with a broader set of possible governance responses and innovation effects.

Externalities

Consider the larger mobile communication system made up of numerous interconnected network elements, of which the handset represents the user end node in the system. Besides handset design and final assembly, each handset vendor makes a few critical components internally. External suppliers make most standard hardware and software components. Internal production and assembly capacity is large enough for moderate to high sales volumes. Should future demand greatly exceed expectations, additional production, assembly and distribution capacities will normally be accessible on reasonable short notice from large-scale suppliers.

Following the strategy lesson from the PC industry, leading software firms should release only the *interface specifications* of its proprietary technology, not its source code. This would enable complementary hardware and software firms to implement and enhance the application and market value of the proprietary technology, but not to clone it. Like Microsoft, owners of standard operating systems may thus gain competitive advantage and profits that go beyond those conferred by low costs and differentiation. Their proprietary standards would set the rules by which rivals must play, and create switching costs for phone users which protects system producer against new entrants (Farrell and Saloner, 1986).²⁵

²⁵ Wireless applications, from simple games to sophisticated business solutions, need a platform to run on a software system that interprets the application instructions, and tell the device how to execute them.

In mobile communications, the proprietary-open strategy has been less successful. Only Microsoft, the new giant entrant from the computer industry, has actively pursued such a strategy, but so far with little success. Should they succeed, their software strategy would probably turn hardware handset makers into less profitable disintegrated commodity producers (software licensees) much as they did to computer makers in the PC industry. Current conditions in mobile communications are, however, not as favorable to Microsoft as they were two decades ago. These less-favorable conditions include not only steadfast resistance from established handset makers against the threatening possibility of being turned into hardware-only commodity businesses. They also include less-favorable technological and economic conditions. To win the technology race in the handset industry, where network externalities are even more important than in computing, even more of the system technology may have to be released and placed in the public domain. That is, to convince a sufficient number of leading complementary firms to participate in developing the larger phone system (network, handset, applications), not only the basic radio access technology, but also operating system technology may have to be released. Such a non-proprietary and open platform strategy may create even more innovations than the Wintel strategy due to larger network externalities. Thus, the following refutable propositions may be stated:

Proposition 1a: The handset makers' choice of a non-proprietary and open technology strategy is positively related to the size of network externalities surrounding the technology, and negatively related to the market share of the handset maker.

Proposition 1b: Given large network externality potentials, the subsequent number of complementary innovations is positively related to the extent of non-proprietary open interface standards.

To illustrate the above propositions, consider recent open architecture initiatives in the cellular handset industry.

Cellular handset makers can either choose the more ambitious strategy of improving or replacing the established standard, or the more modest strategy of developing their products within the specifications given by the older standard. If successful in improving or replacing the standard, extra profit may be gained from first mover advantages in terms of price premiums, licensing fees and production and

Mobile phones now seem more likely than computers and television sets to become the first widely used multi-media communication devices. To help accomplish this, a rather impressive group of communication firms jointly decided on November 12, 2002 to commit themselves to Open Mobile Architecture that will enable a non-fragmented global services market to develop.²⁶ According to the initiators, by following consistent global and open standards they will be able to provide consumers with a wide selection of different competitive, yet interoperable terminals and services, and hence promote significant industry growth and ensure that economies of scale are enjoyed throughout the industry. The initiative will encompass terminal client software modules for mobile terminal vendors and the corresponding server solutions for mobile operators. Open standards will ensure customer benefits such as genuine competitive products, true freedom of choice, control of their own information and services usage, and common usability of the mobile services.

The initiating companies also promise to conduct mobile software development in full compliance with the specifications from the key industry standardization organizations such as the 3GPP and the WAP Forum. They will also actively participate in these standards bodies to expedite the acceptance and deployment of these specifications that will fuel further industry growth. By enabling a multi-vendor ecosystem built on open industry standards,²⁷ mobile operators, systems integrators, IT suppliers, terminal manufacturers, and application developers will be offered new avenues of growth and revenue. Together they are determined to *“form the foundation for an open mobile services architecture, which will benefit the whole industry as the fastest route to true global mass markets, offering equal growth opportunities to all parties in the value chain”*.

marketing learning, increased publicity and improved goodwill. The duration and magnitude of the profits depends on the degree of technical advances achieved and the extent of technological leakage suffered.

