Does Manufacturing Still Matter?
The Organizational Delinking of Production from Innovation

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Introduction

Evidence from the electronics industry suggests that a new American model of industry organization is emerging in the 1990s. American electronics firms are outsourcing an increasing share of their production. As this practice grows, manufacturing capacity is building up in *turnkey production networks* that consist of specialized and highly capable merchant suppliers that provide the industry with a functionally coherent set of commodified production services. When firms that supply external productive capacity develop a *merchant character*, as they have in the American-led electronics industry, manufacturing capacity is essentially shared by the industry as a whole, reducing costs and spreading risks in an increasingly volatile world market. As such merchant *external economies* develop, the link between innovative capacity and market share, on one hand, and firm size and scope, on the other, begins to break down. This link was the cornerstone of Schumpeter's conception of industry structure and his explanation for the rise of the large, vertically integrated industrial firm in the early part of the twentieth century.

Firms that outsource a large share of their manufacturing no longer have to carry the financial, administrative, and technical burdens of fixed capital related to production (i.e., plant and equipment), allowing them to focus on innovation and become more organizationally and geographically flexible. At the same time, such brand-name firms are no longer buffered from competitive pressure by large in-house fixed capital. Barriers to entry are lowered because competitors can tap the same turnkey production networks and therefore gain access to leading edge, global-scale production capacity (unless specific institutional constraints are present). Thus, for the innovating firm, competitive outcomes become more tightly tied to product-level innovation (i.e., product definition, development, and design) as productive capacity migrates into turnkey networks. At the industry level, turnkey production networks make it possible for market share to change hands without the idling of any productive capacity, mollifying the "destructive" aspect of innovation predicted in Schumpeter's conception of "creative destruction."

This paper explores the implications of the following hypothesis: that a significant share of American firms are adapting to volatile and intensely competitive market conditions by "outsourcing" manufacturing functions to specialized merchant suppliers. At the same time, "brand-name" firms have reasserted control over product definition, design, and marketing functions, which are largely being kept in-house, despite the spate of high-profile "strategic

alliances" formed in the 1990s. In essence, I argue that market-creating innovative capacity is being hoarded in-house while market-supplying productive capacity is being allowed to migrate into external economies that can be shared industry-wide. Such external scale economies are coming to reside in a cadre of specialized merchant suppliers that offer access to a *functionally coherent* set of production functions as a service to their customers, the brand name firms. The emerging organizational split between innovation and production is usually enabled by highly formalized links at the inter-firm boundary.

The hypothesis is derived from research on product-level electronics manufacturing (computers, communications equipment, consumer electronics, etc.), where such an organizational shift, from in-house to outsourced manufacturing, has been dramatic in recent years. However, even superficial observations strongly suggest that comparable changes are underway in many other sectors as well (e.g., apparel and footwear, toys, data processing, home furnishings and lighting, semiconductor fabrication, food processing, automotive parts, brewing, enterprise networking, and pharmaceuticals). The aim of this paper is not to prove that the shift is occurring in every American firm, or even to provide a detailed analysis of the changes in the electronics industry. I have presented the latter evidence more fully elsewhere (Sturgeon, 1990, 1991a, 1991b, 1992, 1997; Sturgeon and Cohen, 1996). Instead, the model of industry organization derived from the electronics case is exposed to one of the key theoretical tools that have been developed to predict and explain industry structure and economic development: Schumpeter's notion of innovation in the giant firm. It is my opinion that the emerging split between product-level innovation and production in American industry is clear enough to take the next step of testing, and perhaps modifying, the analytic tools that we currently have at our disposal.

1. From the Modern Corporation to Production Networks: A Paradigm Shift

Through the mid-1980s, the dominant paradigm for the study of industrial organization and economic development was the modern corporation as best defined by Chandler (1977). There was good reason for this focus. By the 1950s, the large multidivisional (and increasingly multinational) enterprise, with its extensive managerial hierarchy, had become an undeniable force in economic development, not only in its heartland, the United States, but also in other countries where its features were adopted as a model for local firms. Regardless of analytic stripe

(e.g., neoclassical, Weberian, Marxist), the large, multidivisional, hierarchically-controlled corporation provided a set of ordering assumptions for theorists interested in explaining its rise and inner logic (theories of the firm), as well as for those working on problems of economic development where the modern corporation played a central role, such as literature on the transnational corporation and development (e.g., Gershenkron, 1962; Vernon, 1966, Williamson, 1975, 1981, Perrow, 1981). For many, the archetype of the modern corporation that emerged from this work was held up as the pinnacle of capitalist development and for nearly all, the giant firm was recognized as the central force in economic development. As an ideal type, it was well understood, and it was assumed that firms would, over time, become closer to its image.

