From Failure to Fortune? European Electronics in the Changing World Economy

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I. Introduction

As the balance of industrial power in the world shifted during the 1980s, Europe began to reshape itself, to reconsider its position in the world economy and how to improve it. Throughout the 1980s, European governments and the European Commission sought to help their corporations establish or improve their position in global markets. Programs for promoting industries aimed not only to revitalize the European economy but also to help recast the political and industrial bargain that underpins the European Community.

The policies of the European national governments and the European Commission focused in particular on developing and promoting the electronics industry during the 1980s.[1] European policies in this article refer to the policies of both Community, in the form of the initiative that created and emerged from DGXIII, and from the national governments. The two sets of policies cannot be easily separated, and certainly cannot be differentiated in these pages.

The reasons for the focus on electronics are as numerous as they are obvious. The electronics industry generates transformative technologies which touch a broad range of economic activities; its development is central to the competitive position of firms in most industries.[2] The industry now approaches automobiles in output and employment, and continues to grow rapidly. The electronics sector has also come to symbolize the foundation of advanced industry in the late twentieth century.[3] The sector's importance, both real and symbolic, makes it an excellent lens through which to view Europe's past and present industrial strategies, its successes and failures, and the challenges ahead.

The European policies -- both those of the governments and the Commission -- developed in the 1980's for the electronics sector, whatever their political benefits, did not lead to industrial success.[4] In the most visible sectors European electronics firms remain weak. Indeed, there have been several dramatic competitive collapses, including the down-sizing of Philips, the several crises at Bull, and the purchase of ICL by Fujitsu.

Three Commission and national government policy choices plagued the European electronics industry in the 1980s. First, government funding of large, national firms tended to push those firms into established and highly competitive market segments; indeed, this was often the intent of the policy.[5] Most spending supported the existing producers along identifiable technological trajectories and for usually unimaginative competitive strategies. Little wonder the firms found

it hard to establish defensible market positions; their governments pushed them into strategically difficult situations. Second, favoring producers over low prices and easy access for industrial users discouraged widespread diffusion of advanced technologies among sophisticated users -- the essential ingredient for creating launch markets for innovative products and entrepreneurial firms to serve them.

Third, European policy makers sought to locate production of key technologies in Europe. One objective was to maintain employment and healthy trade balances. A second objective was to increase technology transfer by forcing foreign firms to locate production within Europe to gain market access. The French government and some in Brussels believed that the Japanese advantage would be blunted if they had to produce in Europe with European labor practices and wage/overhead costs. Or at least Europe would be in a position to channel some of the Japanese advantage into their own industry by forcing technology transfer. If the European governments were right and could buy time for adjustment, European-owned production could be sustained. If they were wrong, at least jobs would be retained and technology transferred; local suppliers would learn from working with Japanese firms; local R&D would build up fonts of knowledge and technology. Europe therefore ended up with a policy that essentially traded imports for foreign direct investment (FDI); that is, Europe discouraged imports but tolerated and often "directed" FDI.[6] The policy worked on its own terms. By the end of the 1980s, motivated by fears of being locked out of "Fortress Europe", both U.S. and Japanese electronics firms made substantial direct investments to establish production, distribution and even R&D, in Europe.[7] It is too early to tell which (if any) of its various goals Europe's FDI strategy will achieve; but in the short term, the strategy only exacerbated both of the problems which the first two policy choices (i.e., pushing established producers into highly contested markets and ignoring users) had failed to solve. The increased presence of U.S. and Japanese producers created even more competition to European firms in established market segments.

In short, things did not work out quite as the Commission and European governments planned. The lesson of the past decade is that neither policies of promotion (such as the HDTV undertaking) nor policies of protection (that encouraged FDI) served to preserve the position of established European producers in their own markets, let alone improve their overall position in global markets.

European corporate leaders and policy makers now wonder whether they can succeed where they failed in the 1980s: that is, can they create a competitive electronics industry? In this article we will consider the nature of the challenges now facing this sector, and how European policy might address them. To understand these challenges we must first turn to the broad transformations occurring in the international economy.

II. Regional Politics in a Global Economy

Though the world may be "globalizing," it still has a geography.[8] The economic world is slowly dividing into three powerful trading groups: Asia, North America and Europe.[9] These three groups together constitute close to 70 percent of global GDP, with the U.S. and European shares each at about a quarter of global GDP, and Asia's share growing very rapidly.[10] Contrary to the common perception that trade is spread widely among the nations of these regions, a large part of trade takes place only within the regions. For example, inter-regional trade makes up only a small part of GDP of the Asian and European regions. For America, foreign trade as a part of the GDP has grown in the last quarter century, but Canada and Mexico still are its first and third largest trade partners respectively. Or consider the pattern of trade growth: trade within Europe has long been growing more rapidly than external trade; trade within Asia since the second half of the 1980s has likewise grown faster than trade with other regions.[11] In fact, as we look at these three regions, what is surprising is not the extent of trade connecting the regions, but the persistence of regional autonomy despite it.

Trade relationships among the regions are very different. Overall, the trade relation between the United States and Europe is remarkably balanced, despite the ever-flaring trade wars over chicken or soy beans, or the debates over aircraft subsidies and public procurement. A quick glance at the trade numbers suggests not only an enduring, healthy trade balance, but that the trade flows have responded to exchange rate changes. As the United States turns inward to its own economic regeneration and Europe to its political as well as economic reorganization, there is certainly a risk that domestic preoccupations of each will give particular squabbles some general significance and undermine fundamentally balanced relationship. But the balanced trade relation between the US and Europe is very different in character from the balance between Asia on the one hand and Europe or the US on the other. Both American and European trade with Asia is growing very rapidly. But both Europe and the US massively import from Asia while

their export and investment positions in Asia are remarkably limited. Of course, all of Asia has a deficit with Japan, as Japanese components and subsystems are assembled throughout Asia into final product for export out of the region.[12] The entrenched export surpluses -- those directly between Japan and Europe/America, and indirectly through other Asian exporters -- generate a more fundamental structural problem that expresses itself as a series of bilateral quarrels and makes the international trading system unstable. In our view, the objectives of multilateralism are ultimately at risk.

Trade is certainly not the only activity that connects the regions. Consider the often talked-about multinational corporations and financial institutions. Though these firms roam the globe, each has a home-- a country that necessarily shapes it character and both constrains and directs its choices.[13] Each "home" has a distinct industrial and technological base and a developed "domestic" regional market. Economic strategies and responses to new competition are generated within particular places, rather than by world corporations that stand outside a home base. Multinational corporations may someday be able to act without national constraint, but not yet. There may be a more global international economy, but that does not end the importance of place--community, district, nation, or region.

Foreign direct investment (FDI) also reveals patterns of regionalization in the world economy. FDI grew much faster than world trade between 1983 and 1989, expanding at a rate of almost 30 percent compared to under 10 percent for world exports.[14] Roughly 80 percent of the flows during this period took place among the advanced industrialized countries, suggesting simple integration. But if we look closer, a regional pattern reemerges. As Sylvia Ostrey notes, "a significant aspect of the 1980s FDI wave is what appears to be the emergence of regional strategies by the triad's MNCs, leading to the likely formation of investment blocs and thereby also hastening intra-regional trade integration. The clustering pattern which is emerging among the countries shows each region dominated by investment from a single triad member: the Americas by the United States; Asia by Japan; and Eastern Europe as well as selected African countries by the EC."[15] That is, the transnational corporate investment flows are themselves shaping three global regions.

