You Don't have to Be A Giant:
How The Changing Terms of Competition in Global Markets are Creating New Possibilities For Danish Companies

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Globalism has become an emblem for a whole series of dramatic changes in the international economy. The hyperbole in the media and popular novels that suggests a whirling era of giant companies, shifting money, and hapless governments, often hides the distinctive features of changing markets. This paper proposes that recent changes in the organization of production and product development are altering the terms of competition in many world markets and creating significant global opportunities for Danish firms. Those opportunities promise to enhance the development of Danish industry and employment. But there are risks. The new opportunities lie both in the new terms of competition that are observed in altered processes of product and component development and in the cross-national production networks that permit small companies to seize these opportunities. We label as "Wintelism" the new terms of competition and the new competitive strategies; we call the new organization of production Cross-national Production Networks (CNPNs). New risks lie in the accelerated pace of product and process development that make it harder and more essential to correctly judge technical developments, competitor strategies, and customer possibilities. The Danish policy question is whether the set of institutions and arrangements that constitute its industrial "market and policy logic"—or to use a different vocabulary, its National System of Innovation—is able to support the pursuit of the opportunities that "Wintelism" and Cross National Production Networks (CNPNs) create.

A COMPETITION OF STRATEGIES

The international economy has changed, there is no doubt. The fact of expanding market ties is not itself in question; at issue is the character of those ties, the pattern they form, and their significance. While the intensity of interconnection—the volumes of trade and investment as a percentage of GDP—has grown dramatically since World War II, we are only now returning to the "intensities" of 1914 which were disrupted by two World Wars and a trade-shrinking Great Depression.[1] Nonetheless, 1996 is, quite evidently, a very different era than 1914. The character of the economic connections among countries and firms in 1914 and 1996 are quite different as well.

What distinguishes the present era that has been code-named "Global" from earlier eras that were code-named "International" and "Multinational"?[2] When international firms first sold abroad, their era, the period of British industrial pre-eminence, was one of trade. Multinational firms produced abroad in a

[1] This is presented by Paul Hirst and Grahame Thompson in several places: *Globalization in Question* (London and New York: Polity Press and Blackwell, 1996); "Globalization and the Future of the Nation State," *Economy and Society* 24, no.3 (August 1995); "The Problem of Globalization," *Economy and Society* 21, no.4 (November 1992). Of course, as Raymond Vernon remarked at the BRIE Working Meeting on Globalization, March 8, 1996, the character, pattern and significance of the international ties pre-1914 were vastly different than those developed today—much more the result of European Colonial rule and preferences.

variety of locations, defining an American era led by Foreign Direct Investment (FDI). In each case, the British international era and the American multinational era, a single dominant style of production organization spread out from a single dominant core country. Firms in other countries imitated, adapted, or struggled to cope with the advances of their competitors in the lead country.

The present "global" era, to use that often deceptive label, has a distinct logic and feel.[3] This is a world economy of multiple centers, each with a distinct capacity for innovation and development. As a consequence, in contrast to its predecessors, this era lacks a dominant style. It is distinctively diverse and uncertain. It is not just that the terms of corporate competition have been altered. Rather, a multiplicity of corporate and national strategies compete to capture advantage in volatile markets. Speed product differentiation, networking, and an emphasis on intellectual property all join the necessities of price and quality to mark the new phase of competition.

This "Global" era's variety is deeply rooted. Innovation and competition come not just from varied corporate strategies, but from multiple geographic directions. There are new competitors, and the position of established players has been reshuffled. From that vantage, the global era began when, driven by extraordinarily rapid domestic growth that induced the building of excess capacity, Japanese firms made dramatic competitive entries into a long list of sectors in Western markets, principally American.[4] Globalism, seen in this fashion, is the arrival of the Asian challenge—Japan's success followed by the extraordinary rates of Asian growth in the second development tier (especially Korea and Taiwan), the third development tier (Thailand and Malaysia among others), and now parts of China. Asia's growth has been premised on a distinctive asymmetry in trade and investment, a seemingly permanent trade surplus with the West. This era is, thus, one in which an increasingly global market coexists with enduring national foundations of distinctive economic growth trajectories and corporate strategies. Globalization has not led to the elimination of national systems of production. National systems endure; but they are evolving together in a world economy that increasingly has a regional structure. Three regional groupings have emerged: North America, Europe, and Asia (consisting principally of Japan, Taiwan, Korea, Southeast Asia, and parts of China)—the countries that provide the principle nodes of the cross-national production networks that concern us here. Together the three regional groups constitute about

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[2] This is drawn from Borrus, Cohen, and Zysman, *Globalization and Production.* BRIE Working Paper #45 (Berkeley: BRIE, 1991). See also, Robert Gilpin, *US Power and the Multinational Corporation: The Political Economy of Foreign Direct Investment* (New York: Basic Books, 1975).

[3] This material is drawn from a forthcoming article by Borrus and Zysman, and from Borrus et al., *Globalization and Production*.

[4] T.J. Pempel "Japanese Foreign Economic Policy: The Domestic Bases for International Behavior" in Katzenstein, ed., *Between Power and Plenty* (Madison: University of Wisconsin Press, 1978). John Zysman and Laura Tyson, "The Politics of Productivity: Developmental Strategy and Production Innovation in Japan" *Politics and Productivity: The Real Story of How Japan Works,* Ed. Chalmers Johnson, Laura Tyson, and John Zysman, Ballinger, 1989.

75% of the world economy. Increasingly, the internal "architecture" of each region – defined by its political/security arrangements and economic institutions – shapes distinctive regional market dynamics that influence national options and corporate strategies.[5] With the reintegration of Central and Eastern Europe, the European economy suddenly has become much more diverse and varied, opening the possibility for production reorganization that is likely to benefit those countries, such as Denmark, with the greatest industrial skill at product development and market definition.

In sum this "global" era is characterized by:

- Expanding cross-national market interconnections (trade, financial flows, etc.)
- A multiplicity of distinctive corporate and national competitive strategies
- Enduring national foundations for those strategies which result in distinctive growth trajectories
- A regional economic architecture

The "global" economy is, as a consequence, a complex and often contradictory story of global markets, national development strategies, regional dynamics, and competing corporate strategies.

MAYBE YOU DON'T HAVE TO BE A GIANT

Two interconnected elements of this story of the "global" economy concern us: the emergence of both "Wintelism" and Cross-national Production Networks (CNPNs). "Wintelism" is the code word we use to reflect the shift in competition away from final assembly and vertical control of markets by final assemblers.[6] Competition in the "Wintelist" era, by contrast, is a struggle over setting and evolving de facto product-market standards, with market power lodged anywhere in the value-chain including product architectures, components and software. Each point in the value chain can involve significant competitions among independent producers of the constituent elements of the system (e.g., components, subsystems)—not just among assemblers—for control over the evolution of technology and final markets. CNPN is a label we apply to the consequent dis-integration of the industry's value-chain into constituent

[5] See Borrus and Zysman, *Lines of Fracture, Webs of Cohesion: Economic Interconnection and Security Politics in Asia* BRIE Working Paper #71 (Berkeley: BRIE, 1994); Zysman, Doherty, and Schwartz, "Tales of the Global Economy: Cross-National Production Networks and the Reorganization of the European Economy", *Structural Change and Economic Dynamics*. (North Holland, 1996); for elaboration, see Zysman and Steve Weber, "Why the Changed Relation Between Security and Economy Will Alter the Character of the European Union" forthcoming, 1997.