The work of Joseph Schumpeter too was deeply affected by the rise of the large corporation. Schumpeter's early work The Theory of Economic Development (1934), first published in German in 1911, focused on the role of the small-firm entrepreneur in driving innovation. Entrepreneurs continually create disequilibrium in existing capitalism through the formation of new firms in an environment of easy market entry. Schumpeter's later work recognized the empirical reality of the rise of the large firm in American industry during the first few decades of the twentieth century. By the time he wrote Capitalism, Socialism, and Democracy (1942), Schumpeter's focus had shifted from the innovative entrepreneur to innovation in the R&D laboratory, from tacit to codified knowledge, from low to high market entry barriers, and from small to large firms (Nelson and Winter, 1982; Malbera and Orsenigo, 1995). He argued that observable productivity increases in the American economy were largely due to innovations delivered by the R&D laboratories of large firms in an environment of high barriers to market entry (Schumpeter, 1942).

During the 1970s and 1980s, changes in the world economy, particularly the failure of large American corporations to adequately respond to new competition from Asia, cast doubt on ideas that used the modern corporation as an organizing principle, plunging a wide range of fields into crisis and triggering research into aspects of industrial organization that had previously been obscured.[1] Until the 1980s the shadow of the modern corporation had rendered

[1] Such paradigm shifts typically involve cycles of theoretical consensus and crisis. Periods of consensus allow for a flowering of theoretical work because effort shifts from *constructing* the "object of knowledge" (what and how) to theorizing *about* the object of knowledge (why and in whose interest). While such theoretical paradigms provide basis for debate by bringing some things into sharper focus, phenomena that do not fit the dominant model tend to be obscured. Periods of crisis arise when things that have been obscured, for one reason or another, are forced to the surface. What were "anomalies" under the old paradigm then become the building blocks of the new (Kuhn, 1970).

alternative organizational forms nearly invisible in the literature, but the faltering of some of the United States' largest manufacturing firms in the face of Asian competition signaled that something was very amiss with the modern corporation. The complacency that had set in over so much of thinking about industry organization and economic development began to unravel.

Thus began the search for a new model. Some revisited the work on periodic crisis and instability that had been triggered by the Great Depression (van Duijn, 1983), while others noted that many of the problems of the modern corporation could be traced to the emergence of powerful new competitors from Europe and Asia (Bluestone and Harrison, 1982), and set about analyzing industrial systems that did not fit the Anglo-American norm (Schonberger, 1982). Still others found pockets of economic vitality based on networks of small firms, and offered new models of industrial development based on their findings (Piore and Sabel, 1984). Much of this work suggested that the era of United States industrial hegemony had passed along with the modern corporation, and that new, more dynamic models of industrial organization were stepping into the breach (Liepetz, 1983).

After more than ten years of research and debate, the task of building a new paradigm for industrial organization and economic development is well underway, although consensus is still far from being reached. Some of what had been obscured has now come into view. The focus has shifted away from the logic and ramifications of the seemingly inexorable expansion of the *internal structures* of the modern corporation to the *external economies* created by the ongoing interactions between firms.

External economies have appeared in different guises in the literature, depending on the scale of analysis. At the most basic level of firm-to-firm contracting, external economies are created when one firm "outsources" or "sub-contracts" an activity that had previously been performed "in-house" to another firm. The totality of the external linkages created by contracting relationships in larger amalgams of firms have been described as "production networks." When such networks are spatially clustered, which they often are, they make up "agglomeration economies" that tend to be located in sector-specific "industrial districts." Ideas about the importance of external economies have come from a variety of academic disciplines. Sociologists and organizational theorists have provided ideas about how trust, reputation, and long-term "relational" contracting can create stable external economies that resist the apparent tendency for capital to aggregate within the ever-larger control hierarchies of the modern

corporation (Richardson, 1972; Thorelli, 1986; Johanson and Matson, 1987; Powell, 1987; Lorenz, 1988; Jarillo, 1988; Bradach and Eccles, 1989; Powell, 1990, 1991; Lorenz, 1992; Cooke and Morgan, 1993). Political scientists and country specialists have provided nationally specific models of industrial organization that rely extensively on external economies. These models have been derived from research on the industrial systems of Japan (Schonberger, 1982; Dore, 1986; Sayer, 1986; Aoki, 1987; Sako, 1989; Womack et. al., 1990; Florida and Kenny, 1993), Germany (Katzenstien, 1989; Sabel, 1989; Herrigel, 1993), and Italy (Brusco, 1982; Brusco and Sabel, 1983; Piore and Sabel, 1984; Brusco and Righi, 1989). Geographers and planners have provided insights into how the spatial and social propinquity of geographically clustered industrial activity work to buoy ongoing external economies (Storper and Scott, 1988; Storper and Christopherson, 1988; Scott, 1988; Storper and Walker, 1989; Saxenian, 1991, 1992, 1994).

