Wintelism and the Changing Terms of Global Competition: Prototype of the Future?

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This paper proposes that two interwoven developments with their roots in American technology competition, "Wintelism" and Cross-national Production Networks (CPNs) are altering the terms of competition in many global markets and shifting the structure of many industries. The Wintelism thread of the story is drawn from, but by no means limited to, the emerging electronics sector. "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.[3] The character or terms of competition in the "Wintelist" era, by contrast, is a struggle over setting and evolving de facto product standards in the market, with market power lodged anywhere in the value-chain, including product architectures, components, and software. Those constituent system elements—from components and subsystems through operating and applications software—become separate and critical competitive markets. Wintelism is not just a story of the ineluctable competitive elaboration of the interior logic of new technology. Rather, this particular thread has been spun out principally by American firms responding to international competition within the confines and logic of the American market and its particularly defined political rules. In turn, "Wintelism" is now influencing the economies and polities in which it has emerged.

The second thread is the production organization counterpart to "Wintelism", Cross-national Production Networks. Cross-national Production Network (CPN) is a label we apply to the consequent dis-integration of the industry's value chain into constituent functions that can be contracted out to independent producers wherever those companies are located in the global economy. CPNs permit and result from an increasingly fine division of labor. The networks permit firms to weave together the constituent elements of the value-chain into competitively effective new production systems, while facilitating diverse points of innovation. But perhaps most important, CPNs have turned large segments of complex manufacturing into a commodity available in the market.

Although Wintelism and CPNs are most prominently evident in electronics, the electronics case suggests developments of general importance across a set of industries. Consequently, the metaphors and optics we use to interpret advanced industrial societies must be reconsidered. The era framed by mechanical and electro-mechanical processes is giving way to an era framed by digital electronics. If the

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[1] *Business Week* March 1997, Cover Article.
[2] *The Economist* March 29-April 4 1997 "Silicon Valley, A Survey." Page 2 of the Survey
[3] 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 groups 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

mechanical era was best embodied under the "Fordist" rubric, then "Wintelism" should be the code word of the present era of industrial competition. In just those terms, an appendix situates the discussion of "Wintelism" in relation to Fordism and other systems of production in global markets.

I. The Architecture of Global

The "global" economy in which "Wintelism" and CPNs have emerged has become an emblem of dramatic change. 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. 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.[4] 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.[5]

What distinguishes the present era that has been code-named "Global" from earlier eras that were code-named "International" and "Multinational"?[6] When "international" firms first sold abroad, their era, the period of British industrial pre-eminence, was one of trade. By contrast, "multinational" firms produced abroad in a 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.[7] 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

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University Press, 1988); Michael L. Gerlach *Alliance Capitalism: The Social Organization of Japanese Business* (Berkeley : University of California Press, 1992).

[4] 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).

[5] 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.

[6] 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).

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, principally American, markets.[8] 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 CPNs that concern us here). Together the three regional groups constitute about 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.[9]

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.

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[7] This material is drawn from Borrus et al., *Globalization and Production*.
[8] 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,* Chalmers Johnson, Tyson, Zysman, eds. (Ballinger, 1989).
[9] 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.

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.

Again, two interconnected elements of this story of the "global" economy concern us: the emergence of "Wintelism" and Cross-national Production Networks. The pattern suggested by these interwoven threads helps to sort out the confusion of the present era. Together they have already altered the terms of competition in electronics and promise to change the way a broader range of sectors operate.

II. Locating "Wintelism": From Assembly to Components, Standards, and Architectures

The current diversity of strategies and the competition among them provide the context for locating the place of Wintelism as a new competitive form. The automobile industry has for much of this century defined our understanding of the industrial foundations of advanced society from the logic of work organization to the requirements of macro-economic policy. So let us begin there.

The Automobile Sector and Innovation By Assemblers: 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.[10]

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 them into significant product segments via the advantages that their distinctive production organization permitted.[11] Again there was a competitive response, this time by European and American firms. In particular, European luxury car producers like Mercedes and BMW innovated in products, while

[10] 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).

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, and indeed they even influenced our understanding of the political requirements of sustained growth. 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.

Electronics and the Move Away From Assemblers: 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 market dominance to alter the terms of competition in other informatics markets.[12]

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 off-shore assembly platforms in Asia to reduce labor costs in their domestic competition.[13] But in that competitive phase, the competition, critical

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[11] Womack et al.
[12] For example, Intel's powerful reach was illustrated the week of 2/9/97 when the stock price of information network equipment powerhouse 3COM fell by 25% in one day. The cause was announcement of declining margins on key 3COM products as it responded to Intel's unexpected market entry.
[13] 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 off-shore 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: It was necessary to capture closed system rents and lock customers into proprietary standards, or, in the case of open systems, to compete on implementation, quality and price.*

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 policy-induced emergence of merchant component suppliers, began subtly to undermine the logic of competition rooted in scale and vertical control of technology. They created the evolutionary ground for the emergence of Wintelism.

The Origins and Consolidation of Wintelism: Just as the "lean production" that has so dramatically altered production strategies in the consumer durables industries could perhaps only have emerged in Japan, so the origins of "Wintelism" are fundamentally rooted in the United States.[14] The semiconductor, which was to create an information technology industry and transform electronics, emerged in a vertically integrated, regulated, communications monopoly, AT&T. Military R&D and procurement provided the initial launch market for the new technology at lucrative premium prices. As costs fell with large-scale military procurement, initial commercial applications spun-off into the computer industry, which, as recounted above, was dominated by IBM. American policy (especially antitrust) prevented both AT&T and IBM from monopolizing the technology to dominate all of electronics, and in fact helped to set an industry-wide pattern of technology cross-licensing. Through licensing and labor mobility (which resulted from typically flexible US labor market policies) both AT&T and IBM became technology pumps, widely spreading to start-up and established producers and users the basic technological innovations on which the chip industry was built.

In that way, policy helped to foster the emergence of "merchant" chip firms whose primary activity was selling semiconductor components to producers of final products, and whose marketing

[14] For the argument on lean production see Laura Tyson and John Zysman "The Politics of Productivity."; For the account on the emergence of merchant chip producers as the origins of Wintelist, see Michael Borrus, Competing for Control; and Braun and McDonald.

strategy was inherently one of diffusion of the new technology. Very likely, the unique merchant industry structure could not have emerged except under cover of the unique US policy umbrella.[15] In turn, the significance of the merchant producers for the emergence of Wintelism cannot be exaggerated. Because their basic role was to diffuse chip technology as widely as possible, they fostered the coming-into-being of other specialized producers throughout the electronics value-chain who could take advantage of it. In effect, they pioneered and instigated the gradual process of vertical dis-integration throughout the American electronics industry. Final assemblers needed no longer to be vertically integrated into component production on the IBM/ATT model. Instead, they could focus on system definition and assembly. Specialization in one part of the value chain bred specialization in other parts: Through the 1960s and 70s, specialized producers of semiconductor equipment and materials emerged, as did producers of software and systems integrators higher up the value chain. The whole process was accelerated by the competitive entry of Japanese producers who helped to eliminate traditional vertically-integrated players from the US market.

In the policy-induced struggle to break loose from IBM's dominant model and to react to the Japanese ascent, new product strategies emerged within the logic of the dis-integrated US industry structure and the possibilities afforded by 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.[16] 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'.[17] The relevant technical standards are licensed rather than published, with either the universe of licensees, the degree of

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[15] Contra-factual arguments are always difficult, but there are few significant merchant firms outside the United States: most of the major semiconductor firms in the rest of the world are parts of large integrated companies—Siemens in Europe, Samsung in Korea, NEC in Japan.

[16] This account of the development of open-but-owned systems 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.

