FOLLOWING THE LEADER: COMPARING INDUSTRIAL STRATEGY FOR COMPUTERS IN JAPAN AND FRANCE

by

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ABSTRACT

Since the early 1960s, American companies have consistently dominated the computer markets in virtually all OECD countries with one notable exception: Japan is the only OECD country where domestic companies have successfully rolled back American corporate domination of its computer market to under thirty percent. Furthermore, Japanese companies have emerged as the only serious long-term challengers to American technological and commercial leadership on international markets. This is quite a remarkable achievement considering Japan's relatively late entry into a market where the development constraints have been as severe as in other industrialized nations.

This thesis examines the historically-parallel transformation of two groups of "industrial followers" - the Japanese and French populations of computer companies - in order to shed light on relevant issues of strategic importance: How do we account for the rapid ascendancy of the Japanese computer industry to international competitiveness whereas other national computer development efforts have been forestalled? To what extent is the Japanese pattern of computer development unique, and to what extent does it conform to the prevailing pattern of international competition? In our comparison of the "deviant" Japanese case with the "control" French case, the

operative questions are defined as: What combinations of conditions could account for patterned variations in (1) aggregate domestic industry outcomes; and (2) the trajectory or path of domestic industrial change over time? Three major sets of conclusions concerning the parameters of international competition, national outcomes, and national trajectories of development, emerge from the comparison. First, it will be argued that the computer industry leader IBM defined the parameters of international market competition for at least two decades following the mid-1960s. Secondly, it will be argued that Japanese and French domestic industry outcomes fell within those parameters. Different national strategies determined just where within the parameters domestic outcomes lie; that is to say, they account for the variance in Japanese and French computer industry outcomes. National strategies, however, did not change those parameters. The competitive success of the Japanese industry is attributable to "market-conforming" strategies that generally respected and worked within the prevailing terms of international market competition as defined by IBM. French strategies, for the most part, have struggled against the terms of international competition and have subsequently failed to advance the competitiveness of the domestic industry. Finally, comparison of Japan and France suggests the path of national computer industry change over time has been non-linear (or multi-linear) and contingent on the interplay between the domestic structure

of state-business power relations, on the one hand, and on the other hand, response from the broader international market. In the short term, different power structures of state-business relations in the domestic policy process account for the divergence in national trajectories of development. In the long-term, however, response from the broader international market had a decisive, if indirect, influence on the partial convergence of national development trajectories. Put differently, the comparison confirms the strategic developmental orientation of Japanese and French computer industry policy. National policy, however, were only able to advance the strategic interests of domestic industry when they conformed to the prevailing terms of international competition as defined by the industry leader IBM. When policy ignored or attempted to challenge head-on the prevailing terms of global competition, their strategic efforts failed, forcing a revision of national policy and a reorientation of collective action on the market. This study affirms the industry leader's role in defining the first order constraints on the development path of industry followers.

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CHAPTER ONE

INTRODUCTION

The Japanese computer industry's rapid ascendancy from relative backwardness to a position that rivals American leadership in international markets presents an interesting phenomenon for consideration. Of all the major industrialized nations that have attempted to cultivate a domestically-based computer industry in response to American industry dominance, Japan is the only country that has achieved any measurable degree of success. In the early 1970s, for example, American companies accounted for about 95% of the cumulative value of computer installments in the non-communist world (Jequier, 1974). The Japanese computer industry was considered some six years behind the American industry in technology, over half of the Japanese computer market was controlled by American firms, and the value of Japan's imports in computer technology exceeded exports by eight-fold. In this respect, the Japanese situation was not much different from the situation in other OECD countries. Since the late 1970s, however, the Japanese computer industry has consistently matched or exceeded the price-performance of each new generation of computers introduced by the leading US firms. By the early 1980s, Japan became the *only* OECD country where nationally-based firms have successfully rolled-back American corporate domination of its domestic computer market to under 30 percent. In a dramatic reversal, Japan was exporting six times the value of its imports in computer and information systems technology in 1984, representing a trade surplus of US $9 billion for that year in this type of technology alone.[1] Although the Japanese computer industry accounts for only 10% of the world market, it has emerged as the only serious long-term challenger to the leadership of American industry on international markets. This is quite a remarkable achievement considering Japan's relatively late entry into a market where the development constraints have been just as severe as in other follower nations.

How do we account for the rapid rise of the Japanese computer industry to international competitiveness whereas other national industry development efforts have been forestalled? To what extent is the Japanese pattern of computer development *unique* and to what extent does it conform to the prevailing patterns of international competition? Unfortunately, aggregate data do not shed much light on the internal dynamics of industrial change or how it came to move along its path. We need not assume that all national patterns of industrial development are inherently unique, nor do we need to assume that they lead inexorably toward some common, converging path of development. If our

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1. By contrast, Western Europe was importing three times its combined exports in this technology in 1984, representing a trade deficit of US $9.2 billion (Anderla & Dunning, 1987:138).

analytical task is to be successful, we must be able to account for both *patterned variations* and *generalized tendencies* in a class of political-market phenomena. This paper argues that the Japanese case should be seen as one particular instance of a general class of political-market phenomena. It is one instance where national governments and business perceived their own technological and commercial backwardness with respect to a strategic technology, and sought to change their competitive position through coordinated action on the market. Comparison of the Japanese case with another case that belongs to this class of phenomena provides an opportunity to discover how Japan made the transition to its competitive status on international markets. Equally important, such a comparison should reveal the practical limits of the Japanese development approach that are shared by other "relatively backward" nations attempting a similar enterprise.