Often these models have been constructed in an effort to explain why firms, industries, and national economies organized according to their tenets outperform industrial systems organized according to the Anglo-American norm. External economies allow for the development of trust; industry-, or at least locality-wide sharing of production capacity; greater opportunities for learning and technology transfer within the system; and perhaps most important, a superior ability to reconfigure the functional elements of production according to rapidly changing output requirements and the rise of new markets.

This work has generated a sorely needed set of alternatives to the paradigm of the modern corporation, but surprisingly, scant attention has been paid to the industrial organization of American manufacturing companies as they have begun to adapt to the new forms of competition that triggered the crisis.[2] Most often portrayed as desperately clinging to the outmoded attributes of the modern corporation (e.g., Harrison, 1994), American firms have been held up as the antithesis of new, more dynamic organizational forms that have emerged in Italy, Germany, and especially Japan.

The invisibility of American-led production networks in academic literature (but see Sabel, 1989; Donaghu and Bariff, 1991; Levy and Dunning, 1993; Gereffi, 1994; Bonacich et.

[2] There is an extensive literature on recent changes in the *internal* organization of American companies in response to new competition, including work reorganization (e.g., employee involvement and cross-training) and the flattening of corporate hierarchies (e.g., Kochan and Osterman, 1994; Florida and Kenny, 1993; Applebaum and Batt, 1994), though research on the effects of downsizing and outsourcing on internal organization is sorely lacking (Biewener, forthcoming).

al., 1994; Saxenian, 1994; and Borrus, 1995) may stem from their recent vintage. On the other hand, it also seems likely that some recent evidence of changes in the organizational characteristics of American firms has been misinterpreted because the system has not evolved in the image of Japanese, German, or Italian industry.

Today, more than twenty years after the crisis of the modern corporation began, we are seeing subtle but unmistakable evidence of recovery by American manufacturing firms. In the electronics industry, for example, dire predictions that American firms would continue to lose entire segments of the industry to foreign firms have proved unfounded. The continued dominance of many market sectors for electronic hardware by American firms has surprised observers who warned only a few years ago that Japanese electronics companies were poised to leverage their dominance in core components (e.g., memory chips and flat panel displays) into dominance of markets for high-volume computer-related hardware, just as had happened in consumer electronics (Hart and Borrus, 1992).

So, there are signs of life in the heartland of the modern corporation. Still, we cannot simply resurrect models of industrial organization based on the modern corporation as if nothing has happened. Even a cursory examination of the industrial system of the United States reveals organizational patterns that look not at all like the modern corporation (Tully, 1993, 1994). The largest single employer in the country is not General Motors, but the temporary employment agency Manpower Inc. The largest owner of passenger jets is not United Airlines, or any other major carrier, but the aircraft leasing arm of General Electric. Since 1992, IBM has literally turned itself inside-out, becoming a merchant provider of the basic technologies it had previously guarded so jealously for exclusive use in its own products. If what we see seems to have little relation to the ideal type of the modern corporation, there may be good reason. Perhaps the American industrial system has begun to adapt to the new, more intense competitive environment that triggered the crisis in the first place. Perhaps we are witnessing the emergence of a *new American model* of industrial organization, and not simply the crisis of the old.

2. Schumpeter's Notion of Innovation in the Giant Firm

Schumpeter believed that the stability provided by oligopolistic market structures created a better environment for industrial research. Large firms have the longevity and financial resources to build up the "knowledge base" required to apply scientific principles to ever more

complex innovative problems. As the importance of codified knowledge increased in the early twentieth century, barriers of entry were erected that reduced the role of small-firm entrepreneurs who tended to base their innovations on tacit knowledge.[3] In the context of monopoly theory, these ideas became known as the *Schumpetarian hypothesis:* "the claim that a market structure involving large firms with a considerable degree of market power is the price that society must pay for rapid technological advance" (Nelson and Winter, 1982, p. 278). In the long run, Schumpeter believed that oligopolistic market structures would inevitably be torn asunder by ongoing rounds of innovation, competition, and new market creation.