²⁶ The initiative was launched by AT&T Wireless, Cingular Wireless, MM02, NTT DoCoMo, Telefonica Moviles, Vodafone, Fujitsu, Matsushita, Mitsubishi Electric, Motorola, NEC, Nokia, Samsung, Sharp, Siemens, Sony Ericsson, Toshiba and Symbian. See Nokia, Press release (November 13, 2001): “Industry leaders announce commitment to open mobile architecture enabling a non-fragmented global mobile services market”

²⁷ These include WAP2.0/XHTML, MMS (Multimedia Messaging Service), SyncML and other 3GPP compliant technologies. Additional important component examples of the initiative include Java™ technology and the Symbian OS, a multi-vendor operating system for mobile devices.

That is, major industry players increasingly join forces to create open interfaces that expand network externalities by making more components accessible to more system producers to the benefit of more phone users. Rapidly evolving technologies may force system producers to outsource components they otherwise would prefer to insource. In particular, since no single firm can be expected to be at the frontier of all the rapidly evolving sub-technologies for next generation mobile systems (UMTS), phone makers will be forced to outsource a larger chunk of total R&D, design and production to external specialist firms. Open architecture makes this possible without causing excessive transaction costs.

Specificities

Nevertheless, custom-design will be the primary means by which handset producers differentiate their products and profit from technology development. When hardware and software components can be custom-designed without also customizing the respective design capabilities and production facilities (flexible specialization), investment in non-redeployable assets will be low, and so will also the need for extra contractual safeguard beyond simple market contracting. So long as only moderate sunk costs from custom-designing the components will be at stake, supply contracts specifying procedures for solving disputes and adjusting the course of action can handle the transactions. Replacing the supply of customized components with *standardized* off-the-shelf components will of course also eliminate the need for extra contractual safeguard.

The more time and effort sunk into custom-designing the components, the larger the non-redeployable assets, and the higher the need for firm-like governance to handle the associated transaction hazards. When total costs sunk into developing customized components are extra large, major handset producer would probably prefer to insource rather than to outsource component development. Due to financial constraint, smaller handset producers will often have no choice but to contract out a larger proportion of customized R&D and design, particularly when time to market is short and first mover advantage high. Financial distress may also force major handset producer such as

Ericsson to outsource a larger proportion of software development and subsequent production.

The following propositions summarize the above reasoning:

Proposition 2a: The probability of outsourcing complementary software and hardware components is positively related to the handset maker's shortage of resources and shortage of time to market, positively related to the extent of open standards, positively related to flexible specialization in component production, and negatively related to investment sunk into customizing the components.

Proposition 2b: When outsourcing of complementary components is chosen by the handset producer, the degree of hierarchical contracting is negatively related to flexible specialization, and positively related to investment sunk into customizing the components.

The recent development of mobile smartphones exemplifies the above propositions. Although the basic communication standards (GSM and UMTS) are non-proprietary and open, operating systems and applications that run on top of these are less open (i.e.; more vendor-specific). For example, the Windows based operating system of Microsoft's Smartphone 2002 is more proprietary and less open than the Symbian operating system of Nokia's smart phones. Nokia's phones come also with a non-proprietary software package, called the Series 60 Platform, containing development tools that allow independent third parties to develop their own applications.²⁸ Developers can either sell these applications as download products directly to phone users, as individual products through Nokia's distribution channels or as standard applications on Nokia handsets. Alternatively, the same applications can be sold through the marketing channels of other vendors, or as part of the standard application package of other phone makers using the same Symbian OS and Series 60 Platform.