FDI influences much more than simple ownership or corporate position in several markets. FDI powerfully drives trade as well. FDI is not just a substitute for trade in which cars or VCRs

that were once produced in Japanese factories or American factories are now produced in European factories. Rather FDI opens up a wedge which often expands trade as subsystems and production equipment are shipped from the home country of investing corporations to the host country where production subsequently takes place.[16] Majority controlled FDI is an impetus to exports from the home country of the investor. And in some places like Japan**,** minority foreign investment stimulates exports from the host country as foreign firms buy into a source of product.[17] Consider, for example, Chrysler's original investment in Mitsubishi as a means of obtaining models to fill out its product range in the United States.

In sum, patterns of trade, finance, and FDI indicate that three regional groups are emerging. Whether or not the three economic groups come to constitute rival blocs will depend on politics within each group and the politics of their economic relations. But even if the regions do not evolve into regional blocs, the emerging economic geography will powerfully influence each region's strategies to maintain competitive industries and develop the technologies necessary to support their growth.

III. Technology vs. Applications Skills: What Strategy for European Electronics?

If the world economy conformed to the popular image of symmetrically interdependent globalization, there might be no need for detailed European electronics policies. In that world, technology would flow rapidly across national boarders and regional boundaries. Europe's size and wealth would ensure that a significant proportion of advanced activities occurred there. But the reality of asymmetrical regionalization implies something entirely different. Technology will not necessarily flow smoothly between the regions, and in particular, from Asia to Europe. There is no guarantee that relevant technologies will be available in a timely fashion within Europe's boarders. Local technological capabilities will need to be nurtured within Europe if only to ensure that European countries and companies can bargain on strong terms for access to markets, technologies and investment opportunities in the other regions. Europe's size and wealth will continue to depend principally upon developments *within* Europe.

What, then, should Europe do in electronics? The answer turns on the role that technologies play in industrial competitiveness. There are two extreme views. Each leads to different policy choices. The first focuses on applications expertise, the second on development and production know-how.

Proponents of the first view argue that while production and employment in a growing sector is important, it is the capacity to apply the new technologies that is ultimately decisive in international competition. In their view, Europe must first and foremost be able to effectively absorb, diffuse, and apply these technologies. The kind of capacities that enable an economy to absorb, diffuse, and apply technology are if not broader and deeper than the capacities required to produce the technology, certainly more difficult to create and maintain.[18] But if we adopt this vantage, evaluating the precise technology position of a nation becomes very difficult. How can one measure, evaluate, and quantify the mechanisms that allow timely and efficient application of innovative technology, for example?

In this first view, a country (or a region) need not be a major producer of electronic or other advanced technologies to sustain a competitive position; new technologies will always be readily available in the market and can be bought, albeit at a somewhat higher price under some circumstances. A country or a region must only be able to apply quickly and effectively these technologies to remain in a strong position. Thus, producers of Danish hearing aids and Italian music boxes can compete effectively based on their sophisticated applications know-how if they are assured access to microelectronics technology.

The competing view, and really the dominant view in most European discussions, is that only an intimate knowledge of the most advanced products permits timely flow of technology and intermediate product into final product. In this case, the reality of a regionalizing world figures prominently. Intimate knowledge could only come from local production and local R&D, or might even require local development, production, and ownership. For example, a strength in consumer electronics or computer aided design (CAD) tools would require early command of advanced component technologies. In turn, advanced electronic products would increasingly turn on CAD tools and the components that go into consumer products. The French socialist notion of technological *filieres,* strands of technological development in which the different activities or steps in production are inextricably interconnected, represents the most extreme version of this concept. The extreme versions of the argument for domestically located intimate knowledge should not discredit the general observation that different production steps do depend on each other. Europe's dilemma is that American and Japanese firms, not indigenous European producers, are the primary source of advanced electronics technology. Broadly speaking, a firm's technology supply base constrains its strategy. Consequently that dependence on foreign

suppliers raises concerns about both political autonomy and constraints on economic development.

European governments continually ask themselves how they should manage this dependence. Should Europe willingly accept imports to maintain lower prices, or should it restrain imports to encourage local producers -- even if that involves penalties for the users who would employ the products? Or instead, should foreign producers be encouraged to develop and make products in Europe to assure closer links between foreign producers and European suppliers and to encourage technology transfer? If the foreign firm only wholesales commodity products or produces standard products largely from imported components in automated factories, then there will be limited technology transfer or learning within the home industry. The same would be true, of course, if a national firm merely assembled imported technological parts. Even if the foreign firms conduct local R&D, that may not be sufficient to assure technology transfer. The projects undertaken may be so narrow and specific to particular products that the host country's broader technology competence is not nurtured.

Theoretical arguments alone cannot resolve this matter. In practice, the country's composition of electronics production, the types of final products and firms' market strategies determine what access to emerging technology is required for them to be competitive. On balance, European governments have reluctantly and nervously accepted foreign substitutes for local production when there is no alternative, but have paid very high prices to support the market entry or re-entry of local producers.

The two vantages outlined above are complements. The first emphasizes applications know-how while downplaying concerns about foreign supplies of technology and focusing on users. The other emphasizes the need for intimate access to rapidly evolving cutting edge technology and focuses on producers. It is vexing that, depending on the circumstances, the prescriptions of either view may be correct. Consequently, the appropriate policy balance (between emphasizing user application, diffusion and the creation of sophisticated markets, on the one hand, or promoting directly the development of particular products, technologies, or supplier firms on the other) is very difficult to specify and will be even harder to implement.

Can we proceed further in answering when governments or companies that have become dependent on suppliers in another country, particularly another region, should be concerned? The terms on which technologies are available becomes the critical issue. The concepts of an

industrial and technological "supply base" and the "architecture" of that supply base can help. Borrus defines the supply base as:

> The parts, components, subsystems, materials and equipment technologies available for new products and process development, as well as the structure of relations among the firms that supply and use these elements. The supply base shapes the possibilities confronting users by enabling or deterring access to appropriate technologies in a timely fashion at a reasonable price.[19]

Logically, supply bases act as a structural constraint on individual company choices. In this sense a supply base regulates firm choices in the same manner as the structure of an industry, as a set of constraints or opportunities. The supply base can be understood as an element of industrial structure or organization external to the firm that defines the choices of the firm.[20] The supply base describes the technologies -- the parts, components, subsystems, materials and equipment technologies -- necessary for product development and production in a range of activities, and describes their interconnections. A supply base consists of a set of inter-related activities; when they are tightly linked (i.e. mutually dependent and reinforcing) they constitute a development bloc.[21]

The concept has intuitive appeal. It does not identify which of those elements or activities are critical to assure production or to create competitive advantage and profit. It does not show us precisely where value is added and what positions are competitively defensible. That can only be determined by a separate, competitive analysis of an individual industry and of its firms' strategies; that is, by an analysis of the terms on which a given industry's firms compete and create advantage.