Nelson and Winter (1982) build on Schumpeter's conception of innovation as the motor of capitalist development in the construction of their theory of "evolutionary economics." To follow the biological metaphor of evolution used by Nelson and Winter, the development of the economy moves according to a "survival of the fittest" logic, with the likelihood of survival increasing with firm profitability. Profitability is determined by the effectiveness of company-specific routines (ways of doing things) that are passed on as the firm develops in the same manner that genes are passed on in biological systems. The "search" routines which firms apply to crisis situations (e.g., the need to respond to a competitor by developing an innovative new product) determines the likelihood of their survival as they adapt, or "mutate," in response to new situations.

Because successful firms tend to invest in additional productive capacity, the dynamic process of industrial evolution tends to create larger firms and more concentrated market structures over time (up to the point where market concentration begins to stifle competition and hence, innovation). Nelson and Winter devised computer simulations that produce these results, using the variables of aggressiveness of investment policies, realization of potential productivity gains, the degree of difficulty in imitating the firm's innovations, and how successful the firm's innovative efforts are. In the simulation where the value for the first variable, aggressiveness of investment policies, was assigned a high value, imitation was made more difficult, latent productivity was better realized, and as a result, industry structure showed markedly higher

[3] However, Schumpeter did not recognize, as Williamson (1975) does, that the internalization of production functions can lead to "information impactedness" (e.g., isolation from the state of the art) that can suppress innovation in the large firm. The literature on production networks stresses the superior environment for learning and cross-fertilization of ideas, and therefore innovation, provided by network forms of industry organization (Powell, 1990).

levels of concentration than in simulations where capital investments were suppressed (in the real world, a firm might restrain investment to restrict output growth and keep prices high).

The assumptions in this model point out the key problem with using the Schumpetarian approach to predict the evolution of industry organization. In this schema, firms tend to get larger over time because successful innovations lead to higher profits and greater investments in productive capacity that put them further ahead of their competitors. Aggressive capital investment becomes a barrier to entry for new and existing firms and as a result, firms become larger and market structure more concentrated over time. But what if we allow for the possibility that increases in market share can be organizationally *delinked* from increases in firm-specific capital investment? In the American electronics industry, for example, firms are increasingly relying on outside sources (i.e., contract manufacturers) for manufacturing capacity. If a firm successfully innovates (e.g., develops a personal computer with dramatically better price/performance characteristics than any existing competitor), it can quickly ramp up production through its contract manufacturers *without the lag or risk associated with building up internal capacity.* In the turnkey network market concentration may increase, but industry structure remains relatively disaggregated. Moreover, barriers to entry based on the holding of productive capacity by leading firms fail to develop.

3. Turnkey Contract Manufacturing in Electronics

In April, 1996, Apple Computer announced that it was selling its largest United States personal computer (PC) manufacturing facility in Fountain, Colorado to a little-known company called SCI Systems. Apple had just posted the largest quarterly loss in its history ($740M) and had narrowly avoided being taken over by Sun Microsystems, so it may not have been suprising that it was shedding some of its assets. What seemed strange about this deal was that, according to Apple management and industry pundits alike, Apple's troubles did not stem from poor demand, but from its inability to meet demand.[4]

[4] Apple's gambit to protect its market share against those companies offering PCs based on Microsoft's Windows operating system and Intel's x86 microprocessor architecture (known in the industry as "WINTEL") by offering cheaper, lower-performance machines backfired when customers flocked to Apple's higher-performance products instead. Apple's manufacturing operations were not nimble enough to make up for this poor forecasting by quickly increasing production of higher-end machines. The PC industry as a whole had grown 25% during 1995 and many key components, particularly memory chips, were in short supply. Orders for high-end machines went unfilled and low-end machines began piling up in inventories. The result was that Apple lost its already tenuous hold on some of its customers, who, unable to buy Apple machines with the capability of fully utilizing the industry's new "killer

Why would a company that is having trouble meeting demand sell one of its most important production facilities? One could easily imagine an effort to improve responsiveness and efficiency at existing facilities, but a move to decrease capacity at such a moment, on the face of it, seemed foolish. Did Apple plan to make up for the resulting loss in manufacturing capacity by expanding its remaining facilities in Ireland or Singapore, moving production to lower-cost offshore locations? A closer look at Apple's restructuring strategy and its partner in the deal, SCI, provides some answers to this puzzle and serves as a thumbnail sketch of the organizational sea-change that is currently underway in the electronics industry.