Series 60 Platform provides unique customization possibilities, which enable terminal manufacturers and operators to maintain and strengthen their brand and differentiate from the competition. Manufacturers can customize Series 60 by adding bitmaps for manufacturer/operator specific graphics; sounds, animations, color schemes

²⁸ See: Nokia v Microsoft: The fight for digital dominance, *The Economist*, Nov 21st,2002; and Nokia, *Series 60 Platform, Introductory White Paper*, Version 1.0, August 2002.

and fonts; operator specific services and applications; indicators such as antenna, battery etc; customer specific data such as operator bookmarks; new hard keys to access specific functionality. Developers can use existing skills and past experience to develop native C++ applications for Series 60, as well as applications running on key enablers, including Java, messaging, and browsing enablers.

Technology leakage

Successful outsourcing requires closer collaboration between external component makers and the handset producer sharing proprietary information. Sharing component suppliers with other handset makers increases the risk of proprietary information leakage and revenue loss. To prevent leakage and potential profit from being captured by competitors, the handset maker may either patent the innovation or protect its secrets by developing and producing the advanced components internally. When the handset firm lacks the expertise and the time needed to develop these components internally, they may either switch to more standardized lower-performing components, or contract out and risk the costs of earlier technology leakage.

Exclusivity clauses can be included that will reduce the risk of technology leakage, and increase the handset makers' share of future income, but not here without negative side effects. Even if the transfer of ownership rights is compensated with an additional risk margin, the component makers' incentives for subsequent innovations are weaker under exclusivity clauses. Future surplus that otherwise could have been maximized and completely retained by selling the future technology component to as many competing phone makers as possible, will under exclusivity clauses be shared with the handset maker and restricted by the sales of this handsets (royalty). This kind of incentive weakening will probably affect creativity negatively. If so, component suppliers will hardly suspend with their rights to acquire the extra profit generated by their innovation without reducing their creative efforts that are needed to actually accomplish the innovation. This will again reduce the total commercial value that the handset producer may appropriate in the subsequent commercialization period.

In this sense, exclusivity clauses, like acquisitions, should be regarded as two-edged swords (Grossman and Hart, 1986). Not only do they help the buyer appropriate

a larger share of the potential surplus. They also tend to weaken the component maker's performance incentives and innovative outputs, and therefore also the total commercial value that can be appropriated by the handset producer in the subsequent commercialization period. As a consequence of weaker incentives, creative effort may drop and performance may decline.

If buying the component supplier is chosen over buying only the property or licensing rights to the technology, this would improve coordination and information exchange in the commercialization phase, but also restrict the degrees of freedom in developing subsequent innovations. By replacing high-powered with low-powered incentives, integration does not only curb the profit motive for expropriation in the commercialization period, but also the profit motive for continuing innovations in coming periods, since after integration, the component maker is no longer the residual claimant to the profit generated by his innovation.

Besides, due to the transition from autonomous to cooperative adaptations, vertical integration may also have some restrictive effects on the likelihood of more radical innovations. Hierarchical governance structures that are helpful in preventing deviation from known courses towards pre-specified outcomes are not equally helpful in promoting the exploration of unknown courses towards innovative solutions. On the contrary, by demanding full control, the handset producer might actually "kill the goose that lays the golden egg" (Williamson, 1985: 159). In other words, while hierarchical control structures have the advantage of more flexible adaptation (including less problematic transfer of technical knowledge), they have also the disadvantage of weaker incentives for innovations due to risk reduction and the impossibility of selective interventions (Williamson, 1985: 135-138).