The strength of the supply base concept, however, is that it allows us to see how distinct sets of technologies develop in a region or a nation, and how access to those technologies then becomes a pressing issue for firms and governments. For example, most of the hardware elements of the new electronics supply base are emerging in Asia, whichever measures and definitions we might use. We must ask: what access will American and European companies, firms with homes outside the region, have to these technologies? Variations in market and institutional arrangements permit us to make systematic distinctions in the accessibility of technology supply bases. A market consisting of many "flexibly specialized" small firms all in shifting horizontal relations, each supplying components and know-how to one another, has a very different architecture from a market in which concentrated suppliers compete with their

customers (the latter describes the vertically arranged Japanese *keiretsu* in which component suppliers also produce the final product).

The architecture of supply is a tool for helping firms and governments judge when dependency is acceptable or dangerous, and how to proceed in either case. Borrus argues they must worry about their supply sources when:

> When suppliers have the ability to exercise market power or to act in concert to control technology flows, or when markets and technologies are not accessible because of trade (and investment) protection, then the architecture of supply can significantly constrain competitive adjustment to the disadvantage of domestic industry. Such an architecture is emerging today. . . A small number of foreign suppliers, principally Japanese, are more and more driving the development costs, quality, and manufacture of the technological inputs critical to all manufacturers.[22]

For Europe, the question thus becomes: how is access to the supply bases of high technology changing? Today, most of the electronics technologies crucial to Europe have their home base in the United States and Asia. Our American preoccupation with the Asian supply base must not obscure for us Europe's concern with its dependence on American suppliers of components and subsystems. IBM, after all, not long ago defined for the computer industry proprietary standards and indeed the very trajectory of its development. And not so long ago American companies firmly controlled the components segments of these industries. However, the rise of Japanese competitors to the top ranks of the industry, the expansion of the Asian supply base, and the changing character of the electronics industry changes Europe's problem. Now, one might argue, dependence on America can be offset by Asian sources. But American component suppliers were usually not in competition with their European customers, and product technology was relatively accessible. With an increasingly Asian (usually Japanese) supply base, suppliers do compete with their customers in a wide range of products.

To better pose the European problem, let us return to three distinct economic regions of Europe, North America, and a Japan-centered Asia.[23] Each has, in fact, its own regional supply base with different capacities and dependencies on other regions.

A critical issue for corporate strategy and government policy then becomes how these three supply bases are linked together; that is, how technology flows among the regions.[24] Technology flows can become strategic. We must, of course, distinguish between *scientific knowledge*, formal and more specifiable, and *technological knowledge*, more implicit and less

easily specified, noting that flows of scientific knowledge are much more open and much more international. Let us specify four mechanisms of technology flow. First, industry technology flows through communities. Such technological communities are inherently more local and national than international. Second, technology can flow through markets. Computers, micro-processors, robots, plastic materials all embody technology. technological know-how is transferred with the sale of product or license. But national markets are often protected, and the flows of technology through products is distorted. Not all buyers have equal access; local buyers are likely to have some initial advantage. This is particularly important when production and design supply bases are in the same region as launch markets for innovative products, as is now the case in Asia for electronics. Launch markets are where innovative products are first sold. There, the demand is not only greatest; there firms usually find the technology required to design and make advanced products. Outsiders will have to develop new products with technologies sourced away from home and may even have to launch them in markets away from home.

The third mechanism of technology flow is the multinational corporation. These firms may act as bees sampling pollen in each of the three regions. But they are likely to make honey at home base, keeping the real expertise and markets in their domestic base. Many of the recent international technology deals and alliances between companies reflect different corporate capacities, capacities that differ because of their distinct home supply base. The fourth mechanism of flow is corporate networks. Increasingly, companies are developing long-standing arrangements among themselves, a trend which may or may not offset the tendency toward giant corporations. These arrangements are seen as new kinds of networks, developed to respond to an era of rapid technological change, product development, and market evolution. They can take several forms: supplier networks, which include subcontracting, OEM or ODM arrangements, and procurement of intermediate inputs; production networks; customer networks; and technology networks.[25] Managing these networks can prove to be a strategic weapon by providing early access to, and influence of, key technologies.

If a firm does not have a technology, it can: (1) develop technology in house (hierarchies); (2) buy on the open market (markets); and (3) team up with others (joint ventures and networks). The circumstances in which each has advantages have been widely discussed. First, in-house projects are needed for proprietary technologies critical to a particular companies. But accumulating knowledge exclusively through internal investment is neither desirable, due to the inefficiencies of hierarchy, or

feasible, due to the limitation on resources. Second, markets are attractive means of assuring access to commodity products. Third, alliances may be attractive for projects that are too expensive or that require technologies not under a firm's control. When to adopt which tactics? A firm must assess its own technological capabilities, the capabilities and position of its competitors, and must ask questions such as: (1) could the firm become dependent on outside sources for critical technologies by alliances or procurement and thus unable to sustain product or production advantage -- that is, does it undermine its own critical capacities; (2) will the firm transfer technology to competitors by joint deals; (3) can the firm, by contrast, learn critical new technologies from a partner.[26]

Should regionalization of the global economy change a company's decision? Implicitly, one issue is whether the risks of cross-regional sourcing of components, subsystems, or production services in the form of contract manufacturing are greater than obtaining them within the region. Networks concentrated in particular regions may better serve firms with that region as home base in the delicate problems of technology development, technology protection, and technology transfer. An "outsider" may be disadvantaged.

There are no general rules that can guide decisions for companies and government about when to buy or develop and on what terms. But the objectives of a national and corporate technology policy can be made clear. The objectives must at a minimum be access and access on a timely basis on terms at least equal to one's competitors.

With these concerns, let us return to the European electronics industry. For much of high volume digital electronics as well as the mechatronics and mechanical components that support final product, the core supply base is in Asia and is dominated by Japanese firms. Companies in Europe and the US often find that these networks in the supply base are closely linked to their competitors.

There are two significant implications for Europe from the discussion so far. First, the character and sophistication of the market for final products is critical. The market itself is an instrument of industrial policy, perhaps the most powerful one available to a government. A highly sophisticated market will induce producers to respond innovatively. An immature market is a handicap for local producers. So, ironically, protection for producers which serves to limit the development of the market may ultimately serve to undermine, not promote, the industry. The second implication for Europe is that the competitive position of national or regional producers of particular products may not be the central question. Crucial issues are the character

of the regional supply base, the access to supply bases outside of Europe, and the ability to apply technology and combine components into systems whether those technologies are initially developed in Europe or not.

IV. Weaknesses in European Electronics

Before considering how Europe might reformulate its policy we must briefly overview the industry as a whole, not just a discussion of one or two sectors. In the presentation that follows we move from areas of clear European weakness that have been the focus of policy debate to areas of potential strength that should be the basis of any rebuilding strategy. Several themes will emerge in the overview. One, common to all the sectors, with very few exceptions, is the virtual absence of a European presence in the Japanese market. Another is Europe's tendency to eschew niche markets where competitive advantage might be created in favor of policies to promote producer positions in internationally significant segments. This tendency has prevented European firms from defining their own strengths.

Semiconductors

The semiconductor sector is the most evident area of European weakness. Europe represents only 20 percent of the world market for semiconductors, compared to 26.6 percent for the United States and 36 percent for Japan. In part, that difference in use of semiconductors reflects Japanese and American exports of equipment embedding components to Europe, but more importantly it reflects very low overall *use* of electronics by Europe. As a consequence, European producers in 1991 held only 10 percent of world semiconductor production compared to 38.4 percent for the United States and 46.4 percent for Japan. The European producers hold less than 40 percent of their own market. More than 30 percent of European use is supplied by foreign companies manufacturing in Europe. The rest is provided by imports. The trade deficit in active components was 4.15G$ in 1990.