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

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 licensor (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 open-but-owned systems was accelerated by two factors that helped to spread and consolidate Wintelist business strategies. *First*, from the supply side, the increasing cost and complexity of continuing innovation made it increasingly difficult for any one company, even IBM, to maintain ownership and control over all of the relevant technologies. *Second*, and by far more critical, major industrial users made increasingly strident demands for increasing interoperability of complex systems purchased from multiple vendors.[18] As, major business users moved their business operations onto information networks that became increasingly central to the implementation of business functions and strategy, users wanted control over their management and operation. Again, American public policy set the context: Over three decades from the 1950s-1980s, US policy gradually deregulated AT&T and introduced competition into the domestic US market for communications services and equipment. That, in turn, provided the communications facilities and services from which industrial users would piece together their information networks. Industrial demand stimulated a burst of innovation in both development and usage of network equipment and services, creating broad new market opportunities.

We must here distinguish between <u>provider</u> supplied networks, really networks with their origins in voice telephony and provided by the once monopolist national providers, and <u>user</u> driven networks. The user driven networks have largely been private corporate data networks developed to use digital information to create competitive advantage in the user company business.[19] <u>Provider</u> supplied networks are defined and controlled by the network company which provides a set of service or possibilities to its customers. User driven networks are at least in part defined and controlled by the user who designs them to fulfill specific functions. These user driven networks, which characterize the American deregulation, generate a competitive market for the constituent equipment and software. Often the technology used to implement the data networks has been clearly different from that used to implement the traditional voice

[18] This point and the following account are drawn from 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.
[19] See a series of piece by Francois Bar and Michael Borrus. Most importantly see *The Future of Networking in the US,* 1994 and *Information Networks and Competitive Advantage: Issues for Government Policy and Corporate Strategy Development*, Firnal Report for the OECD, 1989.

networks. Traditional suppliers to voice networks or even traditional mainframe based computer systems have generally not been players in these new network technologies. When we look at the data on the growth of communications networks, the Europeans keep pace in public network equipment but not in the explosively expanding private network equipment.[20] In our view that divergence between success in public provider network equipment rooted in the old telephony and a more limited success in the new private markets reflects the limited European experience with user defined networks based on data. The American success, including a firm such as Cisco discussed below, reflects the expansion of user driven networks in the United State that established a deconcentrated market for the equipment. The user driven networks and the equipment that implemented them turned on the particular form of deregulation. The American deregulation gave to users access to the control layer of the telecommunications network, while European deregulation has emphasized competition amongst providers and still has not fully opened the public network to user definition of privately designed networks.

In sum, American users, but not European or Japanese, could pick and choose among the most innovative equipment and services from multiple vendors to knit together their information networks. But the pieces from multiple vendors had to fit together—they had to be open enough to enable end-to-end interoperability of the corporate communications infrastructure. Suppliers responded with open-but-owned systems: "open" at the interface to permit interconnection of systems from other vendors, but "owned" to reap a return from innovation. In short, users demanded highly functional and inter-operable systems, US policy stimulated provision of them, and both further encouraged the value-chain specialization with open-but-owned standards that are the hallmarks of Wintelism. Once again, these developments were unlikely to have emerged in other national settings like Europe or Japan, where policy fostered communications monopolies and user reliance on single-vendor, closed systems.

But the move to open but owned systems and value-chain specialization was legitimized, as perhaps it only could have been, by IBM with the IBM PC.[21] 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

[20] Enabling the Information Society-Supporting Market-Led Developments, report from the "Informal Council of Industry Ministers," January 31-February 2, 1997, The Haag, the Netherlands.
[21] There are numerous accounts of this period. Representative are James Chposky 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).

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.

The New Terms of Competition: In this new epoch, firms located anywhere in the dis-integrated value chain can, potentially, control the evolution of key standards and in that way define the terms of competition not just in their particular 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 key producers of components (e.g., Intel); operating systems (e.g., Microsoft); applications (e.g., SAP, Adobe); interfaces (e.g., Netscape); languages (e.g., 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.[22]

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

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[22] 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*

manufacturing assets. For Wintelist firms, ownership and manipulation of their de facto standards are considerably more effective barriers to entry 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 (a point elaborated later). 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 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, the electronics industry, now the driving and expanding industry group, 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.[23] Simultaneously, systems products have moved away from stand-alone proprietary systems toward open-but-owned systems that are meant to be interconnected with (or integrated 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

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

[23] 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.

to define and widely disseminate the architecture for a "network computer" (NC) tailored for Internet functionality, really represent as many 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.[24] 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 Cross-national Production Network.

III. CROSS-NATIONAL PRODUCTION NETWORKS AND MANUFACTURING SERVICES TO CONSTRUCT THEM: THE NECESSARY COUNTERPART

The strategic importance and hence the organization of production have changed as competition and value-added have moved away from assembly. As argued in the last section, Wintelism's defining shift has been to the rapid evolution of the constituent elements of the system being assembled and the creation and evolution of de facto market standards. CPNs and contract production services are the organizational counterparts of that shift. CPNs 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, CPNs 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

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

the lead firm and entire business functions may be outsourced.[25] [See inset sidebar for more detail]

Production of Telecommunications Systems in the Wintelist Era: Cisco System's CPN

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 ATT and its international counterpart, ITT. Pre-Wintelism and CPN, everything from the R&D at central corporate laboratories to product design, engineering, manufacturing, distribution and service was done by one ATT/ITT affiliate or another, usually located somewhere in the US for ATT 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 ATT 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

[25] Michael Borrus, *Left for Dead: Wintelism, Asian Production Networks and the Revival of US Electronics* (tentative title), manuscript in progress, forthcoming, 1997.

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.

Such networks *have evolved to exploit an ever more intricate division of labor based on increasing local technical specialization in Asia*.[26] They are not principally about lower wages or access to markets and natural resources. Nor is there a parallel to the production reorganization and networks that emerge when relatively homogeneous economies integrate. 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. Rather, the Asian story is about the linkages among diverse and

[26] 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:*

heterogeneous economies. East Asia, within which these networks emerged, is a story 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. On top of this base, the networks formed from intra-sectoral trade and investment that links together the diverse production functions across national borders to create complementary production arrangements which individual producers and nations would be incapable of maintaining independently. For example, to create a PC, 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. 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.[27]

The relationships that comprise a given firm's CNP run the gamut from short-term supply contracts to very long-term joint R&D. The predominant relational form varies with the task at hand. Consider the range of tasks: Technology development, such as the IBM-Toshiba joint venture, Display Technologies Inc. (DTI), formed to jointly develop flat panel, liquid crystal display technology, -requires longer term alliances with more intimate involvement and greater "trust". By contrast, procurement of existing product technology, such as a disk drive, where leadership will shift abruptly among suppliers, is likely to be product-by-product or one product- and component-generation at a time.

CNP relational variations also appear to depend on the national home base of the core company or core contract agent. Japanese production networks, for now, are dominated by the core company with extensive use of dominated local subsidiaries.[28] These arrangements—which have their origins in the particular sequence that spread Japanese production across Asia—have proven rigid, slower, and less open to local innovation. American networks are more open and more agile. The supply portion of the American CPNs appear to be almost pure contract networks, largely managed from the United States, consisting of short term bargains, not longer term alliances. Indeed, contract manufacturers and their customers seek to limit dependence on each other. Some even use formulaic conventions, such as no more than 20% of business from any single client. In some cases, depending upon the purpose of the relationship these are treated as short term bargains, in other cases as a series of longer term arrangements

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Production Networks and the Industrial Integration of Asia, forthcoming, 1997 and John Zysman Eileen Doherty and Andrew Schwartz "Tales from the Global Economy" in Journal 1996

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

[28] See Dieter Ernst, *Carriers of Regionalization: The East Asian Production Networks of Japanese Electronics Firms,* BRIE Working Paper 73 (Berkeley: BRIE, 1994).

or even as semi-permanent alliances. The wide range of relationships that define the CPN is thus likely to remain broad and fluid over time, contingent on the specific needs, structures and strategies of individual firms.