[6] By vertical control we mean both *vertical integration* from inputs through assembly to distribution as in the case of American auto producers, and the *'virtual' integration* of Asian enterprise group as when Japanese producers of consumer durables effectively dominate market relations with semi-independent suppliers through the Keiretsu group structure. See Masahiko Aoki, *The Japanese Firm as a System of Attributes : A Survey and Research Agenda* (Stanford, CA : Center for Economic Policy Research, Stanford University, 1993). *The Japanese Firm: the Sources of Competitive Strength* edited by Masahiko Aoki and Ronald Dore. (New York: Oxford University Press, 1994); Masahiko Aoki, *Information, Incentives, and Bargaining in the Japanese Economy* (New York: Cambridge University Press, 1988); Michael L. Gerlach *Alliance Capitalism: The Social Organization of Japanese Business* (Berkeley : University of California Press, 1992).

functions that can be contracted-out to independent producers wherever those companies are located in the global economy. This strategic and organizational innovation, at an extreme, can convert production of even complex products into a commodity that can be purchased in the market. Together, Wintelism and CNPNs have already altered the terms of competition in electronics and promise to change the way a broader range of sectors operate. Although these elements are first evident in electronics, the electronics case suggests developments of general importance. One particular consequence is that together these developments promise to alter the kinds of product-markets and competitive strategies that can be pursued by small- and middle-sized firms and thus their place in world markets.

We develop our story in the following five steps:

- The emergence of "Wintelism";
- Cross-national Production Networks (CNPNs) and contract production;
- How Wintelism and CNPNs together have altered competition in electronics;
- Why the developments may be significant in a range of sectors beyond electronics;
- The implications for Denmark and Danish firms;

I. THE EMERGENCE OF WINTELISM:

FROM ASSEMBLY TO STANDARDS, COMPONENTS, SUBSYSTEMS AND ARCHITECTURES[7]

Let us look again at the diversity of strategies and the competition among them. In the auto industry, competition remains centrally a battle among the assemblers such as Toyota, GM, and Renault who design and integrate the final product. That competition has been dominated by production innovation and marketing. Early on, a high-volume mass production strategy, often labeled Fordist, became the emblem of modern times. Its production principles became a model for all competitors in the industry to emulate. Thus, pioneering American firms entered the European market and established enduring positions on the basis of innovations in mass production. There were significant European product innovations in response, but the European market consisted of stable oligopolies or national monopolies, with competition largely revolving around marginal product developments and marketing.[8]

By the mid-1970s, however, another fundamental innovation in production, labeled flexible volume production, or "lean" production, provided Japanese firms the capacity to enter and alter markets in North America and later Europe. Lean production enabled Japanese firms to compete on the basis of newer price-performance packages and shorter product cycles than traditional mass production techniques could deliver. In effect, firms like Toyota established new market entry points and rapidly expanded

[7] After initial remarks below on the auto industry, the discussion of the evolution of competition in electronics and the emergence of Wintelism which follows is drawn from Michael Borrus, *Left for Dead: Wintelism, Asian Production Networks and the Revival of US Electronics* (tentative title), manuscript in progress, forthcoming, 1997.
[8] James P. Womack, Daniel T. Jones, and Daniel Roos, *The Machine That Changed The World* (New York: HarperPerennial, 1991); Also Alan Altshuler, Martin Anderson, Daniel Jones, Daniel Roos and James Womack, *The Future of the Automobile* (Cambridge: MIT Press, 1984).

them into significant product segments via the advantages that their distinctive production organization permitted.[9] Again there was competitive response, this time by European and American firms. In particular, European luxury car producers like Mercedes and BMW innovated in products, while American and European mass producers closed the production cost/quality gap through selective adoption of "lean" techniques. And after their formidable initial success, some Japanese producers like Honda proved to be less adept at product development than production, and all recently have faced higher costs resulting primarily from the increased value of the yen.

In their turn, then, each set of production innovations, first those at Ford and then those at Toyota, altered conceptions of best practice in organization, technology, and management. Ford's innovation was the implementation of mass production; Toyota's innovation was a reorganization of mass production to create flexibility with volume. Both innovations created decisive market advantage. Perhaps more significant, both influenced production strategies and organization in a broad range of other industries, especially consumer durables. More broadly, each deeply influenced general thinking about market competition and shaped the character of advanced industrial society.

In the new era, we believe that the electronics and information technology industries are beginning to play a similarly influential role. In electronics over the last decade, by contrast to the auto industry, the terms of competition have shifted away from final assemblers and the strategy of hierarchical (i.e., vertical) control of technologies and manufacturing. The character of the shift in market power is popularly suggested in the advertisements of PC producers like IBM, Toshiba, Compaq or Siemens-Nixdorf whose systems are nearly identical and who emphasize components or software that have become de-facto market standards—"Intel Inside," or "Microsoft Windows installed"—rather than unique features of their own brands. In our view, "Wintelism" is the code word that best captures the character of the new global electronics era because Intel and Microsoft pioneered many of its dominant industrial and business practices and are now leveraging their control over PCs to alter the terms of competition in other informatics markets.

The pre-Wintel electronics industry was dominated by assemblers, i.e., systems producers who designed, marketed, and assembled, the final product with a structure and strategy similar to the auto industry. Early post-war American producers like GE, RCA and IBM prospered with quite traditional advantages of scale, vertical integration and, for some products, mass production. Starting in the 1960s, American semiconductor and consumer electronics firms created offshore assembly platforms in Asia to reduce labor costs in their domestic competition.[10] But in that competitive phase, the competition, critical

[9] Womack et al.
[10] For the classic account of competition in this era, see John Tilton *International Diffusion of Technology; The Case of Semiconductors* (Washington: Brookings Institution, 1971).

market, and product development, were all principally American. Limited offshore assembly was really a conservative attempt by American firms to preserve with cheap foreign labor an existing production system. That attempt, of course, failed. On a similar model of vertical control, IBM dominated the computer segment of the electronics industry and extended its franchise into Europe and Asia in pursuit of new markets. Similar strategies produced dominant players like Western Electric and Siemens in the telecommunications segment of the market.

Also starting in the 1960s, in the course of attempting to emulate IBM in structure and strategy, Japanese producers like Matsushita and Hitachi began to overturn established American positions in the consumer electronics market. Much as Toyota and other Japanese auto companies, they did so by applying the lean production principles in order to innovate in traditional consumer electronics products with all solid-state televisions. As in autos, adoption of lean production techniques enabled Japanese electronics firms to create new and distinctive market segments by the late 1970s with the Walkman, VCR, and Camcorder, and by the early 1980s, to challenge US leadership in semiconductors. Here too, however, the dominant market position still lay with the final product assemblers who controlled consumer product definition, and usually both the supply and distribution chains. Their competitive strength was the ability to manufacture high quality at consumer price points with some degree of product variety.

By the early 1980s, essentially all electronics product-markets were dominated by large-scale producers such as IBM, Siemens, Matsushita, NEC, and Toshiba. They produced fully proprietary systems whose key product standards—i.e., the technical specifications that describe the system architecture and enable the pieces of the system to inter-operate as a whole and with each other—were either fully "closed" or fully "open." A fully open standard is one in which the technical information necessary to implement the standard is in the public domain—i.e., fully available on a nondiscriminatory and timely basis to anyone. This was the case with most consumer and many communications interface standards like TV or fax broadcast standards. With the relevant technical information in the public domain, products like TVs and radios built to such open standards became commodities in which scale, quality, and cost, were the defining features of competition in highly contested markets.