First, the sale to SCI did not mean that Apple computers would no longer be produced in the Colorado facility. On the contrary, the deal included a three-year agreement for SCI to continue to manufacture Apple products in the plant. SCI is the largest of an emerging cadre of specialized firms whose sole business is to provide electronics manufacturing services to the industry on a contract basis; accordingly, companies like SCI are known as "contract manufacturers." SCI had the right to use the plant's production lines to manufacture products for any of its other customers as well as Apple, which at the time included more than fifty firms including Hewlett Packard and IBM, companies that compete directly with Apple in the PC market. The majority of the five-year-old plant's 1,100 workers were to stay on as SCI employees.

So, Apple wasn't selling one of its U.S. plants to some burgeoning local electronics company and moving its own production offshore: it was contracting with SCI to continue to manufacture Apple products in Colorado. According to Apple CEO Gilbert Amelio, the company's strategy was to outsource production to companies such as SCI in order to reduce Apple's manufacturing overhead and inventory carrying costs while concentrating the company's resources more intensively on marketing and product design (Electronics Buyers News, 1996). As Kwok Lau, Apple's Director of operations put it, Apple was moving to a "variable cost position" *vis-à-vis* its manufacturing operations. This meant that more of the company's manufacturing assets were to be held by outside companies. Instead of using fixed assets, namely

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application," the World Wide Web, migrated to readily available, powerful, and relatively inexpensive WINTEL machines. By April 1996, Apple's share of the worldwide PC market had fallen to an all-time low of 5.8%, down from 7.7% in the first quarter of 1995. Apple's new CEO, Gilbert Amelio, who was brought in to address the crisis, instituted a three-track plan to revive Apple by targeting new product development on Internet and multimedia products, streamlining the company's crowded product line, and drastically restructuring its operations (e.g., by outsourcing its manufacturing, technical support services, and internal telecommunications system management to third party vendors) (San Francisco Chronicle, April 30 and August 14, 1996).

production facilities owned and operated by Apple, to manufacture computers and peripheral equipment bearing the Apple nameplate, the company was to use the production assets of specialized outside suppliers, such as SCI. After the sale, Apple was able to alter the volume of its production, upward or downward, on very short notice without installing or idling any of its own plants and equipment. Of particular interest to Apple's management was the improved "upside flexibility" (i.e., the ability to quickly ramp up production volumes to meet unexpected surges in demand) that the deal with SCI provided.[5]

Another oddity about the press reports surrounding SCI's acquisition of Apple's Fountain plant was the following statement by Fred Forsyth, Apple's senior vice president of worldwide operations: "By outsourcing the manufacturing activities of our Fountain site to a company of SCI System's size, experience, and broad business base, Apple has the opportunity to benefit from SCI System's economies of scale" (Apple Computer, 1996). Although SCI is a large company, it is less than a third the size of Apple. How could a company of SCI's size achieve greater manufacturing and component purchasing scale economies than a company whose market share in the PC industry has hovered between number one and three since the birth of the industry in the late 1970s? The answer lies in the fact that SCI's sole business is contract manufacturing. The company has no internal product development capacity. Its sales and marketing activities are limited to developing its business as a manufacturer of other firms' products. In fact, despite its size, and the fact that it manufactures no products under its own name, SCI's twenty world-wide plants may well contain more manufacturing capacity than any other single electronics firm.[6]

Was the Apple/SCI deal unusual? Certainly not. If anything, according to some industry watchers, some of Apple's problems stemmed from the fact that it had been too slow to "outsource" its manufacturing operations, even though nearly 50% of the company's manufacturing was already performed by contractors prior to the sale. By selling the Colorado facility to SCI, Amelio was simply placing Apple more completely on a bandwagon that was

[5] As recent events at Apple proved, inability to meet demand during an industry upturn is just as devastating in a fast-moving marketplace such as PCs as being stuck with excess capacity during an industry downturn.

[6] The manufacturing-specific business profile of SCI can be demonstrated by the following comparison. In 1995, SCI generated $1.8 billion in revenues while assembling 50 million circuit boards (devices which provide the functionality for all electronics products); Hewlett-Packard, a well known brand name company that had half of its 20 million circuit boards assembled by contractors in 1994, generated $20 billion in revenues. If SCI generated as much revenue per circuit board as Hewlett-Packard, it revenues would be $50B. By comparison IBM, one of the largest electronics firms in the world, generated $64B in 1994.

already well underway. Since the mid-1980s, and particularly in the 1990s, large and well-known American electronics companies such as Apple, IBM, NCR, Philips, ATT, Hewlett Packard, and DEC have been abandoning their internal manufacturing operations in droves and turning to contract manufacturers such as SCI to build their products. At the same time, many younger, faster growing electronics firms, many of them based in Silicon Valley, CA, have always used contract manufacturers; few have built internal manufacturing capacity even as they have grown (e.g., Sun Microsystems, Silicon Graphics, and Cisco Systems).