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. Whether or not Europeans organize them in Europe, they are likely to be put in place there 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.

Asia's Development and the Emergence of CPNs: 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.[29]
>
> 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 technology catch-up and export-led growth.
>
> Tier Three: "Late Late-Industrialization via CPNs" 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.[30] 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.[31]
>
> 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

[29] Richard Samuels, *Rich Nation, Strong Army* (Ithaca: Cornell University Press, 1994).
[30] 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.
[31] For a description of the potential for developmental insertion, see Dieter Ernst, *Carriers of Regionalization*, supra.

dramatically alter the region's competitive dynamic—as China already has in drawing foreign direct investment away from third Tier developers.[32]

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:[33]

- 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 and governments 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.

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.[34]

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 CPNs 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. By

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[32] 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

[33] This discussion is drawn from the work of and discussions with Tim Sturgeon, a BRIE Research Associate completing his dissertation in Geography. Tim Sturgeon, "The Rise of the Global Locality: Turnkey Production Networks in Electronics Manufacturing" (University of California at Berkeley, forthcoming, 1997).

[34] 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.

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."[35] 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, CPNs now touch the core elements of the industrial economy and the most innovative and 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.[36] 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 plants in North Carolina, Washington State, Texas, Malaysia, Scotland, France, and Germany."[37] Conversely, former vertically integrated assemblers like IBM, Hewlett-Packard, and Apple have disposed of captive production facilities and moved to the new CPN 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.[38] And some of the newest and most successful systems companies own *no* internal manufacturing at all. Examples include: Dell (PCs), Silicon Graphics

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[35] Sturgeon, supra. Sturgeon cites: *Commodity Chains and Global Capitalism,* Gary Gereffi and Miguel Korzeniewicz, eds. (Westport, Conn: Greenwood Press, 1994). In this industry, 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.

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

[37] Sturgeon, "The Rise of the Global Locality," supra.

[38] According to Gilbert Amelio, Apple's new CEO, the company's strategy is to outsource produciton 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.

(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 CPNs 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 CPN 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.[39]

Scale and Control of Production in CPNs :"Wintelism" and CPNs have implications for all firms, large and small. Wintelism and CPNs 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. In principle—and in fact—this has opened new business opportunities for firms operating at much smaller scale than traditional vertically integrated assemblers. For example, for some small firms, the skill at developing sophisticated products for niche markets opens the possibility that they can aim at larger volume markets by applying niche market product development skills to volume markets and contracting-out volume manufacturing. This is to emulate what a firm like Gateway is doing in computers, but to apply the strategy to upper market segments of consumer durable businesses, in effect using the niche market as a prototype for volume entry. Or a small firm may sell to a larger firm seeking to fill a spot in its product offerings what for lack of a better term may be called an entire product system, that is a product already beyond the prototype stage along with a system of production arrangements ready to deliver that new product to the market rapidly. That small firm could act as a contract product development operation.

But many of the constraints associated with scale will remain despite such new opportunities. We are not entering an era of small and flexible firms. Rather, over time, significant imperatives of scale are emerging in different parts of the value chain, notably in production, product development, the dynamics of standardization, and distribution. For example, efficient semiconductor production now requires billion dollar-plus production facilities. So long as chip design firms remain small, they can contract-out

[39] Sturgeon, "The Rise of the Global Locality," supra.

for capacity with so-called chip foundries. But as demand for their products becomes sizeable, it gets increasingly difficult to find adequate production capacity. Then, even small firms need to invest in or buy-into large-scale production facilities in order to ensure themselves of adequate production capacity, just as smaller firms like Actel have recently done in acquiring stakes in new Taiwanese fab lines. Similarly, standards do not rest simply on the domination by a single producer of a particular market. Very often, they require a painstaking knitting-together of a large-scale standards coalition composed of other producers and suppliers who add value around the standard, major users, and even competitors. SUN has created just such a coalition in seeking to standardize its version of JAVA in the face of efforts by Microsoft to take control of the new programming language with a proprietary MS-JAVA version. Even more significant, as argued earlier, in standards competitions lock-in and installed base—i.e., *scale in use*—are critical to enduring market success. Creation and maintenance of standards coalitions and installed bases take time and large-scale resources. And the larger the market, the larger the requisite effort.

This holds true for pure product development firms as well. They can be small as new market entrants, but they must engage in increasingly large-scale investments to maintain a dominant position, once achieved, in a fast growing market. A good example is Cisco Systems, which has grown through acquisition of an increasingly broad array of complementary technology and product companies as its market grew from hundreds of millions to billions of dollars. Finally, in many market segments, maintaining competitive advantage over time rests in large-scale investments in distribution and marketing rather than in technology development. Wintelism and CPNs thus shift the location in the value chain of scale investment (here, from production to distribution) but not its necessity. In sum, while Wintelism and CPNs fragment or dis-integrate the value chain, they do not imply that we are headed to an era of small scale specialty firms becoming dominant within each market segment of the value-chain. The advantages of scale are redistributed, but not eliminated.

In a similar fashion, the logic of the necessity for control over production changes, but is not eliminated, in the Wintelist era where CPNs make production itself into a commodity. CPNs mean that, in many cases, supply and quality can be assured as much by external contract as by internal ownership. But that does not mean that manufacturing no longer matters for the firm. The proper question is under what circumstances does outsourcing seriously undermine the capacity of a firm to control the direction of product development, market response, and industry evolution? And, indeed, under what circumstances must a firm manage the outsourcing internally as an alternative to internal production, and when can a firm safely outsource the oursourcing, that is engage a manufacturing service firm like Solectron to manage the external relationships. In our view, it remains true that firms cannot control what they cannot produce, but the meanings of production and of control must be reconsidered. We believe that one critical link is between product development and production, but its tightness and texture varies considerably from one product-market to another. For example, American disk drive firms own prototype development and pilot production facilities. Some then contract out volume production. For them, control over prototype and pilot production is sufficient to control evolution of their market position. But, as mentioned earlier, HP, despite extensive use of contract network arrangements, vertically integrated into production of the ink jet printer, its key component technologies and some of the underlying manufacturing equipment. It developed much of that technology internally, integrated to maintain control over it, and moved aggressively to drive prices down in a Japanese-style entry. In laser printers, however, where it does not control key components and, in fact, is dependent on a rival, Canon, for the laser engine itself, it chose instead to maintain only a modest internal development project to track evolution of laser engine technology in order to increase its maneuvering room in negotiations with Canon over price and availability.

In short, there is no single answer. Answers turn on unique characteristics of both the product-market and the contract production services in question—on such issues as the structure and openness of potential contract production markets, or the extent to which opportunities arise to reap additional returns through owning complementary assets, or the degree to which production know-how influences not just the cost of today's products but the design of tomorrow's products and product lines. To take the latter issue, for example, the Japanese ability to shrink the VCR into a consumer product or create products such as the Walkman turned on their creation and mastery of mechatronics technology and production systems. By contrast, hands on management of production does not necessarily enable a company to anticipate production revolutions that alter market positions. Indeed, American automobile and consumer electronics producers missed the Japanese lean production revolution and avoided facing its consequences precisely because their internal bureaucracies sustained a production status quo. In those cases, contract producers might have followed developments in production innovation more closely and been less resistant to change. In short, the only certainty is that the question of how much to control what you produce via contract or via ownership, and how to manage in either case, must be asked and answered by each individual firm in an era of elaborate CPNs.