The European market weakness is even deeper than these aggregate figures suggest. There are no robust European producers and Europe does not have an entrenched position in any segment of the sector. Consider commodity memories, which are standard and depend on production skill. In DRAM memory products that drive the advancing edge of process technology, only Siemens remains in the game at all, and only courtesy of junior partner

alliances with Toshiba and IBM--alliances from which it shows no signs of ever graduating to full partnership. Moreover, the equipment which underlies production is dominated by Japan and the United States.[27] (The positions shifted in favor of Japan in the 1980s and have shifted somewhat back toward the United States in the last several years.)

In microprocessors, American producers dominate. The Europeans have no independent position either in traditional all purpose processors or in the new RISC (reduced instruction set computing).

One area of European semiconductor strength is in application-specific (ASIC) and customized chips that are adapted to particular market needs and usually made with processes that are not state of the art. But Americans, and now the Japanese, have established extensive and substantial production facilities in Europe. Both have expanded their operations in anticipation of political restrictions that would close the market to them.[28]

European policy has sought to remedy the situation, but if anything it has made it much worse. Support has gone to those activities that encourage European firms to compete directly with American and Japanese firms in the main industry segment, but not to those that would underwrite and develop European market strengths.

Consumer Electronics to High-Volume High Technology

The next area of weakness is consumer electronics. The Japanese control more than half of the world market in consumer electronics. But Europe still holds a competitive position, especially within its own market. Though the two leading companies are Japanese, Philips and Thomson are in the third and fourth positions, and Nokia, Grundig, and Bosch have strong positions in Europe.[29] European-owned producers control 34 percent of the European market -- significantly more than American-owned producers control of the U.S. market.[30] And European firms can be innovative. Philips has introduced significant new products to the market from the VCR through digital tape in 1992.

European industry has seemingly withstood the Japanese challenge in consumer electronics better than the American industry. The question is whether the European position is in fact defensible. Vulnerabilities persist. The enormous losses posted by Philips in recent years certainly evidences the need to re-formulate basic corporate strategy. The European market for consumer electronics is 28.4 billion dollars, but European producers provide only $15.8 billion--

a trade deficit of $12.6 billion. In other words, Europe is a huge importer, but exports almost nothing to the rest of the world. The deficit is in fact growing at least as fast as the market itself.[31] Moreover, Japanese factories in Europe provide 28 percent of European production.[32] Of course, the Japanese market has been effectively closed--first by policy, and then by a mix of business practice and distribution arrangements. And the Japanese have often employed determined low-cost pricing strategies that sometimes drift into dumping. But the Japanese product strengths and production advantages are real. Without protection, it is our judgment that Asian producers would capture a much higher share of the European market. Overall, the European producers do not appear cost-competitive, are generally slower and less effective at establishing new product niches, and spend less on R&D than their Japanese competitors. And, in any case, evidence shows that the Japanese firms are more profitable.[33]

The impending round of competition in consumer electronics will be of huge significance for the European electronics industry in general. Very simply, many of the components and subsystems that are the core of the new consumer electronics are cutting edge products that define the new category of high-volume advanced digital technology.[34] "The development and application of a broad range of subsystem, component and machinery and materials technologies are increasingly being driven by high-volume that boast leading edge sophistication and extremely high quality at remarkably low costs."[35] The product set that uses these products include: lap-top, note-book and hand-held computers, optical disk mass storage systems, smartcards, portable faxes, copiers printers and electronic datebooks, portable and cellular telephones and pagers, camcorders, electronic still cameras, compact disc players, hand-held televisions, controllers for machine tools, robots and other industrial machinery, and embedded automotive systems like those for anti-skid braking, engine, transmission and suspension control, and navigation.

As high-volume electronics production begins to use the sophisticated technological inputs that industrial systems share, it begins to drive common technological development. By spreading the huge development costs across many more sales, high-volume markets can support the development of advanced technologies previously initiated only by public spending. Consumer markets demand much lower costs -- costs which are achieved through rapid attainment of economies of scale, learning, and the other attributes of the new manufacturing. The associated product development and process skills permit the technology to be cycled much

more rapidly. Cost-savings and rapid cycle times permit expanded R&D, broader experimentation, and the capturing of new opportunities for additional technological learning. The final result is a new technological development trajectory -- new generations of cheaper but sophisticated technologies emerging from high-volume consumer applications but applicable across the board in professional and military product, and therefore essential to the success of all other industries that produce or use electronics.

To create a defensible market advantage in consumer electronics Europe must recognize that, at the moment, the points of leverage and advantage in new product lines are dominated by the Americans and Japanese. First, the Japanese control components and sub-systems that allow them to differentiate their products and production systems which not only create cost advantage but also allow flexible quick response approaches to marketing. Their strong position rests on intense technology development and on the control of the flow of technology to suppliers and potential competitors; that is, the control of the supply base. The Asian region's production network appears to be a hierarchy dominated by Japan. Advanced products and most of the underlying technologies are controlled by Japanese companies, with labor-intensive and standard technology production in the periphery of the region and often under the control of Japanese industry.

Next consider America's competitive advantage. American companies have used skills in product definition, design, and marketing to maintain market position. Amazingly, after having ceded the television and related product markets to Japanese and some European companies, new American firms are beginning to redefine the character of consumer electronics. The American position rests on the ability to define dramatically new products that become new industries such as the Apple II a few years ago or the Apple Newton today. Control of product design, definition, and marketing has often allowed American firms to force component and sub-system technology, no matter how sophisticated, to be sold as commodity products. Similarly, other American firms have created proprietary standards in a supposedly open system world that has allowed them to capture monopoly or semi-monopoly profits. Arguably, European firms such as Philips have innovated in the definition of new products, but they have fallen short in solving the design, manufacturing, and standards problem. Europe must determine why this is the case. Some of the problem certainly lies within the companies, that is in their limited ability

to bring new product to market. But part of the problem also lies in the character of the primary market, the European market, that the companies are addressing.

These relative strengths -- components and product definition -- suggest the pattern of deals between Japanese and American firms. The Americans create distinct product definitions which are often produced for them by the Japanese. The Japanese often then produce next generation design improvements which the Americans often then distribute under their own labels. There is seemingly little room for European companies unless they are able to find new and innovative product strategies.

It will be very difficult for European firms to build positions of long term advantage in consumer electronics. Equally important, it will be hard for them to use this sector as a foundation on which to build broader competitive advantage. The supply base problem, described above, will not be resolved by wishing the recreation of the entire electronics *filiere* in Europe. Europe must secure access to the Asian supply base and work with American producers to maintain an open international supply base for producers from all regions. But securing access to other regional bases will mean little if the Europeans do not work to capture the product definition, design, and marketing game. Developing Europe into a cutting edge market to promote the launch of sophisticated new products requires policies of diffusion, not just producer support alone.