Increased outsourcing has created an unprecedented boom in contract manufacturing revenues. From 1988 to 1992 the sum of revenues generated by 1995's largest twenty contractors grew at an annual rate of 30.7%. Since 1992, however, revenue growth has been accelerating dramatically year by year: from 1992 to 1995, revenues grew 46.4% each year, with the fastest growth coming from 1994 to 1995, when revenues expanded 51.2% (see Figure and Table 1). At the time of this writing, the unprecedented growth in the industry is showing no sign of slowing down (for example, SCI's revenues grew 65% to more than $5.3B in calendar year 1996).

Revenue growth for contractors has come from several sources. First, the purchase of a customer's facility often includes at least short-term prospects for increased business as the contractor assumes responsibility for current and future production volumes. Besides increased volume, contractor's revenues have increased from component purchasing and the provision of new services. Increasingly contractors have been purchasing components for their customers in what is known in the industry as a "turnkey" contract. In this arrangement, the contractor essentially acts as a lender to its customers by purchasing and holding component inventories. Cash outlays are only recouped as finished products are delivered to the customer. Turnkey component buying increases the flow of capital through the contractor, driving up revenues and creating strong market linkages with component suppliers. Also, contractors have been vertically integrating in relation to their specialty, manufacturing. Besides basic electronics manufacturing processes, such as circuit board assembly, most contractors have added a range of back- and front-end services, such as process R&D, design for manufacturability, product-specific process development and documentation, various forms of testing, final product assembly, final packaging, software loading and document duplication, and shipping to distribution. Some contractors have added repair services, not only for products manufactured in their plants but by customer plants as well. The contractors that have grown the fastest have specialized in advanced

manufacturing processes, such as surface mount technology, which drive product miniaturization and performance forward.

Figure 1. Revenues; 1995's Top Twenty Contract Manufacturers, 1986-1995 (billions of current dollars)

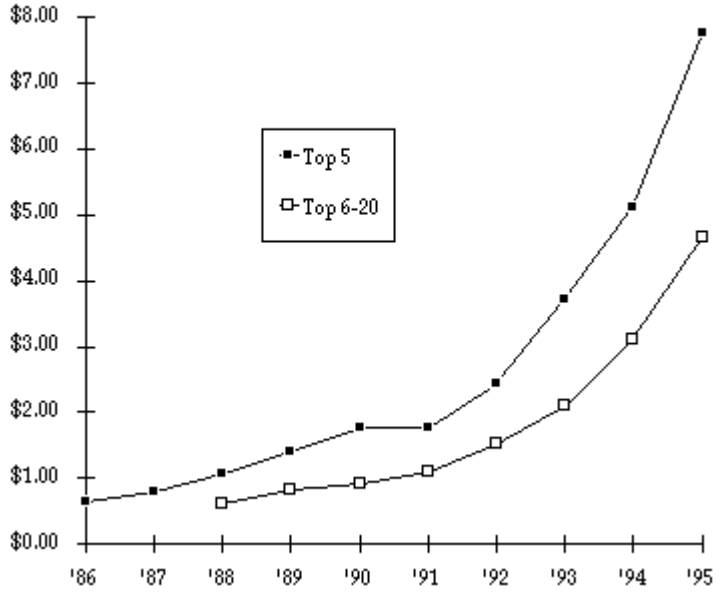


Table 1. Revenues; 1995's Top Twenty Contract Manufacturers, 1988-1995 (thousands of current dollars)

	CM Revenues (thousands of $)			Annual Average Growth Rates		
	'88	'92	'95	'88-'92	'92-'95	'94-'95
Top 5	1,077,366	2,433,127	7,772,792	24.4%	47.3%	51.9%
Top 6-20	606,000	1,534,200	4,672,382	49.1%	45.0%	50.0%
Top 20	1,683,366	3,967,327	12,445,174	30.7%	46.4%	51.2%

Source: Technology Forecasters, 1996. Note: Some data for years prior to 1994 in some companies in the 6-20 ranking are estimated. Calendar years are used where possible.

The Apple/SCI deal, then, can be seen as part of a larger shift in the way electronics production is being organized. The recent boom in contract manufacturing revenues highlights the fact that a basic shift is underway in the organizational fabric of the electronics industry. Production capacity is moving decisively out-of-house, where it can be shared by the industry as a whole. In general, the only firms that can justify making long-term investments in internal

manufacturing capacity are those with steadily growing high-volume demand profiles.[7] Given the ongoing dynamism and volatility that exists in the electronics industry, managers who believe they can count on such demand profiles are increasingly rare.