By contrast, telecommunications and computer firms built to "closed" standards in which the relevant technical information was owned as intellectual property and NOT made available to anyone other than through legally permissible reverse engineering. IBM's mainframe computers epitomized such proprietary, closed systems. Here, too, vertical control over technologies and manufacturing was essential especially in the early stages of competition when new systems were introduced. But once established in the market, competition centered on growing an installed base of customers who could be locked-in to a firm's product line. Lock-in was possible because—unlike in the open standards case

where all products were built to implement the same standard so that users could seamlessly switch between them—the costs of switching between closed systems could be very high indeed (requiring, for example, rewriting an existing base of software and retraining all users). Large installed bases were essentially decisive over time in these competitions—as all of IBM's competitors discovered—because those who had them would almost always have lower per-unit costs for succeeding generations than the competition since such costs (e.g., of development or marketing) could be amortized over more locked-in users. In sum, then, *with both closed and open systems, vertical control over technologies and manufacturing was the key to market success—in order to capture closed system rents and lock-in customers to proprietary standards or to compete on implementation, quality and price in markets for the system that implemented open standards.*

This era of proprietary systems built to open or closed standards lasted until the early 1980s. Throughout it there were shifts in market structure, attacks on established incumbents, a myriad of new entrants, and not least, significant policy interventions that helped (e.g., through protection, antitrust, or procurement) to shape market outcomes. And some of those changes, like the emergence of merchant component suppliers, began subtly to undermine the logic of competition rooted in scale and vertical control of technology and created the evolutionary ground for the emergence of Wintelism. We don't review that evolution here.[11] Suffice it to say that in the struggle to break loose from IBM's dominance and to react to the Japanese ascent, new strategies emerged within the logic and possibilities of digital microelectronics-based systems. The pioneering product was of course, the PC. But the extraordinary pace of technical progress and ever-improving price/performance soon made the underlying microelectronics technologies increasingly pervasive, transforming just about everything from telecommunications switches through automobiles and hearing aids. By the mid 1980s, new electronics product-markets began to converge on a cost-effective, common technological foundation of networkable, microprocessor-based systems (of which the PC is emblematic).

Such systems enabled a dramatic shift in the character of electronics products—from the prior era's proprietary systems built to fully open or closed standards, to the Wintelist era's "open-but-owned" systems built to "restricted" standards. In the new systems, key product standards, especially the interface specifications which permit interoperability with the operating system or system hardware, are owned as intellectual property but made available to others who produce complementary or competing components, systems, or software products. Hence the systems are "open-but-owned".[12] The relevant technical standards are licensed rather than published, with either the universe of licensees, the degree of

11 For an elaboration, see Borrus and Zysman, *"Wintelism" and the Changing Frameworks of Global Competition: Prototype of the Industrial Future?* BRIE Working Paper, forthcoming 1997.

documentation of the technical specifications, or the permissible uses, "restricted" in some fashion. Very often, changes can be made unilaterally by the standard holder in ways that affect availability and timing of access to the interface specification—as Microsoft is routinely accused of doing by its licensee-competitors. In essence, open-but-owned systems combined competitive elements from both product types of the prior era—the standards are licensed in order to create commodity-like competition around system elements chosen by the licenser (e.g., around assembled PCs built to Intel processor architecture standards), while remaining restricted in order to build installed-base and lock-in customers.

The shift to the new systems was accelerated by two factors. One was the increasing cost and complexity of continuing innovation, which made it increasingly difficult for any one company, even IBM, to maintain ownership and control over all of the relevant technologies. The other shift was toward increasingly strident demands from major industrial users as they moved their business operations onto information networks, for increasing interoperability of complex systems purchased from multiple vendors.[13] But the move to such systems was pioneered, as perhaps it only could have been, by IBM with the IBM PC.[14] In order to get to market fast and exploit a market window opened by Apple (who had adopted a quite traditional proprietary systems strategy), IBM pieced together the first open-but-owned PC using its own proprietary BIOS (basic input-output system), and a variety of components and software from numerous third-party vendors. It invited cloning to establish the market. Once firmly entrenched, IBM intended to bring the product back in-house and make it increasingly proprietary. It presumed that a traditional strategy of unsurpassed scale and vertical control of technology and manufacturing would fend off the clones. It was wrong. Unfortunately for the computer giant, it permitted key standards in its PC to be owned by others (especially Intel for the microprocessor architecture, and Microsoft for the operating system) who innovated at the furious pace that focus and specialization permitted. Gradually, they took control of the evolution of the PC's key standards. In concert with the clone-makers, Intel and Microsoft wrested control of the PC itself from IBM. Strategies to set and control the evolution of de facto standards were developed. Business speed (e.g., rapid product cycles, fast time to market) was rewarded. Wintelism was born.

In this new epoch, firms located anywhere in the value chain can, potentially, control the evolution of key standards and in that way define the terms of competition not just in their particular

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[12] The "open-but-owned" rubric was first suggested in conversations with Robert Spinrad, Vice President of Technology Analysis and Development at Xerox.

[13] See François Bar and Michael Borrus, Information Networks and Competitive Advantage: Issues for Government Policy and Corporate Strategy Development, *Final Report for the OECD,* September 1989.

[14] There are numerous accounts of this period. Representative are James Chopsky and Ted Leonsis, *Blue Magic: The People, Power and Politics Behind the IBM Personal Computer* (New York: Facts on File, 1988) and Robert Cringely, *Accidental Empires: How the boys of Silicon Valley make their millions, battle foreign competition, and still can't get a date* (Reading, MA: Addison-Wesley, 1992).

segment but, critically, in the final product markets as well. Market power has shifted from the assemblers such as Compaq , Gateway, IBM, or Toshiba, to, among others, key producers of components (e.g., Intel), operating systems (e.g., Microsoft), applications (e.g., SAP, Adobe), interfaces (e.g., Netscape), languages (Sun with Java) and to pure product definition companies like Cisco Systems and 3COM. What all of these firms have in common is that, from quite different vantage points in the informatics value chain, they all own key technical specifications that have been accepted as de-facto product standards in the market. Each beat-out rival standards. In winning, each created a universe of licensees who produce to the standard and add value to its use—just as applications software firms like WordPerfect, PC assemblers like Compaq, peripherals producers like Canon, or content providers like Grolliers, all produce to Microsoft's Windows operating system standards. Each standard owner maintains a growing installed base of customers who use the products that conform to the standards. Each has been careful to evolve the standards by adding incremental improvements in performance, functionality, features, quality, or costs, within product generations, and dramatic improvements between generations (while remaining backwardly compatible with past versions). In that way, each has effectively 'locked-in' their customer base in the sense explored earlier—that, given the customer's investment in all of the conforming products and in how to use them effectively, she will normally be unwilling to switch to competing standards unless they offer truly radical and compensatory improvements in price-performance-functionality. Switching will not occur, that is, unless it is even more costly to stay put.[15]