The Computer Industry

The weakness of the European computer industry is legendary; the measures of its weakness are extensive.[36] Europe imports roughly one-third of its computer and information technology needs.[37] European firms control only 34 percent of their market, the rest -- whether by import or local production -- is controlled by foreign firms. By contrast, American firms control 92 percent of the American market, while Japanese firms control 84 percent of that market.[38]

But the weakness is even deeper when we look beyond these general figures. The *micro*-computer segment of the industry is controlled by American firms, with the largest European being Olivetti with 5.5 percent of the market in 1991.[39] Bull has become a player by buying Zenith, but Zenith hardly gives it a powerful position in the market. The *mini*-computer segment is dominated by IBM and DEC, while Bull and Siemens hold only 10 percent each of the market. In *mainframe* systems the European position is a bit stronger, but each of the main European

companies is substantially dependent on Japanese or American suppliers for major parts of their product line. Fujitsu now owns ICL, which has 7 percent of the European market. Bull depends on NEC and IBM; Hitachi supplies Olivetti, Fujitsu provides for Siemens.[40]

If anything, the European position has deteriorated over the past ten years. The Japanese have come to challenge the Americans, increasing their share of the world market in the period 1984 to 1990 from 6.5 percent to 18 percent as the American share descended from 62.7 percent to 47.4 percent.[41] The Europeans might comfort themselves with explanations that American success rested on military spending (except that this was only the case in the very early years), and that Japanese successes rested on a large, coherent and highly protected domestic market. However, the fact is that the Europeans largely missed the commercial-based work-station and micro-computing revolutions that are transforming the very character of the computer industry. European firms, often badly organized and insensitive to market requirements, did very poorly with a difficult situation.

Government policy did not help. If anything it made matters worse, as Zysman has argued for many years.[42] As many observe, national policies created a fragmented European market that was slow to adopt new technologies. More importantly, policy makers sought to imitate the product mix and industrial structure they saw in the United States. They reasoned from the structures they wanted to the strategies they wanted the firms to adopt. The policies then pushed European firms directly into market segments dominated by the American giants. Bureaucrats could only, by the nature of the situation, play catch-up; they could not play the entrepreneurial role of imagining and inventing new industrial futures. And the catch-up game was difficult in the fragmented European market. Firms were discouraged from finding their own distinctive technological avenues and consequently the possibility of innovative breakthroughs that could permit European firms to become leaders. These views are beginning to find expression in Europe.[43] In sum, the result has been a deep and enduring technological dependence in virtually all segments of the industry.

Europe made its first mistake by never even debating the notion that a sophisticated market could be the best possible assistance to computer producers. Policies for diffusion and use of advanced technology never received the same attention and weight as did producer-oriented support.[44] The symbolic consequence of producing particular products, not the broad economic

gain from widespread adoption of new technologies, was the emphasis of policy debates. This is particularly significant now because the European position in systems integration -- the development of large scale networks of computers to apply to specific problems -- is much stronger than in the hardware included.[45] European companies have a strong position in their own market. Equally important, the customized and skill intensive nature of systems integration means that the fundamental technological know-how can grow up in Europe even if the company selling the service is American. Systems integration can create the sophisticated market. But there is, in any case, no vision in the policy community about how a solid position in systems integration can be used to rebuild a base in computer hardware. More generally, European firms have not been able to define strategies by which they are able to capture distinct proprietary positions that generate monopoly like profits or at least insulate themselves from a pure cost based and production centered strategy. Doing so will almost certainly come from an exploration of the competitive interplay between software and hardware, but for now Europeans have not found distinctive solutions that will allow them to capture powerful competitive positions that can be translated into standards and proprietary technologies, or found standards and proprietary technology that can be the base of competitive advantage.

Why Defense Electronics Cannot Defend the European Position in Commercial Markets

Defense electronics cannot defend the broader European position in electronics. As in the United States, the emerging high-volume digital technology industry described above is likely to make the *military* electronics industry ever more dependent on advances in the *commercial* industry. At BRIE we have explored this issue in both the American and Japanese economies.[46] We have argued that:

> . . .a completely alternative military technology development trajectory is emerging from the innovations in production and consequent reshuffling of markets examined earlier. . .This alternative drives technological advance from commercial rather than military applications. Technology diffuses from civilian to defense use rather than vice versa, a trajectory characterized as "spin-on" in contrast to its predecessor. The new alternative is prospering most fully in Japan, where an increasing range of commercially developed technologies are directly, or with minor modification, finding their way into advanced military systems. In particular, militarily relevant sub-system, component, machinery, and materials technologies are increasingly driven by high-volume commercial applications

that produce leading-edge sophistication, with extremely high reliability but remarkably low costs.[47]

As argued above, the high-volume electronics industry is beginning to drive the development, costs, quality, and manufacture of technological inputs critical to computing, communications, the military, and industrial electronics. The basic technological requirements of new consumer products now approach, equal, or at times surpass those needed for sophisticated military applications. They have also begun to share a common underlying base of components, machinery, and materials technologies. There are several significant implications. First, by spreading the huge development costs across many more units, high-volume markets can support the development of advanced technologies previously initiated only by military spending. Second, price-sensitive consumer applications demand that the unit cost of the underlying technology components be very low.[48] The necessary low costs can be achieved only by the scale, scope, and learning economies of revolutionary production approaches. The end result is that new, militarily-relevant generations of cheaper but sophisticated and reliable technologies emerge from high-volume commercial markets.

IV. Potential Strengths in European Electronics

Telecommunications

Telecommunications is the most evident European electronics strength and the major firms have been very successful. At least until the late 1980s the European equipment makers held onto the bulk of the European telecommunications market. The share of European telecommunications equipment provided by European suppliers has likewise remained high. Of course, national ministries or their agents served as monopoly buyers, a situation not different from the recognized monopoly of AT&T, but many of the European firms have established themselves as major global competitors with substantial strengths. Some of the companies have been important innovators, and have become leading-edge final producers creating sophisticated home markets. Alcatel led the way to digital switching in France, which was the first country to take this significant step. Ericsson helped the rapid diffusion of cellular telephony in Sweden; indeed, Ericsson has been remarkably successful in international markets by carefully identifying market possibilities, understanding the needs of potential customers, and pursuing them carefully for years. Siemens, a 7.3 billion dollar company, remains entrenched in the German market

while already establishing a real presence in the United States. Given this strength in the telecommunications sector, there are two major issues: first, can the Europeans maintain their position of strength in Europe and extend that into world markets? and second, can telecommunications be the foundation from which to rebuild the rest of the European electronics sector.

Foreign firms are not poised to capture a major piece of the telecommunications equipment markets in Europe. The Japanese firms are not distinctively strong in this sector and are unlikely to represent a powerful challenge in the next few years. Similarly, American equipment firms are not likely to displace their European rivals in the near future. The Europeans are not only quite competitive, but also benefit from intimate relationships with their users. Client markets, particularly the switching market, depend on close and careful interaction with the buyer because the systems are inherently customized. The sales and the work require a sophisticated and permanent commitment to the customer. The American firms are only now beginning to establish those liaisons.

Nonetheless, as the telecommunication service markets are deregulated and at least some competition in services is introduced, the European equipment companies and network providers must confront two problems to hold position.

First, there has been a burst of new peripheral equipment such as cellular telephones and palm computers, many with communications capacity. The new consumer electronics, high-volume high-technology digital equipment, is invading telecommunications. That of course opens up the market to firms other than established telecommunications companies, to consumer firms with whom the Europeans have had trouble competing.