The evidence provided here suggests that American electronics firms are developing new ways of exerting substantial market power without the fixed costs of building and supporting a gigantic corporate organization. The strategy for brand-name systems firms is to outsource all of those functions that do not have direct relation to the establishment and maintenance of market power. Brand names, product definition and design, and marketing are being kept in-house, while manufacturing, logistics, distribution, and most support functions are being outsourced. Outside suppliers must provide necessary levels of technology, quality, and delivery, and be easily substitutable (i.e., operate in a *merchant* environment). When production networks are open in this way, external capacity is better pooled by the industry as a whole, and *external economies* are more likely to be the result.

4. The Delinking of Production from Innovation in the Turnkey Network

Nelson and Winter, like Schumpeter, did not conceive of organizational innovations that would allow for such a delinking of investment in plants and equipment from product-level innovation and market-share growth. At the industry level, turnkey production networks make it possible for market share to change hands without the idling of any productive capacity, mollifying the "destructive" aspect of innovation predicted in Schumpeter's concept of "creative destruction." The contract manufacturers, as long as they are not tied too tightly to any single customer, simply apply more of their manufacturing capacity to the firm that has gained market share, while scaling back (or increasing more slowly) the production of products for the firm(s) that have lost market share. Barriers to entry are reduced and markets remain more fluid because gains in market share are not necessarily associated with large increases in the size of firms. The model moves closer to the Marshallian norm in that barriers to entry are low, as long as suppliers

[7] For example, two firms that have held unusually stable positions as market share leaders in their respective sub-industry sectors, Compaq Computer (PCs) and Seagate Technology (disk drives) have recently expanded their internal production capacity. In February 1994 Compaq announced that it would invest $20 million to add seven new manufacturing lines for desktop and portable PCs at its operations in Houston (EDGE, 1994). In June 1996 Seagate announced that it was building a $19M printed circuit board assembly plant in Malaysia to support its existing disk manufacturing operations in Singapore and Indonesia (San Francisco Chronicle, June 4, 1996). On the whole, however, brand name electronics firms are leaving such investments to contract manufacturers.

offer their production services widely (i.e., according to the merchant model), and limit dependence on any single customer.

Innovation, in this system, has been freed from the shackles of large-scale capital investment, allowing the innovating firm's resources to be more tightly focused on the ongoing process of new product development. On the other hand, the market positions of dominant firms are not protected by large-scale, firm-specific investments in plants and equipment, making market penetration more feasible. For example, Cisco Systems, an innovative Silicon Valley-based company that designs and sells high-performance switches for data communications, has gained a wide market share lead without building any internal manufacturing capacity, depending instead on a world-wide network of highly proficient contract manufacturers for all of its output. If, however, another firm develops a faster and cheaper switch, Cisco's contract manufacturers would certainly be willing and able to build them. In the turnkey production network environment, successful innovation does not necessarily lead to the giant corporation.

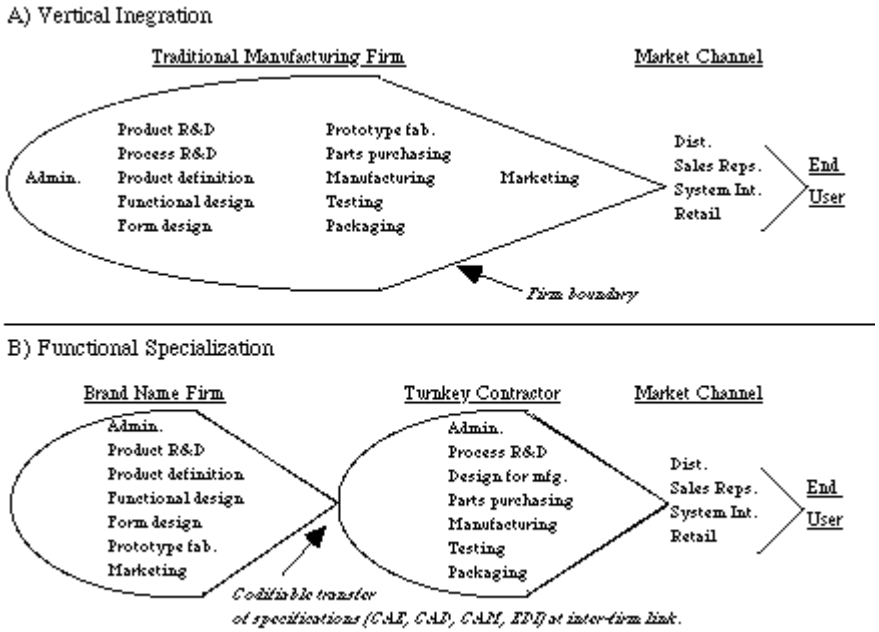
The proposition that innovation can be effectively separated from manufacturing investment may be surprising for some. The growing split between innovation and production in the electronics industry seems to contradict recent literature that argues for tighter coordination between design and manufacturing (e.g., Florida and Kenny, 1991). But as the electronics industry has evolved, certain kinds of knowledge have become increasingly codified. International standard setting bodies (e.g., the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC)) have emerged to help develop industry-wide classification and specification of components and processes. Increasingly, electronics firms are using information technology to communicate across the firm boundary using these standard classification systems as a basis. For example, firms are increasing their use of data communications technology to pass computer aided engineering and design files to compatible computer- aided manufacturing systems on the factory floor. Components with exact specifications can be located and purchased with electronic purchasing systems. The result is a highly formalized link at the inter-firm boundary, as depicted in Figure 2.