OBJECTIVES OF COMPARISON AND RATIONALE FOR SELECTION OF CASES

On a practical level, our task is to identify a range of variation in market performance outcomes for separate populations of computer firms that have been designated as "strategic" by national governments and business, and to search for the conditions that could account for that observed variation. We are interested in *aggregated* *attributes* that may be said to characterize certain populations of nationally-based firms, defined as financed and controlled by domestic capital.[2] The purpose is to ask what conditions could account for the observed variance in these aggregated attributes. Furthermore, we are interested in a *dynamic* rather than a static comparison. In other words, we are interested in tracing the *trajectory* or path of industrial change over time, not only accounting for the different *rate* of change at two different times, but accounting for how it came to move along its path. A dynamic analysis is more complex than a static one because it involves the path of change over time, and the *mechanism* by which change is affected. This requires the systematic introduction of parameters, variables, and the development of combinations of these to account for convergence and/or divergence between separate populations over time.

This paper employs two major criteria for the selection of appropriate cases for comparison. First, they must belong to the same class of a political-market phenomena to avoid the fallacy of comparing "apples with oranges". We are interested in comparing "industrial followers"; our

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2. Here we have in mind such indices of market performance as share of the domestic market held by nationally-based firms in relation to foreign competitors; import/export ratio of the type of products manufactured by the national population of firms; price-performance of domestic products in relation to foreign products; and diversity of product line or relative strength in different product segments of the market.

cases must be instances where national governments and business perceive their own backwardness in relation to foreign competitors with respect to computer technology, and seek to change their competitive position through coordinated action on the market. The second criteria for selection of comparable cases is *similar timing* in the historical sequence of computer technology development. Following Alexander Gerschenkron's (1962) formulation, development timing defines a large number of *contingently relevant conditions* (such as the nature of technology and market constraints) confronting followers in the historical sequence of industrialization. If we compare national cases characterized by similar development timing, it will be possible to convert a large number of potentially confounding background conditions into *parameters*, and thereby isolate a smaller number of conditions influencing the dependent variable (the variance between the cases).[3] Similar development timing greatly simplifies the task of comparison by reducing the number of potentially operative conditions influencing the variance between the cases.

The Japanese and French cases meet these criteria for comparability of cases. Both countries entered the computer market relatively late in comparison with other OECD

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3. "Parameters", as used here, are defined as conditions that are known or suspected to influence the dependent variable, but in the investigation at hand, are treated *as if* they do not vary significantly across the cases.

countries (behind Germany, Britain, and the United States), starting out as relatively peripheral and insignificant players in the international computer industry. Japan and France represent two exemplary cases where national governments, acting jointly with domestic firms, have intervened in massive efforts to "catch-up" technologically and commercially with the leading American computer industry. Both events took place during almost exactly the same time period. In both cases, Japanese and French governments had strong industrial policy reasons to seek outcomes in tension with those of the major American multinationals doing business in their domestic markets. In understanding the interaction between the activities of the American companies and the strategic industrial policies of these two nations, one learns much about the capabilities and limitations of national policies to target strategic technologies for development.

METHODOLOGICAL CONCERNS AND STRATEGY FOR CONTROLLED COMPARISON

For a given dependent variable, the number of conditions or determinants affecting it is at first sight discouragingly great. The number of conditions affecting complex social aggregates, such as populations of nationally-based firms, appears even more foreboding. The initial picture is one of *multiplicity* of conditions, a *confounding* of their influences on the dependent variable, and an *indeterminancy* regarding the effect of any one condition or several conditions in combination. The corresponding tasks facing the investigator are to *reduce* the number of conditions, to *isolate* one condition from another, and thereby *make precise* the role of each condition both singly and in combination with others. How do we tackle these problems to maximize control of our comparison?

Our comparative strategy is essentially to conduct a "deviant case" analysis. In a deviant case analysis, the investigator takes the case that is an exception to the general trend (the Japanese population of computer firms) and attempts to locate conditions that set it apart from a case representative of the general trend (the French population of computer firms). This method is also a method of "reading backwards" to approximate the logic of comparison in an experimental situation (Smelser, 1973).

Our first task is to identify cases that belong to the same class or type of phenomenon, and divide these cases into two groups: the deviant case (the experimental group by parallel) and the case representative of the general trend (the control group by parallel). The most obvious difference between the experimental and deviant methods of comparison is that the data of the latter precipitates from the flow of social life that transpires without controlled experimentation. Most social science analysis is therefore presented with given data; we are obliged to ask why these data are arrayed in a certain way and not some other way. As we are presented with historically given data, the starting point of our comparison is the different outcomes themselves, as between the deviant case and the other case representative of the general trend. The investigator then "reads back" to the point in time when both cases can be observed to be experiencing *similar problems* and departing on *separate paths* in response to those problems; in other words, we seek to identify what historians refer to as the "crucial conjuncture" (Katzenstein, 1978; Hall, 1986) in the development history of the cases.