Second, and more importantly, telecommunications policy in the Community has reached the end of a phase, as Peter Cowhey and John Zysman have argued.[49] This now completed phase involved changes that separated regulation from operation, a round of marginal liberalization that did not alter the dominant position of the telecom operators, and efforts, mostly timid, at European harmonization. That period of re-regulation overlaps the move toward a single market. Together, the result was a dissolution of purely national supplier cartels linked to national public service providers. Those national cartels have not been replaced by an open and competitive European market. Rather, a European-wide oligopoly of equipment suppliers, albeit with room left for some American companies, has been established. The continued privileges of the now

privatized and semi-autonomous telephone companies is essential to that oligopoly. The European experience is not unique. One might note that the breakup of the Bell system in the United States has not eliminated the purchasing biases in favor of American companies, though those biases have eroded. The Commission now finds itself in a stalemate. The Commission initiated the policy with support from large users and built a complex support base from the national governments. That support base, however, has not been strong enough to push forward to a next round of policy. Those in the Commission who created the first round would clearly like a second and more ambitious second phase. That next round of policy would involve some European level regulation, efforts at liberalization that cut into the basic monopoly rate base, and the implementation of innovative services. If those regulatory changes come, they will involve not only a shift of position among European producers, but also entry for American and Japanese firms. For now, the debate appears as a struggle with established producers and network suppliers on one side and telecom users concerned with capturing the competitive advantages that early implementation of new network based strategies can provide on the other. However, there is a distinct possibility the debate will become more urgent.

Revolutionary changes in telecommunications networks use are taking a new form to which European users, equipment suppliers and network providers will be compelled to adapt. The early signs are clear, the implications dramatic.[50] A broadband network future is arriving much faster than anticipated. The new broadband networks open dramatic service possibilities that are enormously attractive, and, indeed, in the few settings where the new networks are being fully implemented without serious constraint, the network traffic is expanding as rapidly as 20 percent a month, and the rate of increase is accelerating.[51] In just a decade, the telecommunications system of suppliers and providers could look very different than it does today. The notion of ISDN with a single integrated digital network may give way to a system with multiple networks linked together--not just because competition creates fragmentation (as some fear), but because each of the networks will have quite distinct characteristics. Each network may be optimized for particular use. Flexible networks may be adapted not just to shifting needs, but re-adapted continually as firms learn from using them and producers learn get feedback.[52] The established telecommunications operators may have trouble adapting without substantial pressure and real regulatory change. Set aside the importance of the networks to the economy. For the equipment makers those new networks are essential, they represent the innovative market of tomorrow. In

sum, the Europeans have a strong foundation in telecommunications, but their position in the next generation of competition will rely on well-formulated and forward-thinking network policy and firm strategy.

The European telecommunications system from equipment suppliers to network providers -- present and potential -- seems well positioned to maintain control of European markets. But can success in telecommunications be the foundation from which to rebuild the rest of the European electronics sector? Here we have our doubts. The hope is that telecommunications companies can create demand for European suppliers of components and sub-systems. This will not be automatic by any means. Consider the components sector. Telecom equipment suppliers in Europe generate a huge demand for semiconductors. That demand is still largely filled by foreign-owned companies, whether they produce in Europe or not.[53] Similarly, there is a hope that as computing and telecommunications converge toward distributed computing that telecommunication networking skills and experience with digital switches would provide an opportunity for Europeans to establish a competitive position in computers. However, neither AT&T nor Siemens have managed to switch over from a telecom base to a major computer position. Nor has IBM been able to move from its dominant position in computers to a strong position in telecom. The reason seems to be that the business problems and user requirements are distinct in each sector so that business organizations and technologies generated in one segment cannot be directly applied to another. Telecommunications may continue to be a bastion of European electronics strength, but it is not evident that it can nurture a rebirth of the industry as a whole.

Professional and Industrial Electronics

Industrial and professional electronics is a second area of real European strength. In this sector, the applications know-how rooted in the fundamental and deep scientific, technological, and industrial traditions of Europe matter the most. In a range of areas --from machine tools, hearing aids, and automobile electronics -- European producers are in fact quite strong. Consider automobiles, for example. The largest automobile electronics firm in the world is Bosch; three of the leading five companies are European and four of the leading ten. Or consider machine tools, which is an industry made up of a myriad of smaller producers. Here Italy and Germany rank among the world largest exporting nations. Indeed, when we look at production equipment

in general, we find that the European position in global markets is very strong. These are all sectors in which creative application of electronics has been and will increasingly be critical. They are sectors which depend on access to advanced electronics, but which also represent a market for innovative producers.[54]

The same two questions that we posed in the telecommunications section confront us once again. First, can the Europeans maintain their market position? There are a number of competitive risks. The most serious is that the bulk of this sector -- automobile electronics and production equipment such as machine tools -- depends on demand from the rest of the industrial economy. If imports of autos displace European production there would be a problem for equipment producers as well. Imports, by definition, dampen the domestic demand for equipment from European-owned producers. Substituting imports with FDI may preserve European final assembly producers, but this substitution could still cut demand for production equipment. If foreign-owned producers import production equipment or bring their suppliers of equipment or components with them, then demand for European producers is dampened in the same way. As evidenced in the American case, Japanese companies (the principal new investors), do have a propensity to create an enclave economy inside the host country.

Second, will European firms be able to weather Japanese production innovations that have proven critical in a range of consumer durable sectors. The American machine tool and robotics companies specializing in standard equipment were unable to respond to the more specialized and differently conceived Japanese products, for example. In that case, the Europeans defended their positions more effectively. They held market niches based on more specialized equipment in the first place. But now a new challenge looms. The Japanese attempt to implement functions in electronics that the German implement mechanically. If there is long-term inherent advantage in electronic approaches, the Japanese will be well positioned. But it is not even that micro-electronics underpins Japanese automation equipment. Rather, there is a different approach to the production line and the place of tools in the line. The difference in our view is driven by the primary final goods in the two countries: volume consumer durables in Japan, and capital equipment in Germany. The result is that the functions and design of tools are different. There is likely to be a serious challenge.

Assume that the European producers do retain their competitive edge in production equipment and professional electronics. Can this be a foundation from which to rebuild the rest

of the sector? Automobile electronics will be an increasing portion of the electronics market as the use of electronically-controlled active chassis, engine operations, safety systems, and entertainment and comfort systems expands and grows in value. Factory automation will become increasingly rooted in electronics. The demand for electronic components will thus expand, creating new opportunities. The question is whether the European companies can seize them. The risk and concern must be that the weakness in the broader electronics sectors will endanger the European competitive position in these segments where European companies hold defensible positions. Recall that in automobile electronics the European semiconductor industry provides only about a quarter of the European demand.[55] However, the one real strength of the European semiconductor industry is, as we noted, application specific or custom circuits. These are the types of circuits critical to differentiating industrial products. Consequently, Europeans here can easily import commodity memory and even standard micro-processors if they can differentiate their electronic functions. The question -- will strength underpin weakness or will weakness drown strength -- remains open.

V. Lessons of the European Electronics Case: Formulating Policy in a Regional World

The surge in Japanese foreign direct investment, huge subsidies demanded by many European producers, the outright takeover of major European companies by American and Japanese competitors, and the failure of other companies have all contributed to a reformulation of European policy. Past policy of support for weak producers has failed to regenerate industrial position in those sectors defined as critical. Past pre-occupation with American dominance seems dated given the rise of Japanese electronics companies and increased Japanese investment in Europe. What are Europe's policy choices today? And how are these choices shaped by the regionalizing global economy?