IV. How Wintelism and CPNs Alter The Terms of Competition in Global Markets

Wintelism and CPNs are shifting the character of competition in a range of global markets starting with, but not limited to electronics.

The Electronics Story

Wintelism and CPNs have mattered mightily to the outcomes of competition in the electronics industry.[40] 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, 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 CPNs created an alternative supply base in Asia—an alternative to reliance on Japanese competitors for underlying component technologies and manufacturing capabilities.[41] 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 CPNs 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 a core managerial skill is orchestrating the CPN, 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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[40] This section is drawn from, and quotes extensively, Borrus, *Left for Dead.*

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

Why Wintelism and CPN may be models in a broader range of sectors: To consider how widely Wintelism and CPNs will diffuse, and by way of summary, we recap here the key propositions of our argument:

I. Wintelism: In this era in which the electronics sector is now the expanding and driving industry group in the economy, "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. 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. The foundations for the technological trajectory of "Wintelism" rest with the emergence of the merchant semiconductor firms in the United States and "user" driven data/communications networks, both developments framed if not unintentionally induced by U.S. policy.
II. Cross-National Production Networks (CPNs) and contract production services are the necessary organizational counterpart of Wintelism. These networks evolve to take advantage of a more intricate division of labor. They are not principally about lower wages or access to markets and natural resources. They have emerged in successive phases from off-shoring internal products to contracting for full-blown production networks. Manufacturing continues to matter, but the strategic problem of production is changed for companies.
III. Changed Terms of Competition in Electronics: "Wintelism" and its counterpart CPNs have already significantly altered competition in the electronics industry affecting which home-based companies have advantage and altering opportunities and strategic problems for large and small firms alike.

The last issue is how far these developments will diffuse. Stated as a fourth proposition, we believe that,

IV. Wintelism and cross-national production networks are likely to be broad features of the international economy that reach well beyond electronics.
V.

Electronics may be the originating sector, the development test-bed, for the new approach to competition and production.[42] 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

[42] In fact, some would argue that the electronics story is itself simply a subset of developments grouped under a variety of labels including "post-Fordism", flexible specialization, and volume flexible manufacturing. We strongly disagree, and outline our views in the accompanying Appendix. In fact, however, resolving that debate is not crucial to our analysis here, since at worst we are highlighting specific, under-appreciated features of a new production paradigm.

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. 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.[43] As microelectronics pervades the consumer durable, professional goods and capital equipment sectors, transforming their products and processes, "Wintelism" and CPNs 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 CPNs are similarly likely to be imitated and to spread into models of best practice, to be taught and diffused widely.[44] 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 CPNs in consumer durables will likely spread 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 Cross National Production Network 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 like Korea's DaeWoo who succeed in Western markets with CPN-based strategies. 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.[45]

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[43] Report on The Electronics Revolution in the Motor Car Industry, published by the Economist Intelligence Unit.
[44] 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.
[45] For an extended discussion of the potential for CPNs in that regard, see Zysman, Doherty and Schwartz, "Tales from the 'Global' Economy."

Fourth, automobiles and other traditional consumer durable industries are being pushed in the direction of Wintelist competition. A series of new "assemblers" rooted in newly industrializing countries are entering and planning entrance into global markets. Often they are "third tier" Asian firms trying to extend from initial entry in components to a position in final markets. These companies can assemble the final product but can neither produce indigenously critical components and subsystems from electronic controls to engines and gearboxes nor provide the production equipment from machines through robotics. Initially, they can provide low cost labor for assembly functions and some engineering talent. The demonstrated ability of Western auto firms to implement advanced plants with radically improved productivity in places the such as Mexico that they themselves often failed to implement at home suggests that these new entrants may find an enduring place in the market. Hyundai or Kia, the Korean producers that provide product that often were simply repackaged Japanese or American designs built with critical imported parts with foreign based equipment are thus only precursors of a new auto sector competition. Those new producers that are not so vertically integrated as their European, American, and even Japanese (virtual integration) predecessors and may create a competitive market for components and subsystem competition. In turn, competitive position in the markets for the particular constituent elements of the product need not evolve into standards based competition reminiscent of the electronics sectors, but in some segments that is indeed likely to happen. Finally, the competitive practices depicted here 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 the continued diffusion of Wintelism" and Cross-national Production Networks now that they touch the core of modern industrial economies. Rooted in the American industrial adaptation and policy choices, they comprise a distinct, nationally founded story with global implications as a model of industry and a new dynamic of competition.

Appendix

"Wintelism" as an Optic on Society and Economy

Preliminary Thoughts

Draft. John Zysman

Is "Wintelism", with its origins in the American electronics industry, a useful optic through which to frame discussions of the present era of international competition and the development of industrial societies? Here in Part II we begin to locate our story as one of a series of approaches to markets and production. Each story of production and competition emerges from a particular moment in industrial history and from a specific place as part of a sequence of developments. Those other stories are:

- mass manufacturing, or "Fordism", that emerged in the United States in the latter part of the 19th century, consolidated itself in the automobile industry, and then became the model of industrial development in the years after WW II
- lean production, and "developmentalism", that emerged in Japan in the 1970s, and
- "flexible specialization", and community-based growth, that was first highlighted in particular Italian and German industrial regions.

Each story is also a synthesis and a method—a more general and influential interpretation of advanced countries.[46] Hence, we could present this material twice: once as the narrower market tale of a sequence of competitive developments, and once as a method and metaphor.

A. Fordism and Mass Manufacture

Mass production is broadly understood to mean the high-volume of standard products made with the complete and consistent interchangeability of parts that could simply be connected using machines dedicated to particular tasks that are manned by semi-skilled labor.[47] (Indeed, the definition is now so conventional that arguments contrasting industrial

[46] The analysis here extends the conversation begun by Cohen and Zysman Stephen Cohen and John Zysman in *Manufacturing Matters: The Myth of the Post Industrial Economy* (New York: Basic Books 1988).
[47] Womack et al. See also, Paul Hirst and Jonathan Zeitlin "Flexible Specialization: Theory and Evidence in the Analysis of Industrial Change" in *Contemporary Capitalism: The Embeddedness of Institutions* J.Rogers Hollingsworth and Robert Boyer Ed. (Cambridge University Press, 1997)

developments to mass manufacture do not always provide a definition.) A range of features are hung on to that basic definition. The features include:

- the separation of conception and execution—managers design systems that workers, slotted into rigidly defined roles to match them to machine function, operate;
- the "push" of product through these systems and onto the market;
- large-scale integrated corporations, whose size and dominance reflected mass production's economies of scale, dominated the markets.

The operation of this system became embedded in the institutional organization of the economy, the rules that shaped market interactions and transactions. Hence "Fordism", as distinct from mass manufacture, becomes a social and political system built upon, or better still to implement, an approach to industrial production and markets in an era dominated by mechanical engineering and metal bending industries. Market control in the Fordist story is in large companies.

The sources of both mass manufacture and its particular manifestation as "Fordism" have their roots in the trajectory of American industrial development. The story emphasizes the innovation of interchangeable parts leading to the assembly line, the homogeneous but prosperous and growing market that created demand for standard product, the abundance of semi-skilled labor suited to the assembly line system of mass production, and the political battles that generated both a particular set of market rules that permitted, even encouraged, vertical integration and labor market organization that implemented management control of the shop floor.[48] Importantly, mass production created, and is rooted in, the consumer durable markets for mechanical (automobile) and electro-mechanical (refrigerators and the like) products, and the technology of interchangeable parts grows out of the metal cutting mechanical engineering sectors. There are, arguably, more than one national form of mass production or "Fordism", but the prototype certainly was the American case.