Summarized, when the commercial success of a system product such as a cellular handset is strongly dependent upon subsequent innovations in its constituent components (and associated network externalities), the costs of exclusivity contracts and corporate integration may actually exceed its benefits, calling for some alternative control mechanisms. By combining (i) the system producer's rights to specify the standard interfaces with (ii) the supplier's property rights to complementary innovations, such a correction might actually be provided. First, the system producer may through

such an arrangement have increased the component suppliers' investment incentives, and secured himself future access to the new technology. Second, he may also have contributed to the long-run accumulation of valuable know-how and technology among external suppliers that subsequently will feed back on the handset producer through later purchases of innovative complementary components. If successfully carried out, high-powered incentives will be preserved among related firms, stimulating a higher rate of compatible and supportive innovations. Although this is not the only conceivable correction mechanism, it surely is one of the most pertinent in the cellular handset industry. Thus, we advance the following propositions:

Proposition 3a: Given outsourcing of new technology components, the likelihood of high-powered supply contracts (e.g.; licensing fees, royalty fees) is positively related to the component's network externalities.

Proposition 3b: The innovation rate in component technology is negatively related to integration of component makers into handset production.

At first sight, available evidence from the cellular handset industry may seem somewhat ambiguous. Non-proprietary standards are combined with integration of handset production into upstream component development. On the one hand, leading handset maker Nokia generously licenses out higher-order system technology to speed up innovation. He also outsources component production to save production costs and put competitive pressure on their own suppliers.

On the other hand, Nokia declines to give up its control over lower-order (higher-layer) application software and most of its component production.²⁹ As a consequence Nokia also refuses to give up corporate integration of design, assembly and branding into upstream component development and production, especially software components. That is, although higher-order hardware and software platforms are open

²⁹ Lower-order components in technology management (Garud and Kumuraswamy, 1995) correspond often to higher-layer user applications in 'Open Data Networks' (National Research Council, 1994). These layers, separated by standard open interfaces, extend from Layer 1: ODN bearer service to Layer 4: Applications (e.g.; electronic mail, teleconferencing), via Layer 2: Transport Services and Representation Standards, and Layer 3: Middelware Services.

and less proprietary, lower-order software may still be kept proprietary, specialized to the unique features of Nokia phones (i.e.; across non-standard and firm-specific interfaces) and integrated into downstream hardware handset production.³⁰

If insufficiently safeguarded, opportunistic exchanges between asymmetrically dependent complementary firms may destroy productive relationships as it apparently did in the Sendo-Microsoft case. The mobile-phone maker Sendo decided recently to dump Microsoft's Smartphone 2002, a slimmed-down mobile version of Windows, that comes with proprietary and closed source code in favor of rival software from Nokia Corp. and Britain's Symbian Ltd. that comes with non-proprietary and open source code. In a lawsuit that followed shortly after the cancellation, Sendo charged his software partner Microsoft with fraud, theft of intellectual property, and conspiracy to destroy the startup (see *BusinessWeek*, February 10, 2003). During the whole process leading up to the cancellation and lawsuit, Microsoft's restrictive policy in giving Sendos' employees access to its proprietary system technology (source code) was a source of constant frustrations and postponements, driving Sendo to the brink of bankruptcy. Once again, asymmetric dependency between complementary firms caused transaction costs to escalate, this time between a tiny mobile-phone maker and a giant software firm controlling the operating system of the phone maker's smart phone.

The general understanding and awareness of this open and semi-proprietary technology strategy with all its trade-offs and transaction hazards is of course high among computer firms entering the communications industry. Increasingly, telecom network and handset manufacturers such as Ericsson, Siemens and Nokia have also recognized this and have responded by extending their non-proprietary part of the system. With a smaller share of system technology privately owned, success-stories such as Intel's microprocessors and Microsoft's operating-system software are less likely. After experiencing the commoditizing effect that proprietary standards had on computer makers, handset makers are now much more aware and prepared than computer makers were almost two decades ago. The number of entrants will be higher, and the competi-

³⁰ Frequently cited reasons for Nokia's dominant position in the handset industry confirm this, namely its superior ability to invent around open standards, besides its design, brand and logistics capabilities.

tion over proprietary technology and industry standards harder and more farsighted than at the start of PC industry.