Our second task is to control for the large number of potentially confounding background conditions as they affect the outcomes of our cases. The experimental method can control certain variables and test hypothesized relations among other variables by *situational manipulation* of data, whereas comparative analysis of historical data must do so by *conceptual manipulation*. In our comparison, we seek to maximize control by converting a large number of potentially confounding background conditions into parameters. Following Alexander Gerschenkron's (1962) formulation, it is the *world industry leader* at a given historical moment that defines the development pressures and constraints for industry followers. We argue in chapter three that the emergence of IBM as the hegemonic firm in the international computer industry in the late 1960s - early 1970s permits us to "hold constant" many conditions affecting the relatively backward populations of nationally-based firms in France and Japan during our period of analysis. Given the dominant position of IBM in Japanese and French markets, and the similar timing of policy programs in those countries, we will show why many conditions affecting the cases, such as the characteristic of technical requirements and market pressures confronted, can be treated *as if* they were the same (hence, *inoperative* as variables) in order to isolate and to evaluate the influence of a smaller number of conditions on the dependent variables. Our empirical cases have been selected in such a way as to minimize the variance of the control variables.

The third task is to isolate the relevant operative variables, and to evaluate their effect, both singly and in combination with others to explain causal patterns and outcomes. As we are interested in a dynamic analysis - how the cases develop over time - this requires the systematic introduction of parameters, variables, and combinations of these into models of industrial change. Consequently, this paper is also concerned with contemporary theories of industrial change. In chapter two, four categories of explanation will be considered: (1) Market competition (Schumpeterian) explanations; (2) Market-failure and

Administrative guidance explanations; (3) Technology and organization of production (Contingency) explanations; and (4) Institutional explanations. Since few available theories are as yet clearly or fully enough formulated to permit rigorous testing, the main purpose of the theoretical chapter is to direct the empirical enquiry toward potentially relevant variables and their relationship to each other as they impinge on market behaviour and outcomes. Particular attention will be focused on how each theoretical category defines the *mechanism* of industrial change to accomplish the dual tasks of isolating the relevant variables and how they may combine to produce certain causal patterns and outcomes.

One may object to our strategy of controlled comparison on the grounds that the *N* of the deviant case is so small that it is difficult to know which of the many respects the deviant case differs from the majority of cases is the crucial one. One may conclude that for this reason deviant case analysis is not as powerful as the statistical and other comparative methods (See for example, Neil Smelser, 1973). To this criticism, we reply that the small *N* of the deviant case in this sort of controlled comparison *need not* be representative in the statistical sampling sense in order to contribute to social science theory development. In contrast to the statistical correlative approach, we seek to identify *contingent conditions* under which each *distinctive* *type* of causal pattern occurs, rather than to address the question of *how often* each outcome and/or causal pattern does occur or can be expected to occur. The rationale that guides our selection of cases is not numbers but *variety;* that is, cases belonging to the same class of phenomenon that differ from each other. This type of strategy is useful for developing a more *differentiated* or typological theory of a particular class of political-economic phenomenon, rather than frequency distributions. The purpose of a more differentiated theory is to identify and to explain *contingent generalizations* and *systematic variations* in a given class of phenomenon. In other words, the critical question addressed is: what *combinations* of conditions generate what kinds of causal patterns and outcomes? What matters is the intersection of conditions, what J.S. Mill calls "chemical causation". I believe that this approach not only has greater explanatory power for complex social aggregates, but also greater *practical value* for policy analysis because it permits more discriminating diagnosis of emergent situations. The potential contribution of a differentiated theory is to be distinguished from general theory that aims at prediction. Our purpose is to interpret the meaning of past events in order to better identify and inform current choice situations rather than prediction.

CHAPTER TWO

THEORETICAL PERSPECTIVES ON INDUSTRIAL CHANGE

1. MARKET COMPETITION (SCHUMPETERIAN) EXPLANATIONS.

One of the most influential explanations of industrial change is derived from Joseph Schumpeter's (1942) analysis of market competition at the micro-level of firm behaviour. Schumpeter saw capitalism as an evolutionary process of "creative destruction" in which the competitive environment consists of a series of technical innovations by dominant firms that "incessantly revolutionizes the economic structure *from within*, incessantly destroying the old one, incessantly creating a new one." (Schumpeter, 1987 edition:83-4) Schumpeter's major contribution to theory consists in his treatment of technological innovation and the strategic behaviour of firms as *endogenous* factors of market competition. These factors are generally excluded from, or abstracted away under the *ceteris paribus* assumption of, neoclassical models of market competition.