Such Wintelist strategies effectively attenuate the link between market power and the *ownership* of the assets of production that characterized the prior era of competition, and at the extremes as with a firm like Cisco Systems, can completely decouple control of final markets from ownership of manufacturing assets. For Wintelist firms, ownership and manipulation of their de facto standards are barriers to entry considerably more effective than the barriers of scale and vertical control over technology and production in the prior era because they are far harder to duplicate. But production and scale do not vanish from the story; they are still significant. Indeed, relevant production know-how still facilitates continuing product and process development in most industry segments. And, in many cases, traditional assemblers can use their additional advantages of scale and vertical control to decisive advantage in playing the Wintelist game. For example, Hewlett-Packard has been perhaps the most successful traditional systems assembler to adjust to the Wintelist era. In PC printers, HP 'drivers' are the laser and inkjet operating system standards (and printers are consequently the chief source of HP's

[15] For a more detailed and technical discussion of all of the aspects of standards competitions outlined above, see Francois Bar, Michael Borrus, and Richard Steinberg, *Islands in the Bit Stream: Charting the NII Interoperability*

profits). In Unix workstations, HP's open-but-owned Precision Architecture has been one of the three principle contenders for market leadership (with SUN and IBM). Even, as in PCs, where it does not own the relevant standards, HP has successfully adjusted its business model to emphasize speed and continuous innovation over manufacturing scale and vertical control.

In sum, this era in which electronics is now the driving and expanding industry group, the electronics industry itself has entered a new era which we call "Wintelism". In this "Wintelist" era, competition has moved away from assembly to the rapid evolution of the constituent elements of the system being assembled, that is, to the system architecture, its components and subsystems, its operating system, languages and applications—and to the creation and evolution of restricted de facto market standards in all of those areas.[16] Simultaneously, systems products have moved away from stand-alone proprietary systems toward open-but-owned systems that are meant to be interconnected into digital information networks. In practice, the core functionality of final systems—and even of the networks they comprise—is often owned and controlled by the independent companies who supply or define the constituent elements. They, rather than the final assemblers, often control both the pace of technical advance and the availability of critical system elements. As a consequence, product rents accrue to them rather than to assemblers. The creative use of intellectual property rights and associated licensing strategies define defensible market position more than manufacturing scale as the basis of competitive advantage. In this era, even competition at the assembler level over system platforms is as much about standards as it is about production: The desire of Sun to widely license its Java language to other assemblers, or of Oracle to define and widely disseminate the architecture for a 'network computer' (NC) tailored for Internet functionality, really represent their efforts to supplant the market dominance of standards and architectures controlled by Microsoft and Intel.

In this Wintelist era, manufacturing and production do not vanish in significance; rather they shift location in the story. It remains true that you can not control what you can not produce.[17] But the ways of implementing and controlling production have changed. As we argue next, Wintelism has an organizational counterpart, a distinctive system of production which we call the international production network, or Cross-national Production Network.

Debate, BRIE Working Paper # 79 (Berkeley: BRIE, 1995) at section 2, and the myriad sources on the economics of standardization cited there.

[16] The shifting character of competition is not simply a matter of the emergence of software, of the Virtual Corporation, or the reorganization of production labeled post-Fordist manufacturing. Flexibility based on digital codes in an era of "virtual" private information/telecom networks has a different meaning than that flexibility rooted in general purpose machine tools. Problems of scale in software-rooted competition are completely different in character and kind from that in the complex assembly of consumer durables with machine tool makers struggling between flexibility and the low cost of long production runs.

[17] Stephen Cohen and John Zysman, *Manufacturing Matters: The Myth of the Post Industrial Economy* (New York: Basic Books, 1987).

II. THE COUNTERPART TO "WINTELISM":

Cross-national Production Networks and The Manufacturing Services to Construct Them

We are arguing that the strategic importance and hence the organization of production has changed as competition and value-added have moved away from assembly. The defining competition has been the rapid evolution of the constituent elements of the system being assembled and to the creation and evolution of de facto market standards in all of those areas. Cross-national production networks (CNPNs) and contract production services are the organizational counterparts of that shift. CNPNs comprise a clever division of labor in which different value-chain functions are carried on across national boundaries by different firms under the coordination either of a lead MNC for its own production or of a Production Service Company (PSC) who manages the production value chain for clients. As important, CNPNs express the reduced need for companies to control production through ownership or direct management of each piece of the value-chain. To be more specific, by a firm's cross-national production network we mean:

> the organization, across national borders, of the relationships (intra and increasingly inter-firm) through which the firm conducts research and development, product definition and design, procurement, manufacturing, distribution, and support services. As a first approximation, such networks comprise a lead firm, its subsidiaries and affiliates, its subcontractors and suppliers, its distribution channels and sources of value-added product or service features, its joint ventures, R&D alliances and other cooperative arrangements (like standards consortia). In contrast to traditional forms of corporate organization, such networks boost a proliferation of non-equity, non-arms-length, cross-border, inter-firm relationships in which significant value is added outside the lead firm and entire business functions may be outsourced. [18]

More is at issue than simply lower labor costs that permit particular components to be built or assembly processes to be conducted at offshore production locations. Rather, intra-sectoral trade and investment link together diverse production functions across national borders to create complementary production arrangements which individual producers and nations would be incapable of maintaining independently. A firm might use specialist producers of computer displays in Japan, printed circuit boards assembled in China, disk drives from Malaysia, digital design and final assembly services in Taiwan, software from Bangelore, and process development in Singapore to create a PC. While these networks have some characteristics of earlier arrangements, the industrialists creating them believe they are doing something new and innovative precisely because they are using a new kind of production system in a new kind of competition.[19]

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[18] Michael Borrus, *Left for Dead*.

[19] Comments of William Miller, Professor Emeritus, Stanford University, and former President of SRI at the BRIE Working Meeting on Globalization, March 8, 1996.

These networks *have evolved to exploit an ever more intricate division of labor based on increasing local technical specialization in Asia*.[20] They are not principally about lower wages or access to markets and natural resources.[21] They are, however, about the linkages among diverse and heterogeneous economies. The East Asian story is one in which the *regional*—that is, *cross-national*—*dynamic* of economic development built complex divisions of labor among economies with very different technical and economic capabilities at very different stages of development. Asian production activities aimed at American and European markets became increasingly complex as Japan was joined by the subsequent tiers of producers.

These complex production networks have emerged most clearly in Asia, but they are used by American and some European firms. Consequently, they are of competitive significance to all. As important, they are not confined to Asia. They are being replicated in North America; if Europeans do not organize them in Europe, they are likely to be put in place by Asian and American producers to serve their own strategies. Below, we tell the Asian story in some detail to give a sense of reality to what would otherwise be an abstract analysis. For Danish producers, the important points are that these networks now exist, that they are easily accessed, and that production service intermediaries have emerged who will provide key-in-hand manufacturing networks (i.e., create and manage the entire manufacturing CNPN) for the company that defines a particular product.

ASIA'S DEVELOPMENT AND THE EMERGENCE OF CNPNS

Post war development and politics have driven Europe toward regional homogeneity. Or at least that was the story until Western Europe abruptly regained its past. That European past consists of a set of countries that are dramatically less developed than the core of Europe and which must now reorient and restructure their production. By contrast, Asian development occurred in a series of tiers that created heterogeneity. Enduring political rivalry has entrenched and preserved it. In brief outline, four developmental tiers have emerged in Asia:

> **Tier One**: "Early Late-Industrialization" is the case of Japan and its 19th century industrialization. Modern Japanese politics is a story of the political creation, in relative international isolation, of a market system intended to assure continued political autonomy.[22]

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[20] For an extensive discussion of this point and elaboration of such networked production structures, see Michael Borrus, Dieter Ernst, and Stephan Haggard, "Introduction" in Borrus, Ernst and Haggard, eds., *Riches and Rivalry: Production Networks and the Industrial Integration of Asia*, forthcoming, 1997.