The emergence of three competitive regions has changed many of the issues facing European industry. For years the Europeans worried about American domination of the computer industry, and in particular of IBM's domination of mainframe markets. American firms will certainly continue to define or powerfully influence the definition of core products in the computer and the consumer electronics industry, but today Europe must also reckon with Japan (and Asia more generally), now a dominant force in the component and volume electronic markets. One might say that Europe has fallen into third place in the global electronics

competition, suffering dependency on not just one but two competitive regions. On the bright side, however, Europe may now be able to exploit a regional rivalry (led by the region's central powers, Japan and the United States) and on some of its existing strengths to heal the weaknesses of its producers. Two questions confront the Europeans in formulating policy for electronics and, with a complex web of industrial alliances linking the several regions and thus creating multiple dependencies, the Americans and Japanese as well. First, can policy help assure a strong supply base for sustained development? Second, should European policy try to bolster position in weak sectors thought to be critical, or try to build from strength in those areas with a defensible position?

In considering the first question, we must recognize that in the short term (if at all) Europe cannot hope to recreate under European control the various elements of a sophisticated electronics supply base. Indeed, no single region can construct an entirely independent supply base. Consequently, assuring leading edge technology becomes a matter of securing access to other regions' supply bases. European policy must make certain that critical products and components are available in open, *competitive* markets; that is, assure that European producers have market access to all supply bases of components, subsystems, production equipment and skills.[56] Since many of those elements are available in the electronics industry only in the United States or Japan, it is essential that Europe maintain access to *both* supply bases. Diversity of supply is essential to guard against exploitative dependency; several suppliers in at least two economic regions ought to be a policy goal.

Ideally, of course, it would be best to have evolving technology close to home to profit from any spillovers. But for the moment this is not a realistic scenario for many segments of the European electronics industry. For now, Europe must settle for maintaining alternative regional sources; that is, it must maintain a healthy U.S.-Japanese competition by playing suppliers in the different regions off one another. Europe could, however, establish itself as a critical test ground if it manages to transfer much of the technology early.

Henceforth, Europe must be concerned with how supply bases are linked and how technology flows from one to another. Regionally structured supply bases change the problem of technology management for both governments and corporations, not only in Europe but all over the industrialized world.[57] They force firms and governments to be concerned with the architecture of supply in the home regions of their rivals. At issue is no longer just access to

export markets in general, but access to technology and to markets that may be critical to the launch of new product.

The second question--whether European policy should try to bolster position in weak sectors thought to be critical or try to build from strength in those areas with a defensible position--can also be posed in the following way: should policy support weak producers in their efforts to entrench their market position or try to foster the diffusion and spread of advanced electronic applications? It would be congenial to argue that government policy should do both. This seems to make market sense: help buyers to expand the market and producers to supply it. However, the policies conflict when support for producers results in higher prices or reduced supply for clients, the final producers (as is the case with the semiconductor tariff). It is important to remember that Japanese policy protected final producers, but generally allowed imports of intermediate goods required for production. (Of course, FDI by importers who might establish a strong market position in Japan with local production was blocked so local Japanese producers could later attempt entry into these sectors.) [58]

Policies to support the diffusion of advanced technology are important to support general economic development, to speed application of technology, and to maintain the competitive position of final producers (users). A deep, diverse, and sophisticated user base is a means to *induce* supply from local sources, a means to create competitive producers, a mechanism to incite innovation. Powerful general purpose suppliers of chips or computers might be attractive symbols, but they are not likely to be built simply by European policy. A network of sophisticated suppliers to users is needed to create the foundation of skills and equipment from which breakthrough innovations might emerge. A web of advanced users would mean that there was pressure on suppliers to generate sophisticated responses. As important, a sufficient European demand would allow innovative products to establish a sufficient home base that they might set a global standard.

Computers and semiconductors were often thought to be the core technologies of the information era. Without them, it was argued, position in all other electronics sectors would be blocked. This takes us back to the dilemma posed at the beginning of the paper: for effective application of technology, will arms-length market access of advanced technology suffice, or is intimate involvement with the producers required? The dilemma is false: there must be a balance. A strong applications position can *create* a foundation for strength in the production of

underlying components. Worldwide, this trend is evident: strength in semiconductors (and in other component technologies) often reflects the final products and market position of the customers (internal or external to the firm). While the situation is obviously reciprocal and some draw the conclusion that semiconductor technology permits final product strength, we would argue that final market position in fact begets semiconductor strength. Final market strengths should therefore be the basis for formulating a strategy to induce innovation in supplier or intermediate industries.

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[1] Wayne Sandholtz, High-Tech Europe: The Politics of International Cooperation (Berkeley: University of California, 1991).

[2] For a definition of transformative industry see Stephen Cohen and John Zysman, Manufacturing Matters: The Myth of the Post-Industrial Economy, (New York: Basic Books, 1987) and Laura D'Andrea Tyson, Who's Bashing Whom: Trade Conflict in High-Technology Industries, (Washington, DC: The Institute for International Economics, 1992.)

[3] "L'Informatique et les automatismes," Michel Catinat C.C.E. DG XIII, presented at "Le Devinir Industriel de La France: Cooperer," Seminaire International, Paris 7,8,9 September 1992, p.11.

[4] "The Report of the Information and Communications Technologies Review Board," June 1992. This review board, chaired by Wisse Dekker of Philips, was invited by the European commission to review the progress of the major programs in information and communications technologies.

[5] Ibid.

[6] See Laura D'Andrea Tyson, Who's Bashing Whom, chapter 6. See also the excellent article by Robin Gaster that discusses European FDI policies, "Protectionism with Purpose: Guiding Foreign Investment," Foreign Policy, Fall 1992.

[7] Yui Kimura in "Japanese FDI in the European Semiconductor Industry," Does ownership Matter? Japanese Multinationals in Europe, Mark Mason and Dennis Encarnation eds., (Oxford University Press, forthcoming).

[8] Winfried Ruigrok and Rob van Tulder, "The Ideology of Interdependence," unpublished dissertation, University of Amsterdam, 1993.

[9] This argument is widely disputed. For a view parallel to ours, see Lawrence B. Krause, "Trade Policy in the 1990s: Good-bye Bipolarity, Hello Regions," World Today, Vol. 46, No. 5 (Royal Institute of International Affairs, May 1990). For skeptical view, Jeffrey Schott, "Is the World Developing into Regional Trading Blocs?" (Washington, D.C.: Institute for International Economics, 1989). In our view, the difference is largely one of vocabulary.

[10] In 1987, Japan alone accounted for 12.4 per cent of global GDP, and Japan plus the East Asian NICs accounted for 15.8 per cent. (These figures are based on data in Bureau d'Information et Prevision Economique, Europe in 1992 (Paris: BIPE, October, 1987) Since then the Japanese share has risen.)

[11] Trade within the EEC has grown faster than the trade between the Community and the rest of the world since the establishment of the EC in 1958. From 1967-87, the ratio of intra-regional trade to inter-regional trade rose from .79 to 1.15. (Colette Herzog, "Les Trois Europes," in Europe, Economie Prospective Internationale Revue du CEPII Numero Special, La Documentation Francaise 43, 3ieme trimestre, (Paris, CEPII 1989)). Discounting intra-European trade, Europe's percentage of world exports and imports dropped drastically: exports from 44.6 per cent to 13.8 per cent and imports from 42.6 per cent to 11 per cent. (Ibid.)