As elaborated by contemporary economists, market competition through technical innovations at the micro-level of firm behaviour is seen to be the principal mechanism of industrial change. This dynamic view of competition involves continuous investments in technology creating a sequence of temporary monopolies on new products, with rents earned on existing products financing the investments required for the next round of innovation (Flamm, 1988:4). This is particularly important to the computer industry where new generations of products have emerged regularly, and at increasingly shorter intervals.[1] The more rapid the pace of technical innovation on the production-side, the higher the elasticity of substitution between old and new products on the demand-side; this feeds-back into greater pressure on producers to compete through accelerated innovation (Dosi, 1981; Kuwahara, 1984). Given sufficient qualitative differentials between succeeding generations of products (for example, measured in terms of price/performance of computer systems), a newly introduced product is usually more cost-effective for the user than the product it replaces.[2] The user will consequently replace the existing product when the potential return from productivity increases of a new product surpasses the remaining undepreciated cost of the existing product (Kuwahara, 1984:42). This behaviour of product-users in turn has a direct bearing on the strategic behaviour of producing firms; R&D project cycles must now be shorter and

1. For example, the average product life-cycle of mainframe computers has been reduced from 8-10 years in the 1960s to 3-5 years in the 1980s. The product life-cycle of components, such as integrated circuits, is even shorter, sometimes measurable in terms of *months* (Kuwahara, 1984:42).
2. With respect to new generations of computer technology, the cost-savings effect for users can be quite dramatic. Technological change reduced the cost of mainframe data processing from $1.20 (US) per instruction set in 1970 to just $0.01 per instruction set in 1983 (Anderla & Dunning, 1987:16).

continuously repeated and capital investment amortized more quickly to stay abreast of the competition. The next product then will require the cycle to be repeated.

In contrast to neoclassical economic theory, there is no assumption that this type of competition will return the market to a state of "equilibrium". Each new cycle of competition represents a *qualitative departure* from the previous one, which accounts for the *evolutionary* nature of market competition not captured by the static equilibrium models of neoclassical economic theory. Firms that want to remain in business must continue to innovate - have follow-on projects "in the pipeline" - lest they be trapped in producing obsolescent products that fewer consumers want, resulting in lost market share and decreasing returns for the firm. A further contrast with neoclassical economics is also instructive. Under Schumpeter's conception of industrial change, price competition is no longer seen to be the dominant explanation for competitive differences between firms. Far more important is being first on the market with a superior product and advancing rapidly along the learning-curve. Changes in prices and quantities do occur, but they are, in the first instance, a by-product of qualitative advances in production processes and outputs, which are the results of the innovative behaviour of firms and not a result of the fact that markets are not cleared. Under conditions of intense product competition and rapid technological change, the best price competitive efforts of technology imitators or "free-riders" could be repeatedly frustrated if the innovator maintains a flow of process design innovations related to new generations of products.

2. MARKET-FAILURE/ADMINISTRATIVE GUIDANCE EXPLANATIONS.

A second category of explanation for industrial change can be found in the "market-failure" literature.[3] The market mechanism (current movements in prices and quantities) is generally regarded as more efficient for guiding resource allocative decisions than government or bureaucratic guidance. In certain situations, however, the market fails to direct a "socially-optimal" amount of resources for a nation's industrial development and growth. (This will be elaborated below.) In such situations of market-failure, it is argued that government intervention at the micro-economic level can help to redirect resources and investment activities to produce welfare-improving results.[4] Three types of market-failure affecting the (1) R&D, (2) production, and (3) marketing stages of the computer industry have been identified in the literature:

3. Analysts in this category tend to be "methodological individualists" in the sense that the basic unit of analysis is the individual entrepreneur or firm as a rational actor.
4. It is important to stress that government intervention, as conceived here, is not intended to be "market-displacing" as in command economies. Rather, government intervention functions as a "corrective mechanism" to market imperfections resulting from the unintended consequences of collective action. According to this perspective, government is more properly conceived as an "encompassing institution for collective action" (Mancur Olson, 1985).

(1) *Public goods characteristics of basic R&D.*

Basic or generic R&D information, once invented, resemble public goods. They represent a potential resource from which many can benefit, but for which few are willing to pay. We can shed more light on this problem by examining it from the perspective of Public Choice theory. Basic research is likely to generate *general and diffuse benefits* (positive externalities) for the national economy as a whole. But individual entrepreneurs or firms are reluctant to invest in basic research given that the benefits of this new knowledge cannot be completely appropriated by *individual agents* who pay the initial costs and absorb the risks for generation of such knowledge.[5] An innovator in effect confers a positive externality on other producers, who can imitate the innovation at a cost lower than the cost of original discovery, or on consumers, who benefit from the lower prices that results from such competition (Kotowitz, 1985:4). Because the public benefits are far in excess of privately appropriable benefits, private incentives and private investment for such research is likely to be too small to be socially optimal. Put differently, market

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5. The patent system is designed to mitigate the "appropriability" problem by conferring property rights in the innovation on the innovator. However, the *enforcement* of patent rights is notoriously difficult, especially across national jurisdictions. Numerous studies have shown that most businesses do not place much faith in the patent system for protecting their proprietary rights (See M.J. Peck, 1986:223).

signals cannot relate general and diffuse interests (future national growth potential from basic R&D) to concentrated special interests (short-term profitability signals facing individual firms). It is the cumulative, long-term effects that are important for a nation's industrial competitiveness. In the worst case scenario, the rate of new domestic investment for R&D may decline relative to foreign producers until foreign competition forces domestic producers to exit the market.[6] Government policy that provide selective R&D incentives for private firms can induce comparatively higher aggregate levels of R&D activity than is otherwise possible through reliance on market incentives alone.