In the turnkey network, suppliers tend to focus their business on *functionally coherent* sets of production activities that have wide application in the industry in which they operate (i.e., low asset specificity, highly codifiable transactions, standard nomenclatures), making the act of switching to new customers easier. As a way to broaden their market and reduce their risk,

turnkey suppliers tend to focus on process-specific *base processes* that cut across specific firms and product categories such as food processing, metal machining, semiconductor manufacturing, circuit board assembly, and brewing; rather than on processes that are idiosyncratic or highly customer-specific. Turnkey suppliers, then, tend to be *functionally specialized.* However, within the parameters of the base process, product variation can be very large. Most of the contract manufacturers in the sectors mentioned above use highly automated manufacturing systems (apparel assembly (i.e., sewing) is a major exception) that can be programmed to produce a wide variety of products.

Figure 2 presents a conceptual map of the shift from the vertically-integrated organizational form of the modern corporation to the functionally specialized form of the turnkey production network. Note that R&D remains a vital function for each firm in the turnkey network, where it is functionally specialized into product and process applications.

Figure 2. The Shift from Vertical Integration to Functional Specialization: The Rise of the Turnkey Network



5. Conclusion

In all of his work, Schumpeter offered a powerful dynamic vision of capitalist development that was derived from Marx; he saw that capitalist firms endogenously created, in

many respects, the environment that would condition their future development. Innovation was the driving force in Schumpeter's conception of economic change; it could be deployed through any of five strategies: new products, processes, markets, transportation technologies, and/or approaches to industry organization. This last possibility, the ability to use innovative approaches to industry organization as a competitive tool, is especially important for the case study of this paper, since this is exactly the approach currently being applied by the American electronics industry. It is this last entry, organization, that provides the link between Schumpeter and recent literature on the performance advantages of external economies, outsourcing, and production networks.[8]

However, seen from the perspective of the late twentieth century, it is clear that Schumpeter's conception of which organizational strategies might be effective was too narrow. His focus on the organizational strategy of vertical and horizontal integration and ever increasing firm size is understandable given the industrial structure that was on the rise at the time of his writing, but today a wider range of organizational possibilities should be recognized. At the same time, Schumpeter was right that industry organization can be deployed *as a strategy in its own right* and is not simply a function of other strategies, as Chandler would have it. This paper seeks to help revive industry organization to its rightful place alongside other tools of capitalist competition. Industry organization, the social division of labor, if you will, has been and is now a central force in capitalist development (Sayer and Walker, 1993).

[8] The idea that innovative approaches to industry organization as a competitive tool is one of the things that sets Schumpeter apart from Chandler, whose work focuses on the first four entries to Schumpeter's list of possible innovative strategies. Chandler (1962, 1977), in contrast to Schumpeter, sees industry organization (expressed in his case by increasing internal organization as firms expand their scope of operations) as falling automatically from the strategies related to new products, processes, markets, and transportation technologies. As a way to simplify their model, Nelson and Winter consciously avoid assigning any causal significance to firm-level organization, instead choosing to revisit the territory of the monopoly theorists (e.g., Chamberlin, 1933) by focusing on industry (a.k.a., market) structure. "Largely in the interests of establishing an understandable linkage between individual firm behavior and industry structure, our formal models in this book suppress considerations of internal structure and organizational change" (Nelson and Winter, 1982, p. 38). The choice weakens Nelson and Winter's model considerably and represents a significant break with Schumpeter.

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