5. SUMMARY AND IMPLICATIONS

The purpose of this paper has been to describe and explain the ongoing disintegration trend in the computer and telecom equipment industries. Integrated enterprises whose primary function it was to safeguard relations among interdependent component makers and prevent leakage of proprietary technology, created a series of negative side effects that caused disintegration in the second period.

That is, firm-specific interfaces created not only interoperability among interacting components, but also lock-in effects and restricted network externalities among customers who subsequently were forced to buy more from the original vendor, rather than from competing vendors, and to interact primarily with customers using terminals from the same producer rather than with all other customers. Furthermore, by charging captive customer a higher price while paying equally captive internal suppliers standard transfer prices, integrated system producers managed to capture a higher share of value added, but only at the costs of negative effort and creativity incentives among internal suppliers, especially as open standards become more widespread, and external sourcing under the contracting mode more efficient.

As increasingly captive customers thus realized the disadvantage of proprietary closed standards in terms of higher prices, incompatible competitive products and networks, and slower innovation rate, competing new entrants (component suppliers, computer firms, telephone operators) soon realized the same, and started their attack on the old vertically integrated industry with a stream of low-priced, open-standard, interoperable and high-performing products and services. Gradually, leading integrated firms also started to realize the negative effects of proprietary closed standards compared to proprietary open standards, after which they started downsizing, specializing their core technology, standardizing their interfaces, and outsourcing a larger share of component production.

That is, the normal strategy of restricting complementary firms access to technical knowledge may in network externalities industries easily become counter-productive, even to the original owner of such knowledge. Creating and capturing consumer surplus from extended network externalities is rather the main objective, and to maximize externalities, comprehensive interoperability must be established on the

basis of common interface standards. Rather than waiting for some global multimedia standard to emerge, leading players invite complementary firms to join them in developing an industry-wide open architecture. In essence, complementary firms collaborate upstream in the development of technology standards in order to compete harder downstream in the final product market. When one of the firms is also the owner of the core system technology (source code) that determines the future compatibility of the other firms' components, conflicts may explode causing transaction costs to escalate. For component suppliers that also are competitors and potential challengers of the lead firm, this is simply not a viable business model.

Giving up its monopoly power by giving away its platform technology solves the conflict. That is, by *sharing* the standard interfaces (and even the source code) with a selected number of participating (and even rival) firms which develop complementary products that quickly add value to the system, and by *outsourcing* a larger proportion of the component production to more cost-efficient external suppliers, leading system producers such as Nokia and Ericsson may profit more from their remaining lower-order (higher-layer) technical innovations, than by keeping all their technologies secret, developing complementary products internally and insourcing a larger proportion of component production. The reasons for this is partly the resultant growth in network externalities and consumer surplus caused by industry-wide and non-proprietary interface standards, partly the entry barrier that widespread diffusion of non-proprietary technology will erect against giant outside owners of proprietary technology, such as Microsoft.

To safeguard such a non-proprietary strategy, the participating insider firms generously agree to share technology and refrain from suing each other for bilateral patent infringements and property rights intrusions. Within this family of compatible products, the expected decline in profit margins due to earlier technology leakage and sharper competition are likely to be outstripped by the sales increases stimulated by the development of complementary products and the associated network externalities.

Although being frequently discussed in the theoretical literature, the above negative externality and incentive effects among captive suppliers and customers respectively, have previously not been treated within a more comprehensive system

model. In such a model, cost-benefit trade-offs between different governance structures are identified and explicated, and strategic-contractual remedies implemented by farsighted leaders as unexpected consequences are gradually revealed (Williamson, 1993: 128-129). As illustrated in the above industry and business cases, increasing disintegration based on more open and less proprietary standards should be expected as net positive effects turn into net negative effects at the end of the second period. To promote successive waves of incremental innovations, and prepare for the occasional events of breakthrough innovations, contractual safeguards should be combined with competition and the high-powered incentives associated with open markets. Altogether, this blend of contractual protection and competitive challenges is expected to offer the best environment for the development of telecommunications in general, and for the commercialization of the new communications technologies in particular.

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