(2) *Imperfect information in growth industries.*

Most investment decisions for growth industries are made on the basis of imperfect information about future demand. As a result, growth industries are plagued by wide investment fluctuations, alternating between periods of supply shortages and excess capacity. When demand suddenly increases, the market mechanism has no signal to tell some firms to invest to meet new demand and others to refrain

6. For example, the dramatic loss of market share by American semiconductor firms to Japanese firms during the 1980s (particularly in the memories market) has sometimes been explained in these terms (Borrus *et al*, 1982). Whereas US firms were investing at least three times as much as Japanese firms in the early 1970s, investment by the latter (especially since the government sponsored VLSI project) have exceeded spending by the former by 1984 (Langlois *et al*, 1988:47).

from investing; if all producers rush to invest, the result will be excess capacity, duplication of efforts, and wasteful competition. This can drive down profit margins of all firms in the industry, leaving them with few resources to invest when demand later picks-up. Economists from J.M. Keynes (1947) to G.B. Richardson (1960) have argued that the uncertainty surrounding individual investment decisions is a prime cause of destabilizing investment fluctuations and unstable growth. This has important implications for public policy. Government coordination of investment to meet demand may be necessary to provide firms with enough information on which to base their investment decisions and to stabilize growth (Richardson, 1960:49, 68-70)

(3) *Transactions-costs of computer systems producers.*

The transactions-costs perspective focuses on the costs incurred during exchanges of goods and services across corporate boundaries. The market mechanism ("real-time" movements in prices and quantities) work well for "spot contracts" where goods and services are exchanged on the spot - for example, exchanges of money for commodity in hand. They fair less well, however, when transactions involve *future values*. Computer makers, for example, find it difficult to make contractual agreements by detailed specification of their final systems products in advance because such products are dependent on inputs of other components undergoing rapid technological change (David

Teece, 1988). No single computer systems producer has the "in-house" capability to produce the full range of components that go into a final system product but must depend, in varying degrees, on external suppliers. When exchanges involve future values, market governed transactions make it difficult for systems producers to predict a stable cost/revenue structure, resulting in potentially costly contingencies for production and investment planning.[7] In such situations, *organizationally-mediated transactions* become a less costly alternative to market transactions (Oliver E. Williamson, 1975). The firm can economize on transactions costs it would have incurred on the open market by joining a cartel, a group, or some other inter-firm cooperative arrangement that provides greater predictability regarding the terms of exchange. However, cartels are inherently unstable. Self-enforcement of cartel agreements is difficult because of the potential for opportunistic behaviour ("cheating") among individual members (Williamson, 1975:242-5). In short, cartels provide significant transactions-costs savings for members, but this alone cannot ensure their long-term stability. This has

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7. Some theorists suggest vertical-integration (defined as expanding in-house or captive production of components and other system "inputs") may be an attractive solution to account control. However, steadily rising costs in R&D and component manufacturing have made this option prohibitively expensive compared to outsourcing. Even IBM has increasingly outsourced for many of its components and intermediate technologies, despite the fact that it reputedly has the resources to focus solely on captive production.

important implications for public policy. Some analysts have argued for looser government interpretation of anti-trust legislation, and concomitant government support of cartels to provide greater predictability regarding the terms of exchange, particularly as they relate to computer and related information technology industries (See David Teece, 1988).

3. TECHNOLOGY AND ORGANIZATION OF PRODUCTION SYSTEMS: CONTINGENCY EXPLANATIONS.

A third category of explanation for industrial change focuses on corporate adaptation to the demands of their technology and technical environments. We can benefit from the established sociological literature on organization and administrative behaviour, particularly the work of "Contingency theorists" who concentrate on the problem of uncertainty in the production process.[8]

Contingency theorists argue that technical considerations have priority over economic considerations; before we can know the costs of and potential returns from doing something, we must know *whether* and *how* something can be done (Thompson, 1967). In industries characterized by

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8. In contrast to economic explanations that conceive of the "firm" as a profit-seeking, profit-maximizing phenomenon, the Contingency perspective conceives of the firm as a *socio-technical system*, consisting of an interface between non-human and human elements organized for the purpose of production (Trist, 1981).

rapid technological change and high degrees of technical uncertainty, technological considerations are said to have *causal priority* over economic considerations in determining the organization and strategy of corporate behaviour, and the general direction of change in the industry at large.[9]

According to this perspective, industrial change is fundamentally concerned with the *coalignment* of organizational structure with the demands of technology into a viable domain of production activity. A few definitions are in order. Technology is defined as the *non-human aspects of production* that may include the characteristics of inputs, transformative machinery, and outputs. Organization structure - here defined as the patterning and differentiation of behaviour - is coterminous with *production activity control*, such that the most appropriate structure will match the type of technology and technical environment confronted by the firm (J.D. Thompson, 1967; Lawrence & Lorsch, 1967). Contingency theory posits a recurrent tension within the firm. On the one hand, predictability is required for controlling work processes to ensure the effectiveness of task performance; on the other hand, technological contingencies reduce the predictability of work flows, resulting in control loss that jeopardizes

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9. If one were to conceptualize the direction of industrial change as bounded by technical and economic parameters, then technical considerations would occupy the upper bounds of those parameters.

the effectiveness of task performance. This tension gives rise to a dynamic administrative process, and is chiefly responsible for structural change in production systems.