[21] Such firm relationships to create a more intricate division of labor seem to take two forms. One division of labor will aim at creating economies of scale, hence grouping particular component or assembly activities of a similar character that are presently below optimal size. That first division of labor may result from the integration of a set of relatively homogeneous economies. When a region such as Europe began to generate a single market or when the United States and Canada reduced auto barriers, firms sought to capture newly possible economies of scale. What concerns us here is the second set of networks that emerge from linking diverse production locations.

[22] Richard Samuels, *Rich Nation, Strong Army* (Ithaca: Cornell University Press, 1994).

Tier Two: "Cold War Late-Industrialization" consists of Taiwan, Singapore, Hong Kong and Korea—the original newly industrializing Tigers who jumped to the advanced industrial frontier using strategies of export-led growth.

Tier Three: "Late Late-Industrialization via CNPNs" includes the major Southeast Asian countries of Indonesia, Malaysia, Thailand, the Philippines, and the coastal provinces of mainland China, along with potential newcomers like Vietnam and Myanmar. The defining characteristic here is the central role of cross-national production networks. These countries do not have the local domestic manufacturing that developed indigenously in Japan and was created through successful learning in the second tier countries. The lack of indigenous manufacturing experience rendered Southeast Asian countries more dependent on MNCs for their industrial development.[23] Increasingly, their development strategies revolve around insertion into the cross-national division of labor defined by partially overlapping or competing cross-border networks under the control of Japanese, US, Korean, European, Taiwanese and other overseas Chinese multinational corporations.[24]

Tier Four: "Large-scale Late-Developers". It is likely that India and especially China, the enormous, populous late-developers, will be able to follow largely indigenous strategies rather than the export-led and network-led development of Tiers two and three. Their entry will dramatically alter the region's competitive dynamic—as China already has in drawing foreign direct investment away from third Tier developers.[25]

In sum, four Tiers of development in this region riven by political and military rivalry have created a heterogeneous production environment. In turn, Asia's highly articulated regional production networks emerged over time from this heterogeneous production environment in several steps. To stylize slightly:[26]

- Outward processing, Branch Plant Production: In this first phase, firms established two types of production. With outward processing, firms established production units or contracted with production units for narrowly defined activities that required extensive low cost labor. Branch plants were established to jump walls of protection to gain access to local markets.
- Contract Factories and OEM Manufacture: Firms were created by local or regional entrepreneurs to perform a range of tasks and produce a range of components or sub-systems defined by MNC final product producers. These firms are continuously striving to extend the range of production and to integrate forward and backward from specific assigned points in the production chain.
- Cross-National Production Networks: These networks involve the reweaving of the varied individual activities into entire production systems that exploit local specializations throughout the region. Those networks were initially organized by MNCs.
- Turnkey Production Network Services: Production network intermediaries such as Solectron arise who can manage the entire manufacturing network for a customer by providing turnkey production networks.

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[23] See Mitchell Bernard and John Ravenhill, "Beyond Product Cycles and Flying Geese: Regionalization, Hierarchy, and the Industrialization of East Asia," *World Politics* 47, no.2 (January 1995), especially pp. 195-200.

[24] For a description of the Japanese networks and the potential for developmental insertion into them, see Dieter Ernst, *Carriers of Regionalization: The East Asian Production Networks of Japanese Electronics Firms,* BRIE Working Paper 73 (Berkeley: BRIE, 1994).

[25] On the impacts of China's Scale, see Stephen Cohen, Brandeis conference paper, 1996. On China's impact on FDI in the region see Dennis Encarnation, forthcoming, 1997.

[26] This discussion is drawn from the work of and discussions with Tim Sturgeon, a BRIE Research Associate at completing his dissertation in Geography. Tim Sturgeon, "The Rise of the Global Locality: Turnkey Production Networks in Electronics Manufacturing" (University of California at Berkeley, 1996).

While these network forms evolved sequentially, it is awkward to refer to them as stages. Empirically, they overlap in time, in particular countries and in the experience of particular MNCs that are initially at the core of the process. While each step required MNC, indigenous firm and host country capacities that were created at least in part in the prior step, the emergence of the more elaborate arrangements did not replace the earlier ones. Rather, the several forms co-exist, representing possibilities for different corporate production strategies.[27]

Such arrangements were, of course, used prior to their adoption in the electronics industry. For quite some time, in industries like garments, footwear, furniture, and toys, it has been established practice for "brand name" companies to depend on CNPNs for essentially all of their manufacturing requirements. For example, US brand name apparel and footwear companies have been utilizing a disaggregated industry structure to create non-equity-based production networks on a world scale since the 1970s.[28] By contrast, disaggregation and production outsourcing did not begin in earnest in the electronics industry until the mid-1980s, a trend that has increased dramatically as the 1990s have progressed. The emergence of contract production and cross-national arrangements in consumer durable sectors such as electronics and now, perhaps, automobiles as well, turns the phenomenon from one of marginal interest to one of real significance. Instead of being confined to essentially labor-intensive low or middle skill products in mature sectors, CNPNs now touch the core elements of the industrial economy and the most rapidly expanding sectors.

The new production model is increasingly pervasive in electronics. Its scale and pace of development is suggested by the rapid growth of the most visible manufacturing network service companies. They have grown over the last decade from a marginal to significant industry segment accounting for over $40 billion in sales in 1995.[29] The top ten firms grew last year by over 56% to almost US$10 Billion. Some estimates suggest that such firms now represent 10-20% of total product-level electronics manufacturing, (up from less than 5% in 1982) and 40-50% of highly volatile electronics industry segments, such as PCs and modems. Firms that provide global scale manufacturing services, such as SCI Systems and Solectron, now produce on the scale of the MNCs themselves and are growing extraordinarily quickly, in part by purchasing customers' formerly captive (i.e., vertically integrated) facilities. For example, in 1986 Solectron generated $60M in revenues and had all of its production capacity in Silicon Valley. By 1995, the company had grown to more than $2B in revenues and had

[27] One question, not addressed here, is which types of firms adopt which form for which purpose. Sturgeon addresses this in his dissertation. See also John Stopford, "Building Regional Networks: Japanese Investments in Asia," London Business School, May 1966, unpublished manuscript.

[28] *Commodity Chains and Global Capitalism,* Gary Gereffi and Miguel Korzeniewicz, eds. (Westport, Conn: Greenwood Press, 1994).

[29] The material in this paragraph has been prepared with Sturgeon and is based on his dissertation and the relevant data sources cited there.

plants in North Carolina, Washington State, Texas, Malaysia, Scotland, France, and Germany. Conversely, former vertically integrated assemblers like IBM, Hewlett-Packard, and Apple have disposed of captive production facilities and moved to the new CNPN model. By 1994, 50% of HP's 20 million circuit boards and 11% of its 4.5 million final products were being assembled by contract manufacturers, as was fully 50% of Apple's production.[30] And some of the newest and most successful systems companies own *no* internal manufacturing at all. Examples include: Dell (PCs), Silicon Graphics (workstations), Cisco Systems (networking), Diebold (automatic teller machines), Digital Microwave (communications), Telebit (modems), LAM Research (equipment), and Octel (communications).