The particular mass production approach to manufacture and markets entrenched a particular set of technologies, if one sees social context shaping technology. Alternately, if one sees the unfolding of technological possibilities driving market arrangements, the particular possibilities of emerging technology generated the particular approach that we call mass production. In either case, for most analysts advanced industrial society seemed characterized by large, integrated firms seeking to impose on markets products produced on high-volume, dedicated lines manned by semi-skilled workers. Scale implied rigidity, and the economic

[48] Noble on labor.

management counterpart of that corporate rigidity became the policy question of how to avoid business cycles. Booms and busts implied worker dislocations, and the social/political management counterpart of business cycle management became how to use a welfare state to cushion not only the economic dislocations but the political dislocations. “Fordism” thus implied an analytic method. The analytic method was to ask what institutions and policy sustained a dominant system of production, and how a balance is maintained between the micro-economic logic of production and stability in the macro-economy.

“Fordism” thus became mass production with Keynesian demand management, full employment, and a welfare state. It was both a characterization of an era and a goal to be pursued. With its emphasis on mass markets and arrangements of labor, welfare, and national demand management, attention was focused on *national* capitalisms. The significance of local or regional institutions faded. How widely the “Fordist” system actually diffused is both unclear and critical to later argumentation. There were two diffusions; one is the system of mass production and the other is the particular set of policies associated with “Fordism”. The answers are different for each. For example, when the Japanese auto industry was reconstructed in the 1960s it evolved into a lean system of flexible volume production. Japanese growth in the same period hinged on rapid internal development and export markets, not on demand management. If “Fordism” was never fully implemented, then post-”Fordism” is a misstatement; there are alternate lines of industrial development, not a clear sequence.

In any case, Fordist mass production was associated both with American industrial development, military success, and post-war hegemony. Beginning in the 1960s two alternate configurations—flexible volume production and flexible specialization—emerged, or at least caught our attention. Both claim to provide both static flexibility, the capacity to vary product mix within a particular generation of production, and dynamic flexibility, the ability to move between product generations and steadily advance the productivity of the production system itself.[49] While each is rooted in the industrial development of a particular place, each has served as an alternate *general* model of firm competition and national policy.

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[49] Cohen and Zysman, *Manufacturing Matters.*

B. Flexible Mass Production, Lean Production, and Developmentalism

Japan's automobile and electronics firms burst onto world markets in the 1970s and consolidated powerful positions in the 1980s. Their success has its foundations in the interconnected production innovations loosely called flexible volume production, lean production, or flexible volume production.[50]

Characterizations of the Japanese production system emphasize that it provides flexibility of output in existing lines as well as rapid introduction of new products which permits rapid market response. High quality measured in defects has come hand in hand with lower cost. The elements are in fact bound together.[51] Pulling a product through the system links the factory more closely to the market while reducing the need for buffer stocks. Reducing buffer stocks, which certainly reduces stockage costs, makes just-in-time delivery of components a necessity, and supply flow management a critical matter. Transferring considerable responsibility to the production line also creates mechanisms for detecting and correcting defects within the system that can then be interpreted by formal methods of statistical process analysis. The use of production centers with a variety of lighter-weight tools permitted flexibility in product mix, while at the same time adjusting the line management to the necessities of numerically controlled (NC) machine tools.[52] The core Japanese assembly companies of the lean variety have been less vertically integrated than their American counterparts, but they have been at the center of vertical Keiretsu that have tightly linked the supplier companies to their clients.

A distinctive approach to volume manufacturing, however labeled and characterized, emerged in Japan during the years of fast growth and was firmly in place by the time of the first oil shock in the early 1970s. In our view the distinctive features of the Japanese production system were a logical outcome of the dynamics of Japanese domestic competition in the rapid growth years.[53] A sketch of the argument begins with the intense competition among Japanese firms in the domestic market behind protected barriers using imported technology and materials.

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[50] Cohen and Zysman, *Manufacturing Matters;* Coriat; Ramchandran Jaikumar, "From Filing and Fitting to Flexible Manufacturing: A Study in the Evolution of Process Control" Working paper 88-045 (Boston, Mass. : Division of Research, Graduate School of Business Adminstration, Harvard University, c1988); Womack et al.
[51] Ibid.
[52] Jaikumar, "From Filing and Fitting to Flexible Manufacturing."

With rapidly expanding markets, no foreign rivals, easily available finance for critical companies in favored sectors, and a competition among firms implementing borrowed technology, companies needed to ride the production curve and learning economies to success. The logical consequence was that it was strategically necessary to maximize market share.[54] This in turn had its own consequences. First, the large and now well known core assemblers such as Toyota or Matsushita were at the beginning members of groups of companies, labeled after WWII as Keiretsu, and short of capital. Contracting with related supplier companies shared the capital demands and market risks; the assemblers thus generated tiers of supply relationships and the necessity of joint component development. The introduction of the Kanban system of "pull through" thus implied and could induce just-in-time delivery. Just-in-time delivery required limited defects.[55] Small firms thus had a significant role in the story, but within a sphere dictated by the large core companies and not generally as independent players. Japan was characterized by vertical, tiered production relationships dominated by the largest companies. The large assemblers, thus, maintained both control over the supply chain and the link to the market. Second, while borrowing technology and continuously expanding production in growing markets, firms had to organize internally to effectively capture the learning curve possibilities. Firms that were more effective at responding to markets and organizing internally to capture learning curve gains had a distinct competitive advantage. Some accounts emphasize the strategic insights at Toyota where the lean production system first was implemented fully. Other stories emphasize the difference in shop floor organization and union structures within company unions between, for example, Toyota and Nissan.[56] In any case, effective development of flexible volume production required distinctive strategies from market to shop floor organization through supply chain management. National government programs such as those that subsidized numerically machine tool development mattered in this series of production innovations, but the significant government interventions were less sector specific actions influencing particular

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[53] 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,* Chalmers Johnson, Tyson, Zysman, eds. (Ballinger, 1989).
[54] Murakami Yasusuke and Yamamura Kozo "A Technical Note," in Yamamura, *Policy and Trade Issues of the Japanese Economy: American and Japanese perspectives* (Seattle: University of Washington Press, 1982).
[55] Murakami and Yamamura, "A Technical Note."
[56] Nobuhiro Hiwatari "The Political Economy of Enterprise Unionism and Industrial Collaboration in Japan" (Tokyo: Institute of the Social Sciences, 1993).

companies than the creation of the competitive market logic than induced goals of market share and exports.

Protected domestic markets and exports were decisive, in our view, and generally understated in the accounts of the emergence of the distinctive system of lean flexible volume production. These elements are emphasized in stories about trade politics, but not those about industrial and technological innovation. While company rivalries behind protected markets induced many of the strategies that produced flexible volume production, exports helped permit the transformation from "fragile" to "lean" production. Domestic demand, savings, and investment are the key to the story of the Japanese high growth years. But exports are not simply the product of that internal success, but rather were key to production innovations that facilitated international market positions. The argument is simple.[57] The relationships of production and development in these productions systems are, at best, delicate. Just-in-time delivery, subcontractor cost/quality responsibility, and joint component development push on to the subcontractor considerable risk in the case of demand fluctuations. True, there were techniques to continuously reappraise demand levels and indicate to "client" firms their allocations so that the client firms could in turn plan. This reduced unpredictability throughout the system. But if demand moved up and down abruptly, those techniques would not have mattered. True, government and corporate programs to reduce the capacity break-even point in small firms helped. Nonetheless imagine that Japan's emerging auto sector had to absorb continuously the stops and starts of the business cycle that typified Britain in the 1950 and 1960s. Would the trust relationships that are said to characterize Japan have held up? Could the fabric of small firms have survived to support just-in-time delivery and contractor innovation? Simply a smooth and steady expansion of demand typified the Japanese market in sectors such as autos and facilitated these arrangements and developments.[58] The high growth rates—combined with the need to re-equip Japan in the post war years—created the basis of the continuous expansion. But domestic growth did fluctuate and the rivalries for market share led consistently to over investment, that is excess capacity, in the Japanese market. The story about Japan told by Yamamura and Murakami, Tsuru, Zysman, and Tyson, and by Tate in the case of the auto

[57] John Jay Tate *Driving Production Innovation Home: Guardian State Capitalism and the Competitiveness of the Japanese Automotive Industry* (Berkeley: BRIE, 1995).
[58] Tate (1995).

industry shows that the excess capacity was "dumped" off onto export markets. Seen differently, these exports permitted a steady and smooth expansion without which the production innovations outlined here would not have emerged. The developmental strategies of Japan were essential to its production innovation.