James D. Thompson (1967) argues that technical contingencies are not *randomly distributed* throughout the firm; There is an *identifiable structure* to the location and magnitude of contingency demands that provides a pattern to which the firm can systematically adapt itself for effective performance. Two general and seemingly opposing dimensions of technology are said to be crucial for predicting the magnitude of contingency demands on the firm. They are: (1) *Complexity* - defined as the degree of differentiation and specialization of components or elements of a system; and (2) *Interdependence* - defined as the degree of "connectedness" among components or elements that make up a system. In principle, the degree of technical complexity and interdependence can be *measured*, such that *patterned variation* of technology along these dimensions will suggest *systematic ways* to (re)structure the organization for effective performance. The predictions are as follows:

(1) Increasing technological complexity multiplies the location of contingency demands for the firm i.e. more "surprises" can appear to disrupt work flows. A rational administrative response to technological complexity calls for a *reduction of formalization and hierarchy* in the

organization of R&D and production, and the creation of semi-autonomous divisions or sub-units to permit localized handling of technical contingencies as they arise. In other words, increasing technological complexity requires a corresponding degree of structural complexity - an increase in structural differentiation and functional specialization of work processes.[10]

(2) When technology and organizational structures become more complex, this creates additional problems for coordination and integration of sub-tasks. In general, it tends to diversify the location of decision-making, while limiting their individual impact on overall task performance, thus making it necessary to bring in increasing numbers of specialized persons or groups involved in increasingly complex decision-making processes. Jay Galbraith (1973) argues that the technologically complex organization will develop *lateral connections* among sub-units to minimize information processing and overload on the hierarchical structure. The development of lateral connections allows more direct flows of information among structurally differentiated, functionally specialized, and reciprocally interdependent sub-units than "up and over" through hierarchical channels. In this way, differentiated

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10. This principle underlies the evolution from "functional" or unitary forms of corporate organization to the creation of "product-based" or multi-divisional forms (Alfred Chandler, 1962).

and specialized work units are able to communicate their requirements and respond to the needs of each to facilitate effective coordination of overall task performance.

The period of our study encompasses the transition from third generation to fourth generation computer systems technology, a transition towards greater technological complexity (Levin, 1982; Flamm, 1988). We might therefore expect that computer systems manufacturers will devise increasingly differentiated and specialized work units to manage the contingencies posed by their technology. Furthermore, the human work processes required to integrate the elements of a computer system have become increasingly interdependent - towards a pattern of *reciprocal* interdependence (Levin, 1982; Peck, 1986). We might also expect that computer manufacturers will devise lateral connections between highly differentiated and specialized R&D and production groups within the firm.

4. INSTITUTIONAL EXPLANATIONS.

The three categories of explanation discussed thus far share a common element. The firm engaged in Schumpeterian competition, corporate adaptation to technology, and government intervention in situations of market-failure, all attempt to explain industrial change primarily from the perspective of a single or focal organization. Even analyses that presumably focus on population-level conditions - such as the market-failure/administrative guidance perspective - do not fully implicate the situationally-embedded nature of relations among units in their analyses. The "market environment" is often characterized in atomistic terms of an amorphous, faceless mass of competitors, resource pools, potential partners, and regulators.

Institutionalists stress the larger, more inclusive organizational arrangements - variously described as "policy-networks" (Katzenstein, 1978), "state-societal structures" (Hall, 1986), and "national systems of innovation" (Freeman, 1987) - that aggregate the endeavour of many actors in particular ways. These more inclusive "system-level" structures are said to play two crucial roles: First, each market actor's behaviour is constrained by the actions of others, that is, by the institutional settings presupposed by their collective interactions (Hall, 1986). Secondly, and equally important, an actor's perspective position within those institutional settings conditions which aspects of the external world are likely to be perceived as meaningful and of interest to the actor, and thus, the likely direction of its behaviour. These structures generate imperatives of their own, independent of technological and economic change, which can be powerful determinants of policy and market behaviour in their own right.