In all of these cases, the move to CNPNs and contract production services permits system firms to concentrate on Wintelist product definition and market strategies while conserving capital and gaining production flexibility. The implications are that while Wintelism creates a whole range of market opportunities in sectors that were previously dominated by giant assemblers playing in controlled oligopolistic markets, the new CNPN possibilities provide small producers with a cost-effective production strategy to exploit the new market opportunities. In short, as Tim Sturgeon concludes, to the extent that network production structures have emerged in a wide range of localities, are highly capable, and have developed an open, "merchant" character, an infrastructure for the implementation of global production strategies *without* FDI has been put in place.[31]

III. HOW WINTELISM AND CNPNS ALTERED COMPETITION IN ELECTRONICS

Wintelism and CNPNs have mattered mightily to the outcomes of competition in the electronics industry.[32] They were the principal means by which the US electronics industry recovered from its mid-1980s nadir in competition with Japanese firms to reemerge as the global technical and market leader by the mid-1990s. In the mid-1980s, Japanese firms dominated consumer electronics and semiconductor memory, materials and equipment, and looked entirely capable of repeating the feat in computers, office systems (e.g., copiers, faxes), and customer telecommunications equipment. There was the danger, widely debated in the industry, that US producers of the latter systems would become dependent, as had their consumer counterparts, on their competitors in Japan for supply of the underlying technologies, processes

[30] According to Gilbert Amelio, Apple's new CEO, the company's strategy is to outsourcing production to companies such as SCI in order to reduce some of Apple's manufacturing overhead and inventory carrying costs while positioning Apple to concentrate more intensively on marketing and design. *Electronic Buyers News*: April 8, 1996 Issue 1001, page 8.

[31] Sturgeon, "The Rise of the Global Locality." There are, of course, a range of questions we have not addressed above. These questions include: How do core firms maintain control over their CNPNs and, conversely, under what circumstances will network outsourcing undermine the capacity of the core firm to control the destiny of its own products? Under what circumstances is internal production still necessary?

[32] This section is drawn from, and quotes extensively, Borrus, *Left for Dead.*

and manufacturing capabilities that went into their products. The danger was that such competitive dependence would be, as it was in consumer electronics, a first step toward market exit.

That did not happen, however. As described earlier, Wintelism shifted the industry's product-market strategies away from final assembly and toward the distinctive value-added products backed by standards strategies in which American innovations and entrepreneurial companies were strong. Simultaneously, the American CNPNs created an alternative supply base in Asia—an alternative to reliance on Japanese competitors for underlying component technologies and manufacturing capabilities.[33] Simultaneously, the networks helped to lower production costs and turnaround times while keeping pace with rapid technological progress. In the bargain, the networks spawned Asian-based direct competitors to Japanese firms in several of their stronghold markets (e.g., memory chips, consumer electronics, and displays). In effect, taken together, Wintelism and CNPNs enabled US firms to pioneer a new form of competition in electronics: one that grew out of the distinctively American market environment and was adapted to overseas opportunities. It is, as we have stressed above, a form of competition in which 'core assets' are the intellectual property and know-how associated with setting, maintaining and continuously evolving a de-facto market standard, a process that requires perpetual improvements in product features, functionality, performance, costs and quality. And the core managerial skill is orchestrating the CNPN, that is, managing the continuously changing sets of external relationships and melding them with the relatively more stable core of internal activities in order to access relevant technologies, design, develop, and manufacture the products, and get them from product concept to order fulfillment in minimal time.

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[33] The story of how the US firms built their CNPNs and constructed the alternative Asian supply base is told in detail by Borrus in *Left for Dead*.

Production of Telecommunications Systems in the Wintelist Era:

Cisco System's CNPN

by Michael Borrus

Consider a firm like Cisco Systems, the world's leading supplier of routers, switches, and hubs for corporate communications networks and the Internet. Compare it with the network equipment business of the pre-divestiture AT&T and its international counterpart, ITT. Pre-Wintelism and CNPN, everything from the R&D at central corporate laboratories to product design, engineering, manufacturing, distribution and service was done by one AT&T/ITT affiliate or another, usually located somewhere in the US for AT&T or Europe for ITT. The vast bulk of the underlying technologies, components, parts, software and subsystems were produced internally by the two companies. The finished product was "sold" directly to local phone companies. Control was hierarchical and centralized in the US AT&T was the epitome of the hierarchically managed, vertically integrated, multidivisional corporation. ITT was the epitome of the modern corporation's multinational extension to other markets.

By contrast, much of Cisco's R&D is done at its corporate headquarters in Silicon Valley, but a portion is also done through technology development alliances with key suppliers such as chip companies and software vendors. Associated engineering is done in Cisco affiliates in Japan and California, but sometimes also by lead vendors. The products are assembled in California and Japan, from components and manufacturing services (e.g., board-stuffing, PCB design) that flow from a variety of independent suppliers throughout Asia (including Taiwan, Korea, Japan, Singapore, Thailand, and Malaysia) and the US and sometimes Europe. These suppliers are bound to Cisco through a variety of non-equity contractual arrangements. Cisco's Japanese "subsidiary", however, which is responsible for customizing the products for the Japanese market, is "owned" by Cisco and 14 major Japanese electronics companies (each with an equity stake), that together form a formidable coalition aimed at making Cisco's "owned" but open protocols the standard for corporate communications in Japan.

Several independent companies in California, Asia and Europe (including most of its Japanese partners) produce to Cisco's standard, adding value in the form of products or services that interface in some fashion with Cisco's products—and without which Cisco's products would not be complete because they could not fully perform core functions (a significant difference from the more traditional model of behavior in which a firm might sell into the Bell System in competition with Western Electric, but the customer did not need the outsider product to have a complete system). The final product is sold directly to customers but also through a variety of third-party channels including value-added resellers and systems integrators. After-sales service is frequently undertaken by third-party suppliers.

As the example suggests, the new form of competition is no longer confined largely to equity investments and outsourcing in the manufacturing stage of production. It now extends throughout the value chain and to an increasing variety of non-equity, but not arms-length relations. Consider, for example, Internet software producer Netscape Communications' product development and distribution relationships: Product development is done in conjunction with a variety of independent development partners such as SUN, Macromedia, Real Audio, Xing Technologies and many others who develop "plug-in" packages of software functionality (e.g., Javascript applets, authoring tools, audio and video players) designed to work seamlessly with Netscape's browser-server products—and without which the product would not be fully functional. The software is distributed directly to customers and through a variety of independent channels including on-line service providers such as Compuserve and AOL, traditional carriers such as Pacific Bell, specialized retailers such as EggHead Software, value-added resellers who provide Web set-up services, and mass marketers such as Costco.

As the examples suggest, this new form of competition has left no part of the information technology and electronics sector untouched: It holds true as much for Microsoft as for hardware vendors such as Cisco, as much for large-scale systems builders such as HP as for integrators such as Anderson Consulting—and as much for standard-followers such as Compaq as for standard-holders such as Netscape. For these firms, in important ways, key attributes of the new network form of production organization reflected unique characteristics of the domestic US environment. Indeed, while most firms in the industry gravitated toward a network model in response to similar global market conditions, those models differed by ownership and control: The distinctively American model contrasts with equally distinctive production networks under the control of Japanese, Taiwanese and other indigenous Asian capital—though for reasons explored before, those alternative network models were competitively less effective than the American in the last round of market rivalry.