Thus while the Fordist story highlights national strategies for demand management, this story of lean production and developmentalism highlights the interaction among advanced countries in international competition. The Fordist method looks at the problem of offsetting rigidities in national capitalism—managing the business cycle and its social and political consequences. The Japanese case of lean production obliges us to consider the comparative development of capitalism, the interaction of national systems in international markets, and the distinctive "logics" of market competition that are therefore created. A four-step approach to link institutional and social contexts to the dynamics of national markets and technology systems characterizes this analysis.[59]

Step 1: Each economy consists of an institutional structure. The institutional organization of politics and markets defines the choices of each actor. It induces nation-specific political and economic dynamics.

Step 2: That institutional structure of the economy, combined with its industrial structure in a more classic industrial organization sense, creates a distinct pattern of constraints and incentives. This defines the interests of the actors as well as shaping and channeling their behavior. The interaction of the major players generates a particular "policy logic" and a particular "market logic". Since the national institutional structures are different, there are, as a consequence, many different kinds of market economies.

Step 3: Market logic, specific to a particular national institutional structure, drives corporate choice, thus shaping the particular character of strategy, product development, and production processes in a national system. A specific market logic (and political logic) then induces distinct patterns of corporate strategy (and government policy), and therefore encourages internal features of companies (and the government) that are unique to that country. There are typical strategies, routine approaches to problems, and shared-decision rules that create predictable patterns in the way governments and companies go about their business in a

[59] See John Zysman, "How Institutions Create Historically Rooted Trajectories of Growth," in *Industrial and Corporate Change*, Vol. 3, No. 1, Oxford University Press, 1994

particular political economy. Those institutions, routines, and logics represent specific capacities and weaknesses within each system.

Step 4: Not only trade competition but patterns of technological development must in part be understood as an interaction of these national market logics. Differences in corporate strategy and access to markets and technology create patterns of international trade competition.

The mechanisms and sources of the Japanese flexible volume manufacturing system have had attracted intense attention because of the stunning world market success of the Japanese companies in consumer durable industries requiring complex assembly of a large number of component parts. The innovators were the core auto and electronics firms who in a hierarchical manner dominated tiers of suppliers and sub-system assemblers; the production innovation was the orchestration and re-organization of the assembly and component development process. But flexible volume production was not the only significant innovation.

C. Flexible Specialization

This story must be told twice. The first time we tell it in order to examine its analysis of particular industrial innovations in Italy and Germany. The second time we tell the story to explore the more general claims which are broader and bolder, but more suspect.

1. The Contribution of the Original and Core Story

The "Third Italy" and the Germany of Baden-Wurttemberg were the first prominently displayed examples of an approach in which craft production, or at least the principles of craft production, survived and prospered in the late twentieth century. *The particular political economy of the two countries is shown to have given rise to distinctive patterns of company and community strategies.*[60] *Indeed, these two cases gave rise to the notion of flexible specialization*. "Craft production or flexible specialization", argue Hirst and Zeitlin, "can be defined as the manufacture of a wide and changing array of customized products using flexible, general purpose machinery and skilled, adaptable workers."[61] Communities consisting of groups of small companies, organized in what are perceived as Twentieth century versions of industrial

[60] Charles F. Sabel, Horst Kern, and Gary Herrigel *Collaborative Manufacturing: New Supplier Relations in the Automobile Industry and the Redefinition of the Industrial Corporation*. (Cambridge, Mass: International Motor Vehicle Program, Massachusetts Institute of Technology, 1989); Charles Sabel *Work and Politics* (Cambridge: Cambridge University Press, 1982); Suzanne Berger and Michael J. Piore *Dualism and Discontinuity in Industrial Societies* (New York : Cambridge University Press, 1980).

districts are argued to able, in at least some markets and some circumstances, to adapt, invest, and prosper in the radical uncertainties and discontinuities of global market competition more effectively than larger, more rigidly organized companies. Their technological dynamism distinguishes them from the small firms that emerged during the Great Depression of the 1930s. “These districts escape ruinous price competition with low-wage mass producers,” Sabel argues, “by using flexible machinery and skilled workers to make semi-custom goods that command an affordable premium in the market.”[62] The emphasis in these discussions are the *horizontal connections,* the connections within the community or region of peers. Indeed some versions of the flexible specialization story emphasize the capacity of firms that are one day the prime contractor arranging matters with their business neighbors to shuffle their roles and serve as subcontractor the next. This community of peers is certainly distinct from the *vertical or hierarchical connections* of the dominant Japanese companies. The community of peer firms maintains the institutional infrastructure of business and the links to the market. In some presentations, these communities arose earlier and alongside mass production but were not noticed because the analytic and public focus was elsewhere, or were not significant because the distinctive capacities of these communities of companies were not decisive, or more broadly significant, until later. In other arguments, flexible specialization emerges out of the logic of the limits of mass production itself. Italy, in this line of argument, develops dualism within the advanced Northern Regions and companies. The dualism comes from the rigidity of large firms which have not only fixed capital costs, but fixed labor costs and the costs of large scale labor conflict. Preserving a core production within the parent company that is going to be needed even with radical expansions and contractions of the economy, smaller lot production is contracted out so that the companies would not be rigidly locked to the additional or marginal production.[63] The small lot producers were initially assumed to be higher cost manufacturers that provided in their flexibility, albeit at a higher price, a desperately need antidote to rigidity. In fact, many of these small producers broke loose from their origins, becoming efficient producers along new principles and attacking markets they did not initially imagine. These companies emerged within and in response to the system of mass production. The creation of these modern craft

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[61] Hirst and Zeitlin, “Flexible Specialization.”
[62] Charles Sabel, “Flexible Specialization and the Re-Emergence of Regional Economies” in *Post-Fordism: A Reader Ash Amin, ed.* (Oxford: Blackwell Publishers, 1994).

producers and the social infrastructure on which they depend was a political outcome emerging amidst intense social conflict.[64] Of course the two stories, the early existence of efficient craft-styled production and the emergence of a new generation of craft companies, can be accurate.

The contribution of this original and narrow version of the flexible specialization story is substantial and several. First, a significant innovation in production and competition emerging in Italy and Germany was identified. Second, the character of the political and social process generating that production system was delineated. Third, more generally, Sabel's *Work and Politics*[65] argued persuasively that production systems were not inherently rooted in a technological structure, but rather a production system and institutions of a political economy more generally were created by conflict and rivalry. Fourth, the community, or more generally the sub-national region, not just the nation, is a significant actor in the stories of industrial development. In stronger versions of this argument, the case is made or implied that the emergence of "flexible specialization" has underpinned the growing *political* significance of the regions, while in other presentations communities politically suited to provide the infrastructure that "flexible specialization" requires breed this new brand of competitive strategy.