Most institutionalists adopt what might be called an "historical-structuralist" perspective. The path of industrial development over time is said to be constrained by the domestic structures of a nation-state. Such domestic structures are seen to be the cumulative product of prior commitments and political struggles in a nation's history, and are said to be largely resilient to change (Katzenstein, 1978; Hall, 1986). According to Peter Katzenstein, "Except in the most extreme circumstances, *negotiations on current issues in the international political economy will probably reflect, rather than reshape these historically-evolved domestic structures.*" [Emphasis added] (Katzenstein, 1978:323-4)

The general conjecture is that distinctive patterns of economic response and policy characterize different nations. Countries will tend to respond in defined manners, in a few similar ways, to a wide range of problems. The long-term mix of solutions vary less than the problems. When the solution fits the problem there is a policy success, but it is hard to build a solution if the problem requires an approach outside the bounds established by the domestic structure of political-market relations. Consequently, nations are said to embody *defined capacities* for generating solutions to certain problems of industrial development, and distinctive weaknesses for others. From a dynamic perspective, nations with different domestic structures are said to be on *distinct trajectories* or divergent paths of industrial development.[11]

In applying this conception to our analysis, Japan and France are said to share similar historical traditions as *mercantilist nations* that persistently seek dynamic comparative advantage in high-growth, high value-added sectors through strategic state intervention, largely unimpeded by domestic complications or by foreign pressures that may arise (Stoffaes, 1986:38-40; Zysman & Tyson, 1989). These countries are said to share two crucial institutional features that make strategic industrial development possible. First, Japanese and French state institutions are often paired together as the strongest of the mixed capitalist states. Both states, it is frequently argued, have had stable ruling conservative coalitions favouring rapid economic growth for much of the period after 1945, and a centralized administrative apparatus largely insulated from undesired influences and staffed by a mandarin elite. Secondly, Japan and France are said to share similar power

11. A frequent corollary is that some nations are said to enjoy a comparative advantage in international trade of manufactured goods by virtue of their domestic structures. Whereas traditional (Heckscher-Ohlin) trade theory teaches that national comparative advantage is the result of differences in fixed factor endowments (defined in terms of capital, labour, and natural resources), some institutional analysts argue that domestic structures can *create* comparative advantage by influencing the *direction* in which those factor endowments are put to use by national economies over a period of time (Zysman, Tyson, & Dosi, 1989).

structures in the national economy that facilitate state guidance in the development of strategic industries.[12] Although there may be several variations of the strategic "industry targeting" argument, the general hypothesis can be summarized in this manner: The mercantilist state seeks to protect the home market for a technology deemed to be "strategic" so that the growth of demand enables a domestic firm to achieve economies of scale and efficiency by advancing along the learning-curve. This form of industry protection entails the denial of market access to foreign and particularly to American producers, and active state support for domestic firms until the latter achieves international cost and quality levels.[13] At the point of competitive equivalence, domestic firms begin their export drive for overseas markets and the domestic market is opened.

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12. The institutional mechanism for targeting of strategic industries is often explained through the peculiar nexus of organized relations between the state, banks, and industrial firms. John Zysman (1983) characterizes Japan and France as having "credit-based financial systems with state administered prices" that facilitates a pattern of "state-led" growth. Although not clearly stated by Zysman, the power of the state is relative to the needs that other domestic market actors have for the financial resources that it could command, compared to other sources in the domestic economy, and its willingness to exchange those resources in return for influence over those market actors. Through the mechanism of the financial system, the Japanese and French state are said to be powerful enough to alter the terms of domestic market competition to create the outcomes it favours.
13. See for example Henry Rosovsky (1985) "Trade, Japan and the Year 2000", New York Times, September 6. A similar argument is made by John Zysman and Laura D'Andrea Tyson (1989).

Since the late 1980s, a new group of scholars have challenged the historical-structural perspective which has dominated institutionalist conceptions of political-market behaviour for some time. The "revisionists" (for lack of a better term) argue that domestic structures are subject to continuous negotiation and greater variability over time than was previously supposed. National patterns of industrial change and outcomes are said to be neither consistent nor predetermined by historically-derived institutions because of contingent and uncontrollable factors that turn policy-making into an independent, trial by trial process of collective bargaining and learning (Samuels & Levy, 1991). Consequently, many paths to industrial development for a given nation are possible; National development trajectories are said to be non-linear or multi-linear. Past history is a limited guide to predicting the structure of a nation's political-market relations, its capacity to respond to current situations, and the future trajectory of industrial development.

The revisionists present a less unified and less strategic state in so-called "strong-state" countries such as Japan and France, and one prospectively more responsive to domestic and international pressures (Samuels, 1987; Calder, 1990). Greater pluralism in the domestic policy process is emphasized, as are the increasing number of transnational linkages between domestic firms and their foreign counterparts, particularly in the dynamically competitive high-technology industries, that tends to frustrate the mercantilist aims of the state (Langlois *et. al.*, 1988). Foreign governments and multinationals can adopt counterpolicy to negate the effects of the strategic industrial policies of mercantilist states. Furthermore, they argue that the increasing complexity and costs of generating high-technologies (such as computers) necessitates exchanges of technical expertise and a level of demand that can only be achieved on a global scale. The rapid pace of technological change, and the need to quickly amortize high front-end development costs, no longer allows domestic companies the luxury of testing the home-market before probing abroad. In other words, attaining international cost and quality levels for high-technology industries requires the simultaneous development and integration of domestic markets with foreign markets.[14] An industrial policy that seeks to close-off domestic markets to nurture a strategic industry, even for a temporary period, is impractical and self-defeating.