IV ARE THESE DEVELOPMENTS CONFINED TO ELECTRONICS?

In our view, Wintelism and cross-national production networks are likely to be broad features of the international economy that reach well beyond electronics. Electronics may be the originating sector, the development test-bed, for the new approach to competition and production.[34] But the enormous possibilities for creating distinctive products and new product segments, and for increasing the functionality of existing products, suggest that the new approaches will diffuse more widely to other industries. The course of diffusion of the new organization and practice is unpredictable, but there are clear channels through which it can flow.

First, as argued earlier, digital, microelectronics, is transforming products and processes in a wide range of sectors. Some, such as telecommunications have been converted from electromechanical to electronic processes. In others, such as automobiles, electronics is capturing a substantial portion of the product value-added. The more evident automobile entertainment packages are not the significant part of the story. Rather, every major subsystem in the modern automobile from brake, suspension and powertrain controls through keyless entry, seat memories and lighting controls, and soon navigation systems, is increasingly premised on microelectronics. The increasing value of electronic components means that cars will be built around electronic systems, thus offering the customers more features at lower cost while reducing lead time and inventory. Firms that effectively cope with the new technologies will be the winners. As a recent *Economist* article concluded, few products will be immune from this revolution. As microelectronics pervades the consumer durable professional goods and capital equipment sectors, transforming their products and processes, "Wintelism" and CNPNs will become increasingly viable strategic alternatives—perhaps indispensable—in those sectors.

Second, as argued earlier, "best practice" models of corporate organization and strategy tend to spread well beyond the firms or sectors of their origin. Indeed, ideas about mass production dominated thinking in many industrial and service companies even when, in retrospect, "Fordist" notions were wildly inappropriate. Wintelism and CNPNs are similarly likely to be imitated and to spread into models of best practice, to be taught and diffused widely.[35] In fact, we believe that as the ideas spread, they will be found applicable in sectors such as automobiles that were organized on a centrally controlled vertical model in earlier periods. The Japanese auto sector, in its hey-day in the 1980s, and Japan's consumer durable sectors more broadly, suggest the possibilities of assembler-controlled "virtual" vertical integration within a single country. The possibilities of CNPNs in consumer durables will likely spread

[34] Report on The Electronics Revolution in the Motor Car Industry, published by the Economist Intelligence Unit.
[35] For example, *Business Week*'s famous issue on the "Virtual Corporation" is one such effort to diffuse similar ideas, although we think it misconstrues essential features described above.

with the off shore investments of the Japanese and Korean firms and now the emergence of third tier auto producers in Asia explicitly organized on a network model.

Third, firms that might never have developed CNPN approaches to production can soon, if not already, buy them in the market and concentrate their own efforts on Wintelist product opportunities. Simultaneously, the manufacturing service firms capable of providing turnkey networked production systems will certainly attempt to spread their message in order to expand their business. And clear demonstration effects will be provided by the success of high profile early adopters, perhaps especially traditionally large integrated companies like IBM that migrate to the new models and newer Asian producers who succeed in Western markets like DaeWoo. Indeed, the networks, and the Wintelist strategies that empower them, are likely to spread widely beyond Asia as MNCs bring the new approaches to other markets. We believe, for example, that the new approaches are likely to be an essential feature of the integrated European economy as the former Eastern Europe returns to the Western marketplace.[36]

Finally, these practices have already proven that they can diffuse across sectors. As mentioned earlier, they have already moved from precursor sectors like the textile/apparel complex into electronics. There would appear to be few constraints on continued diffusion now that they touch the core of modern industrial economies.[37]

V. THE IMPLICATIONS FOR DENMARK

What are the implications for Danish firms and for Denmark of Cross National Production Networks (CNPNs) and "Wintelism", developments which have altered the character of industrial competition? We have, to be certain, only the outsider's sketchy understanding of Danish industry. Denmark, we were both taught, fed grain bought on the world market to cows and pigs and, in the process, created modern dairy farming. Educational and technological institutions were developed to support this emerging strategy, institutions which also provided an underpinning for an industry consisting of small/medium sized niche market players competing on quality. A distinctive pattern of trade and innovation rooted in small- and middle-sized companies and supported by a distinctive national

[36] For an extended discussion of the potential for CNPNs in that regard, John Zysman, Doherty and Schwartz, "Tales from the 'Global' Economy."

[37] As suggested earlier, fabric is produced, often in highly automated plants, in one place; cut and processed in another, and stitched and assembled and finished in still others. Many "assemblers" are simply product definition and marketing companies who provide design, distribution, and above all, brand names like Nike. Why not call this practice "Nikeism"? Textile/apparel innovation is basically limited and does not generally define the broader texture of the industry as a whole. There is much less room for the constituent suppliers to capture market rents and semi-monopoly positions.

system of innovation resulted. If that characterization of Danish industry is at all accurate, there ought to be significant leeway to adapt strategies and institutions to the era of competition now emerging.

Wintelism and CNPNs together separate product development from production and radically minimize the capital requirements and the range of in-house production skills needed for volume production and mass market strategies. They also provide a merchant, open-market source for many of the critical elements of systems, making them available for distinctive final product development. These factors suggest three types of new business opportunities available to Danish industry. Our comments are intended to provoke discussion and are not meant as a recipe. The question is whether Danish firms and the Danish national system are suited to capturing these new possibilities.

Niches, Prototypes, and Volume: The skill at developing sophisticated products for niche markets opens the possibility of smaller companies with product development skills that can in fact aim at larger volume markets. Thus, as in the fashion business, producers often have a limited, sometimes almost custom, line for a very high-end market while developing volume business outlets at different price points for different quality products. The high-end business, whether directly profitable or not, often establishes the value of the general trademark for the broader market. Hence we have Armani and AX. Hence we have Armani and AX. Another way of highlighting this opportunity is to ask whether Bang and Olufsen could now pursue both a high-end line that establishes standards and a volume business via contracting for the appropriate production network. Certainly Bang and Olufsen's distinguishing expertise in mechanical engineering as well as in consumer electronics has generated very distinctive products that have permitted them to find defensible niches in an industry traditionally characterized by volume production. Bang/Olufsen certainly must choose strategies that will reinforce as well as build on the core capacities and thus will continue to permit distinctive product development. It must avoid strategies that would undermine those capacities without replacing them . Where lies the Bang/Olufsen position in the emerging world of networked digital multi-media, cross national and often contract production organizations, and continuous profound component innovation? These questions are significant precisely because the new production organizations and contract production systems open questions for all producers about possible new product lines and market strategies, while the emerging component technologies are altering not only the products themselves but changing the problem of managing technology development.

To return to our argument here, this first opportunity is for the niche market skills of product development to be applied to volume markets through contract manufacturing. The niche market product becomes the prototype of, or a parallel development for, volume market products. Certainly, this is neither automatic nor easy; there are new difficulties and issues. Are niche markets more insulated from the pace of new product introduction forced by technological evolution and shifting fashions? If capital

does not have to be committed in advance for volume production, substantial obligations are still likely to follow if volume product introductions fail. Nonetheless, a new opportunity would seem to be there.