The evident question to pose to the arguments of the original, but narrower, version of the argument is how significant are these developments? We might define significance in terms of:

a) The percentage of production involved in flexible specialization. As we shall see in a moment this requires defining what is a firm or community of firms involved in flexible specialization. Whether smaller craft-styled firms have become a larger or more significant feature of the economy has been taken as one element of that debate. One question is whether pools of small start-ups, such as those in Silicon Valley, that with each generation of technological development produce new giants and in which the small start ups themselves are often spin-offs of giant firms, should be considered examples of flexibly specialized peer companies, or simply part of a different and equally interesting industrial dynamic.
b) Whether flexible specialization defines core terms of competition in a particular sector or is simply peripheral. For example General Motors and Toyota define the core features of the auto industry, not their second tier suppliers.

The original basic story identifies one of several roads to industrial development and responses to competitive markets in the last part of the twentieth century. This initial story which

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[63] Berger and Piore (1980).
[64] This story is most brilliantly told in Sabel's first and magnificent book, *Work and Politics*(supra). It is told again by Sabel and Piori in *The Second Industrial Divide* (New York: Basic Books, 1984), a lovely synthesis of the analysis and argumentation of these two talented scholars.
[65] Sabel, *Work and Politics.*

highlights the role in the new industrial competition of craft firms, that emphasizes that the forms of the market and political economy are political created and not simple unfolding of an interior technological logic, and which highlights regional/local institutions and community learning is to us a significant and substantial contribution. But the argument is pushed beyond these boundaries, both as an empirical claim and an analytic method. It is to the large case which we turn now.

2. To the Breaking Point? Stretching the Argument About Flexible Specialization[66]

The difficulty is that the concept has been so stretched that arguably anything could be counted as "flexible specialization" that is not traditional mass production but is adaptive to world markets involving flexible use of skill. Consequently the analytic and heuristic utility of the notion is diluted. The stretching occurs as the insights and concepts developed from the original cases are reformed to seek insight into new settings and to provide an optic on new questions. But in the process the notions are stretched to the breaking point. Our look at how and why that happens proceeds in three steps.

First, how do we decide what is or is not an instance of "flexible specialization"? The concept of "flexible specialization" was initially associated with observations of companies and districts in Italy, and then Germany, of small- and middle-sized firms that embodied craft skills, were grouped in communities that provided support through a range of institutions and mechanisms, were given life by at least a minimum of trust and cooperation among the firms, and had direct access as individual companies or as a community of companies to the final markets for their products. Hence this community of "craft peers" could stand independently in a global economy. Those products, to rephrase the definition, are customized, made by skilled adaptable workers using flexible general purpose machinery.[67]

But how do we decide what falls into and what does not fall into even such a restricted definition? Consider some cases: First, Cadence adapts scientific workstations (principally SunMicrosystem machines) to the task of designing semiconductors. The machines could be construed as general purpose, but their applications are very specific, and once tuned to those applications they could hardly be used efficiently to do mail processing which is another

[66] Even this broader and, in our view, flawed, argument has made a contribution. But because we believe it now presses debate into needless diversions, the difficulties need to be emphasized in order to advance the common purpose of understanding the evolution of advanced industrial economies in their multiple forms.

application of the same machines. Indeed, how flexible or how dedicated the machine is depends on how much money you pay to Cadence, which computer code and which form, to which a customer has access. What is the meaning of digital flexibility, and how does it correspond to notions of flexibility rooted in mechanical machines? The workers are certainly skilled, the source of technology is in Ph.D. training and is often highly mathematical in its conception. The core employees are skilled engineers or better. The entry level skill is rooted in formal training, not industry experience. Are Ph.D. and MA engineers too distant from the notion of skilled craft work to fit our category? The firm was founded by arch-rival companies from Japan and the United States to provide a set of tools none could afford on their own, but they hardly form a community and notions of trust do not characterize the relationships of the founders. Indeed, Cadence works because collaboration without trust was possible. Cadence, a startup, has benefited from Silicon Valley's set of business institutions that foster and support new ventures. Though once a start up it is now has a turn-over of (). Where should we place Cadence?

Second, indeed, the semiconductor industry itself is composed in the United States of probably two hundred firms, but vast bulk of the world market is controlled by the top 10 firms. Indeed, the direction and terms of competition of the industry is for the most part set by the large and dominant firms; the very terms of competition, and the exceptions to that, are likely to be on their way to becoming giants themselves. Those giants have a very firm division of conception and execution and the long runs associated with mass production. Intel, to take our title case, can build a billion dollar plant and amortize that plant in four months. That is very high volume. Phillips has recently proposed a new plant in England that should cost $1.5 billion. The rest of the firms are smaller players, significant because they represent technical and market threats to the established players. Indeed, most are efforts to parlay a particular skill--design or production—into a position of one of the enduring giants. From one vantage, the semiconductor industry is a world of flexible specialization. In our view, it is a whirlpool story of competition over design, standards, platforms, and networks with a core of giants and a periphery of would-be entrants and niche market players.[68] The connections for supply and production are as

[67] Hirst and Zeitlin, "Flexible Specialization."
[68] For the debate see Martin Kenney's arguments with Anna Lee Saxenian in her book *Regional Advantage: Culture and Competition in Silicon Valley and Route 128* (Cambridge, Mass: Harvard University Press, 1994).

powerful outside the region as within. Focusing on the loosely defined notions of "flexible specialization" or trying to pose Silicon Valley as a kind of high-tech Italy hides more from view than it reveals. Thus, importantly, how useful is it to group together into a single analytic category these smaller European craft-based firms and often very large knowledge firms rooted in the application of formal engineering or science?

Third, and the last of our examples, is the move of larger multi-nationals to adopt more flexible strategies.[69] The process of corporate reform to produce systems that look "in fact, like one of the small firm districts….with the difference that the service company rather than the municipality and employers associations provides the production units with whatever they cannot provide themselves."[70] Let us set aside the question of whether particular cases are accurate representations, or typical representations, of corporate competitive reform. Should we see a corporate core operation, of any sort, as simply another version of community social institutions? Are operating units of companies that own those operating units, or of contractors that are dominated by their large clients, usefully conceived as cousins to community operations of peers? Indeed, rather than forming a piece of a single community with its suppliers, the large firm often plays off different "industrial districts", if you will, against each other. Loyalty, as in the case of Toyota's ties to Johnson Controls' seat division in Europe and North America, is just as often to a large firm which in turn creates local operations. Choosing the small industrial region optic when characterizing the large firms may highlight commonalties, such as the use of skills, but hides and obscures the differences in power, strategy, community ties, and styles of operation that are distinctly different.

Ambiguity permits concept stretching. It is one matter to define the core elements of flexible specialization in order to point at empirical instances; it is another to specify them so clearly that we can decide which instances should be included in the group; and it is altogether a third, but equally important, matter to make sure the definition and the specification indicate clearly which instances should be left out. Until this is done it is hard to agree on what evidence emerges from the stories of given companies, industries, and regional groupings.