Trade within Asia, for example, has grown faster than trade between Asia and other regions since 1985. ("The Rising Tide: Japan in Asia," special supplement, Japan Economic Journal (1990), p. 4. See also Takashi Inoguchi, "Shaping and Sharing Pacific Dynamism,: The Annals of the American Academy of Political and Social Science, Vol. 505 (September 1989)). By 1988, intra Pacific-Basin trade had risen to almost 66 per cent of the region's total trade, from about 54 per cent in 1980. (Data calculated from various sources by Lawrence B. Krause, "Pacific Economic Regionalism and the United States." (Paper prepared for the symposium on the "Impact of Recent Economic Developments on US-Korea Relations and the Pacific Basin", University of California at San Diego, November 9-10, 1990).

[12] Japan's trade with the rest of Asia in 1989 surpassed her trade with the United States, more than doubling since 1982 to over $126 billion: "The Rising Tide: Japan in Asia," special supplement, Japan Economic Journal (1990), p. 4.

[13] See "Everybody's Favourite Monsters," a survey of Multinational corporations, in The Economist, March 27, 1993.

[14]"Foreign Direct Investment in East Asia," prepared by Sylvia Ostry for a joint research project designed by Sylvia Ostry, Center for International Studies, University of Toronto, and the Berkeley Roundtable on the International Economy, 1992.

[15] Ibid., p. 3

[16] See Dennis Encarnation, Rivals Beyond Trade: America versus Japan in Industrial Policy, 1925-1975 (Tokyo: Charles E. Tuttle, 1982).

[17] Ibid.

[18] See Gerd Junne, "Competitiveness and the Impact of Change: Applications of High Technologies," , Industry and Politics in West Germany, ed. Peter J. Katzenstein, (Ithaca: Cornell University Press, 1989), p.250.

[19] Michael Borrus, "Re-Organizing Asia: Japan's New Development Trajectory and the Regional Division of Labor," BRIE Working Paper #53 (1992).

[20] Paolo Guerrieri, "Technology and International Trade Performance of the Most Advanced Countries," BRIE Working Paper #49, (1991). Seen from this vantage of a supply base that underpins final production, it is not surprising that Guerrieri finds that export competitiveness in production equipment is linked to the competitive position of firms in the final goods sector for which the equipment is used.

[21] Erik Dahmen, "'Development Blocks in Industrial Economics," Scandinavian Economic History Review, 1, 1988.

[22] Michael Borrus, "Re-Organizing Asia," page 26.

[23]. Michael Borrus and John Zysman "Industrial Competitiveness and American National Security," in Sandholtz, et al., The Highest Stakes: The Economic Foundations of the Next Security System, (New York: Oxford University Press, 1992).

[24] John Zysman, "Trade, Technology and National Competition", International Journal of Technology Management, Special Issue on Strengthening Corporate and National Competitiveness through Technology, v.7, n. 1/2/3 pp. 161-189, based on a paper presented at an OECD Conference in Paris, June 1990, ed. Bela Gold, Inderscience Enterprises Ltd., 1992. Or see John Zysman, "Trade, technology and national competition," (with assistance from Laura Tyson, Giovanni Dosi and Stephen Cohen) Technology and Investment, eds. Eurico Deiaco, Erik Hornell, and Graham Vickery, Royal Swedish Academy of Engineering Sciences, 1990.

[25] Dieter Ernst's very interesting recent papers point to these issues. See, for example, "Networks, Market Structure and Technology Diffusion: A Conceptual Framework," BRIE Working Paper (forthcoming, 1993).

[26] Indeed, these networks may be permanent features that represent mechanisms to manage technological diversity in an era of rapid technological change.

[27] Jay Stowsky, "From Spin-Off to Spin-On: Redefining the Military's Role in Technology Development," BRIE Working Paper #50 (May 1991).
[28] "Composants electronique" prepared by Didier Huck, Minister of Industry for the seminar "Les Nouvelles Armes du Defi Industriel," September 7-9, 1992 Paris, Ministry of Finance Conference Center, pp. 5-6.
[29] "Electronique Grand Public," prepared by Thierry Triomphe for the seminar "Les Nouvelles Armes du Defi Industriel" September 7-9, 1992 Paris, Ministry of Finance Conference Center.
[30] Panorama of the EC Industry (1990) Section 10-17ff.
[31] Triomphe, "Electronique Grand Public."
[32] Ibid.; indeed 32% is by Asia as a whole.
[33] Ibid.
[34] Michael Borrus and Jeffrey Hart, "Display's the Thing: The Real Stakes in the Conflict Over High-Resolution Display," BRIE Working Paper #52 (1992).
[35] Ibid.
[36] The European computer market is much smaller than the American market; computers are simply not as widely used. The per capita figures for personal computer installed base illustrate this fact (source is Dataquest, Inc. "PC Europe" [1992: San Jose, CA]):

Europe - 1 personal computer for every 10 people
United States - 1 personal computer for every 4 people

[37] Catinat, "L'Informatique et les automatismes," page 11.
[38] Ibid.
[39] Dataquest Inc. (1992), "PC Europe."
[40] Ibid.
[41] Ibid., p. 7-8.
[42] Zysman, Political Strategies and OECD Innovation Policy
[43] Catinat. p.8.
[44] Ibid.
[45] Catinat, "L'Informatique et les automatismes".
[46] See in particular Sandholtz et al., The Highest Stakes, chapter 2., "The Power behind "Spin-Ons" by Steve Vogel, and chapter 4, "From Spin-Off to Spin-On: Redefining the Military's Role in American Technology Development" by Jay Stowsky.
[47] Michael Borrus and John Zysman, "Industrial Competitiveness and American National Security" in Sandholtz, et al., The Highest Stakes, p. 31.
[48] Ibid.
[49] Peter Cowhey and John Zysman, "European Telecommunications at the Crossroads" Unpublished paper, BRIE April 2, 1992.
[50] François Bar and Michael Borrus, "The Future of Networking in the U.S.," BRIE Research Paper #4 (September 1992).
[51] Ibid.
[52] François Bar and Michael Borrus, Information Networks and Competitive Advantage, OECD-BRIE Telecom Project, Vol. 1, (Paris: OECD, 1989).
[53] "Le future de l'industrie europeenne des semiconductors," (May 1991) prepared by the Communications Direction of Thomson Groupe under the direction of Jean Philippe Dauvin.
[54] Ibid.
[55] Ibid.
[56] See Michael Borrus, "Re-Organizing Asia: Japan's New Development Trajectory and the Regional Division of Labor," and Kenneth Flamm, "Semiconductors," in ed. Gary Clyde Hufbauer, Europe 1992: An American Perspective, (Washington, D.C.: Brookings Institution, 1990).
[57] John Zysman, "Regional Blocs, Corporate Strategies, and the End of Free Trade," in The Impact of Globalization on Europe's Firms and Industries, Marc Humbert, ed. (London: Pinter, 1993).
[58] Pierre Buigues and Alexis Jacquemin, "Foreign Direct Investments and Exports in the Common Market: Theoretical, Empirical, and Policy Issues," Mark Mason, ed., Does Ownership Matter: Japanese Multinationals in Europe, (New York: Oxford University Press, 1993).