Selling Turnkey Product Systems: Production is not the only barrier to the strategy outlined above. The barrier of marketing and distribution may prove even more critical. Firms may find that developing prototypes and even entire production networks to supply a product is possible, but also discover that the tasks and risks associated with volume markets are still too great. In that case, can a firm contract to deliver a product system that consists of more than a prototype, but rather a production model and entire production system, to a volume distributor—be it Phillips or Compaq or Samsung. Here the distinct deliverable is a completed product system, a production model and key-in-hand production system. For many companies that control a distribution system, filling that system with a product is the task. For firms like Samsung, distinctive upper-end quality designs are seriously lacking. Clearly there is a market to go beyond the prototype to production system.

Contract Manufacturing and the European Management of Cross-National Production Networks: Common to each of the first opportunities would be the ability to manage international production networks. As noted earlier, companies providing just that "product" to the marketplace are growing rapidly in North America and Asia. Precisely because the CNPNs are underdeveloped in Europe, there is an opportunity to become a provider of such networks.

Evidently, if a Danish final product company worked with an existing Danish firm, of whatever sectoral provenance be it shipping company or trading company, to develop a provider of cross-national production networks, that firm could provide such networks more widely in Europe. Moreover, the likelihood that such networks can be built from almost entirely European sources is very high. Zysman has argued elsewhere that cross-national production networks are in fact emerging, thus linking East and West Europe and, in so doing, perhaps making Europe a more competitive regional economy. So the supply of CNPNs is itself a business.

The production reorganization implicit in the production networks is likely to reinforce employment opportunities in Denmark. It is not a matter of moving the same production to lower wage locations, but rather of creating new product lines, expanding existing lines, and generating new businesses. Jobs in product design, development, and the more skilled elements of production are likely to expand in Denmark as they have in Japan. Note that the rise of the value of the yen in the past years has encouraged a substantial movement of production out of Japan into the rest of Asia. Nonetheless, Japanese trade with the region has remained in substantial surplus with the export to the new production locations of high value-added components and production equipment. The key for Denmark will be how effectively it develops advanced technology and how effectively its national system of technology

development can be applied to the market opportunities made possible by "Wintelism" and cross national production networks. There is every reason to be optimistic.[38]

The ideas outlined above are speculative possibilities proposed for discussion and not a list of recipes ready to be cooked. Nonetheless, some version of the ideas outlined here may well be necessary. However the developments described above play out, volume markets will be more available to niche market players who already use the flexibility of production systems and the strength of their distribution system to address niche markets that have hitherto been protected by their discrete character. The only question is which firms will exploit these possibilities as they emerge in Europe. Will Danish firms become expert at using the new strategies and players in the provision of networked production services?

CONCLUSION: THE RISKS AND THE REQUIREMENTS

The opportunities sketched above all emphasize market knowledge, distinctive not imitative product ideas, and a capacity to follow the evolutionary paths of critical technologies—all characteristics that Danish industry has shown in abundance. But can small and middle-sized Danish firms manage the particular market and technology disjuncture represented by the transition to Wintelist strategies and CNPNs? In many ways the decomposition of competition into the constituent elements of a product or a system eases the task of smaller firms. The more technology that is available as a product in the market the broader the opportunities for smaller niche firms. Merchant startups producing the components and subsystems which embed advanced research have spun out from larger companies or off from universities. They are making technology broadly available in the market that might once have been available only through internal corporate development companies. One model of technology development within startup, not necessarily small, must focus on firms spawned by a sense of the market and set up with a piece of technology wrenched from somewhere, reaching around them into diverse sources. The image of technology flowing from a central laboratory of an integrated assembler, perhaps in response to articulated market demand and perhaps just a technology push, into the product line was always a limited part of the development story. With the electronics industries doubling in size every decade, fully half of that growth is coming from firms that did not exist a decade earlier developing

[38] Consider, for example, the story in the Danish press on January 28, as reported by *DK Today*, an on-line news service:

> "DK IT WORLD LEADER"
>
> "DK could well be the leading country as far as IT and Internet trade is concerned. According to a survey by the Institute for Future Research DK is ahead of even USA with respect to the numbers of PCs in homes. Three quarters of Danes under the age of 50-60 are now using computers, and practically all families with young children own one or more computers. In fact most children now have pre-school computer knowledge. And home shopping by the Internet could explode as soon as a reliable means of payment has been introduced, because Danes are used to paying with the Dankort (credit card)."

technologies that were once speculative at best. The small firm does not have to mimic the technology development structure of the large firm of two decades ago. The problem of "not invented here (NIH)" becomes the question of "why invent here WIH)" as technology becomes one more element subject to a make buy decision. But the detailed global monitoring of technology and product development becomes essential. Can small firms manage this task alone? Do they require allied institutions, public or private, to facilitate and ease that task?

Or put differently, does the Danish national innovation system provide the context and support for Danish companies to exploit and adapt to these developments in global markets?[39] Danish development, first and still primarily rooted in an agro-industrial complex formed around a few large private food processing companies and a system of farming cooperatives, would not seem to be a firm base for this competitive style rooted in the electronics industry. Conversely, the emergent success in networked electronics and software suggests the possibility that smaller Danish firms can compete for dominant position in market segments and that the new electronics era may permit Danish industry to break loose from the hold of its agro-industrial past.

In any case, it is evident that the capacity within the firm to follow market. developments and technological evolutions may have to be reinforced. But, that need not be a task exclusively for firms. There are undoubtedly public policies or joint industry actions that can facilitate these efforts of market and technological monitoring. Public policy support for joint institutions to permit and facilitate close monitoring of markets and technology is certainly in the tradition of the Danish innovation system and may be part of the solution.

A second issue is whether international markets can adequately substitute for a comprehensive local and regional technology supply base. Borrus has argued that the supply base is the local capability to provide

> "parts, components, subsystems, materials and equipment technologies available for new products and process development, as well as the structure of relations among the firms that supply and use these elements. The supply base shapes the possibilities confronting users by enabling or deterring access to appropriate technologies in a timely fashion at a reasonable price."[40]

The components and subsystems may be available in international markets, but is early warning of them adequate? Is the subtle knowledge of how to apply and develop them sufficient? There is no automatic answer. We note, however, that in many cases, so long as the international supply base retains an open,

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[39] Charles Edquist and Bengt-Ake Lundvall, "Comparing the Danish and Swedish Systems of Innovation" in *National Innovation Systems* Richard R. Nelson, ed. (New York: Oxford University Press 1993).

[40] Borrus, "The Regional Architecture of Global Electronics: Trajectories, Linkages and Access to Technology," *New Challenges to International Cooperation: Adjustment of Firms, Policies, and Organizations to Global Competition*, Peter Gourevitch and Paolo Guerrieri, eds. (University of California, San Diego, 1993).

merchant character, the dispositive skill is applications knowledge. For example, the Danish firm Oticon solved the problem of applying digital signal processing to the hearing aid from Denmark with components developed in Silicon Valley.

Also critical will be continued support by policy to the emergence of the leading-edge user-markets that are often the driver of an entire wave of technological advance. For example, the success of Nokia and Ericsson in Cellular telephony is directly linked to the policy of creating cellular usage in the Nordic countries. Could this conjunction of rich, educated populations and directed public policy be used self-consciously to create leading edge markets in other Nordic industries? In short, on the role of public policy, as much as in firm strategy and organization, turns the potential for Danish industry to seize the coming era of Wintelism and CNPNs for its own competitive advantage.