The study and discussion of flexible specialization pursues a variety of agendas, which in itself would seem to enrich the enterprise. However, the conflation of agendas often confuses

[69] Sabel, "Flexible Specialization."
[70] Sabel, "Flexible Specialization."

the question of evidence and argument. Those fascinated by "flexible specialization" have several fascinating intellectual agendas about which they are very clear. One agenda is to demonstrate both that "each social world contains a number of possibilities"[71] that often coexist in myriad blends and that the particular possibility that becomes dominant is the product of political and social development not some inherent efficiency or advantage. "Thus flexible specialization is concerned to rewrite history in order to show that the complexity of the past helps us to recognize that there are a variety of options in the present."[72] The power of the normative enterprise of demonstrating the empirical plausibility of a world that echoes of independent skilled craftsman has drawn many to the heuristic and empirical tasks. Now we are sympathetic to this enterprise of discovering possibility and share many of these analytic concerns about the political/social formation of industrial systems.[73] Historical work that shows that there appear to have been alternate roads of development in the past that were closed off by political or social choice is quite fascinating. Such historical case material cannot demonstrate the contra-factual argument that these principles of production could have constituted a fully blown industrial system nor that, for example, craft-based production could have sustained productivity development that was fast enough and broad enough to have truly given rise to an industrial society. Could a craft-based auto industry have emerged that drove productivity and provided transportation that was then within means of most of the population? If the sector is the wrong unit of analysis, since the auto as a dominant means of transport implies a particular approach to urban development and the policies to support it, then would that alternate industrial reality have been able to have provided the productivity increases across an economy that led to the American industrial miracle of the first half of the century? The contra factual enterprise by its nature can only provide hints of possibilities. Similarly, the discovery of aspects or elements of flexible specialization in Silicon Valley or Japan, if we are for a moment to accept the empirical characterizations, do constitute evidence that several forms of production may co-exist. They do not constitute evidence that the region or national system should be characterized as being flexibly specialized. It is plausible to contend that this "normative-empirical enterprise"

[71] Hirst and Zeitlin, "Flexible Specialization".
[72] Hirst and Zeitlin, "Flexible Specialization".
[73] See John Zysman, "How Institutions Create Historically Rooted Trajectories of Growth"; and Zysman, "Nations, Institutions, and Technological Development" *International Journal of Technology Management*, Vol.12 Nos.3/4, Special Issue, 1996.

is to be insulated from many forms of empirical challenge, since the purpose is to suggest possibilities and provide clues. But the converse must also be recognized; what serves as hints and clues of possibilities may not be rigorous enough or sturdy enough to constitute elements of data.

Similarly, "flexible specialization" is at once held out as an ideal type serving heuristic purposes but refusing empirical test, and as the basis of testable hypotheses about the character of industrial transformation. "Flexible specialization" is, thus, proposed as an ideal type whose appropriate measure is its "heuristic productivity" not its truth value. Hirst and Zeitlin write that "the appropriate criterion for the assessment of such ideal types is not their truth value but rather their heuristic productivity: how far does the conceptual framework of flexible specialization illuminate the observable processes of industrial change?" Again, as above, the result is that case material that is used to demonstrate the interest and utility of the ideal type becomes evidence of a particular kind of industrial transformation. The optic "flexible specialization" may identify interesting elements and insights in particular cases, but unless the ideal type is rigorously translated into deniable hypotheses—given precise operational research boundaries—those cases may not be useful for empirical tests. Hence hints and elements of flexible specialization suddenly become "empirical observations" or units of evidence that are accumulated as if they constituted a data set that could then provide evidence of a particular course of industrial development. Indeed, many of the cases labeled as evidence of "flexible specialization" are open to alternate interpretations and characterizations. When David Friedman, for example, finds a machine tool district in Japan he begins to characterize Japan as a misunderstood miracle, setting his community case against Chalmers Johnson's characterization of Japan. (Let us set aside the fact that Johnson's enormously provocative book consisted of an ideal type argument of the developmental state as introduction/conclusion and a history of MITI in the middle. That book, and the questions that ideal type compelled, would have to be judged enormously productive by the same criteria that the "flexible specialization" community would apply to itself.) Yet though fascinating and a useful reminder of the complexity of the Japanese development, Friedman's machine tool story itself steps around the powerful role of national policy in creating the Fujitsu Fanuc's Numerically Controlled Machine Tool controller as a standard that permitted the bevy of smaller firms and districts to specialize and thrive in the fashion Friedman describes. It avoids the role of national policy in creating a reserved market for Japanese producers both by excluding foreign competitors and by inducing demand among small- and middle-sized companies. If we are to consider his story as a piece of evidence in the empirical debate about the directions of production practice, we would not be willing on the basis of his evidence to characterize the Japanese machine tool industry as a whole as an instance of "flexible specialization" let alone the story of Japanese industrial development as a whole.

Let us characterize the difficulty. By asserting that the intellectual enterprise is largely heuristic and of a normative-empirical character, the argumentation surrounding "flexible specialization" shields itself from rigorous test. The problems emerge when the case material developed for these purposes is then redefined and becomes evidence in an empirical debate. Many of the cases and instances that emerge from this scholarship are fascinating in themselves as hints, often frustrating in our view by what they ignore or mischaracterize, but simply not acceptable as evidence for a general story.

Third, the use of the ideal type as a mechanism itself obscures possibilities. Just as the ideal types of "modern and traditional" locked Social Science into a debate about a single road from universal past to common present and thus hid the richer complexity of several paths from different pasts to distinct presents, the ideal type distinction between "mass production" and "flexible specialization" makes it harder to formulate the variety of trajectories of development. Barrington Moore's great and lasting achievement was to break apart that sterile debate and argue that the relation between landlord and peasant structured the processes of political and economic development so that they moved along separate paths to separate presents. Let us state the problem in a loose formalism. Using ideal types there is a tendency to argue that anything which has elements of Y and which is not X can be grouped as Y. Anything which is not "mass production" and has elements of what are seen as core components of "flexible specialization" should be taken into the set of "flexible specialization". Indeed, as we review many of the cases introduced in support of the "flexible specialization" insight, we conclude that while they contain elements of that ideal type or contain elements that are reminiscent of that type, the particular facts are often crammed into a mold of the "flexible specialization" side of a dichotomy. But perhaps, what is in front of us is neither Y nor X, but Z or B or C. Those other possibilities cannot, thus, be seen or identified. They are hidden by the methodology and multiple agendas of "flexible specialization". This is an ironic, and unfortunate, result for an enterprise that begins rooted in a commitment to display the variety and complexity of society and its past.

3. The original "flexible specialization" story thus defines one route to adaptation and adjustment in the world economy. The broader enterprise of demonstrating roads untravelled in the past and possibilities unexplored in the present is fascinating and intriguing. The heuristic tools suggest analogies to experiences elsewhere and certainly provide policy guidance to communities and regions seeking to advance their competitive position. The contributions of these efforts are substantial. But when the broader enterprise takes the ideal type as a possible future and uses clues and hints as hard evidence of that unfolding future, the "flexible specialization" enterprise becomes a set of blinders.

D. Where Do We Situate the "Wintelism" and CNPN Story

We don't intend here a systematic comparison, but rather a flavor of the difference in approach. "Wintelism" and CNPNs, rooted in the American industrial adaptation and policy choices, is a distinct national founded story with implications as a model and a basis of competition. Where lean production is largely concerned with the reorganization of volume production along new but still vertical principles of operation, "Wintelism" is concerned with the shift of competition and value-added away from assemblers in which the precise organization of production or firm structure of the particular component makers is a secondary matter. Technology itself certainly does not dictate organization of firms or production, but equally conceived in Romer's language as recipes, the recipe books of an electronics era are inherently different from the recipe books of a mechanical engineering era. It is the interplay of technological constraint and social process that is of concern. Thus, for instance, flexibility itself has different means in a digital rather than material construct. Small firms are often means of entry for new technologies and approaches into established markets, and hence the entrepreneurial start-up is the metaphor. Small firms are likely to grow large or remain peripheral niche players. Product functionality is often created by components and controlled by the component companies. Market control and product rents turn on standards and hence scale of use rather than scale of production, if you will, becomes decisive. The competition among de facto market created standards is essential. While the original "flexible specialization" concerned with the internal organization of the community as the basis of horizontal trust based relationships among peer companies, the cross national production story is about arms length relationships among firms from distinct communities that may be socially organized along very different lines. Thus the claim here is that another moment in industrial history is producing from a particular national base, once again American, new dynamics of competition that are best understood as Wintelist and Cross National Production.