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14. For a discussion concerning this issue, see "Introduction" in G. Heiduk & K. Yamamura (eds.) Technological Competition and Interdependence, Seattle: U. of Washington Press, 1990; and Robert Gilpin (1987), chapters 5 & 10, in The Political Economy of International Relations, Princeton: Princeton U. Press.

The main conceptual disagreement between the "historical-structural" and "revisionist" perspectives centres on the extent to which domestic industrial policies and political-market structures can *create* comparative advantage. The issues range from the practical possibility of shifting profits from foreign to domestic firms to the magnitude of possible gains. In computer technology, American industry has been preeminent, with comparative advantages that translate into major opportunities for American companies in Japanese and French domestic markets. The Japanese and French government had strong industrial policy reasons to seek outcomes in tension with the major American computer firms. In understanding how American companies interact with the strategic industrial policies of Japan and France, one thus has an important test of the effectiveness of Japanese and French policy and the responsiveness of domestic structures to international pressures, particularly with respect to the development of strategic computer technology.

CHAPTER THREE

THE JAPANESE AND FRENCH COMPUTER INDUSTRY IN THE CONTEXT OF INTERNATIONAL COMPETITION (late 1960s - 1970s)

The transformation of the Japanese and French computer industries during the late 1960s and early 1970s are neither wholly unique nor isolated events, but represent different national responses to similar pressures originating in the international computer industry. This chapter begins with a discussion of IBM's rise to hegemonic status on international computer markets, with a focus on how this giant multinational had fundamentally redefined the parameters of competition for all industry followers for at least a decade following the late 1960s. The discussion will then turn to a brief examination of how the changes in the international market have affected national market conditions in Japan and France during the same period. It will be argued that the new competitive environment characterized by IBM's hegemony on international markets had imposed fundamentally similar types of market opportunities and constraints for the Japanese and French computer industries. The rise of IBM as world industry leader by the late 1960s - early 1970s would set the initial context for strategic policy choices in response to similar problems, making this period a "crucial conjuncture" in the development history of the Japanese and French computer industries.

3.1: THE EMERGENCE OF IBM AS THE HEGEMONIC FIRM IN THE INTERNATIONAL COMPUTER INDUSTRY

Seldom in the history of modern business has a single American company come to dominate such an enormous share of the world market for a technology deemed to be of strategic importance to industrialized economies. In 1966, IBM held 70% of the US computer market, 73% of Germany's, 50% of Britain's, 74% of France's, 40% of Japan's (but 60% by *value* of sales), and 80% of Italy's.[1] IBM consolidated its leadership over the following decade such that by the mid-1970s, it controlled some 65-70% of the world market for computers, and derive over 50% of its total revenues from markets outside of the United States (Flamm, 1988:101).

IBM's introduction of the System 360 line of general purpose computers in 1964 is generally regarded as the company's true beginnings as the international industry's acknowledged leader. The System 360 was the world's first "third generation" computer produced for commercial applications that used integrated circuits instead of discrete transistors that characterized second-generation

1. When the comparison is made by the value of computers, Japan falls sharply to fifth position, indicative of the Japanese industry's weakness in producing sophisticated computers in the higher-end of the market compared to the Europeans and Americans in the late 1960s (See A.J. Harman, 1970:19).

machines. Furthermore, the System 360 was considered "revolutionary" compared to other computers in use at the time because it employed a computer architecture that was flexible enough to perform both high speed numerical computations (what are now called "scientific" applications) and manipulate large volumes of character data quickly ("business" applications). These technical innovations gave IBM the initial lead to exploit the booming general purpose business computing market, which began to supercede the military and space applications market in the 1960s.

IBM marked another important milestone by introducing the first integrated, world-wide strategy for manufacturing and marketing the System 360 that would create the world's single largest unified market for mainframe computers. IBM had already moved toward a world-wide operation when it established its World Trade Corporation in 1949 to oversee its international business in punch card machines and other office equipment, but it was not until the introduction of the System 360 - with its standardized mainframe architecture and operating systems software aimed squarely at the business applications market - that IBM first began to draw heavily both on the resources of its foreign R&D and production facilities, and the advantages of its extensive international marketing and service network.[2] By the mid-

2. In the early 1960s, IBM was producing six different and incompatible lines of computers, and successful competitors offering superior price performance to several IBM machines

1960s, all aspects of IBM's computer manufacturing operations, marketing, and services were geared toward a single international market. Research and development, component production, and systems assembly were allocated among different units around the globe, based on relative costs, availability of specialized resources, and local preferences for different models of the System 360 in different countries (See A.J. Harman, 1971:20). IBM became a "total systems vendor" *par excellence*, and it achieved this on an international scale. Other American computer manufacturers - such as RCA, GE, and Honeywell - also shifted outwards into international (primarily European and Japanese) markets, but none managed to achieve the same degree of global integration in manufacturing and marketing as IBM. Furthermore, IBM did not rest on the laurels of its initial success with the System 360, but maintained continuous and heavy investments related to new generations of products, plowing-back an average of 50% of net income into R&D since the mid-1960s, that kept its competitors scrambling to keep pace (Flamm, 1988:86). Thus, five years after the introduction of the System 360, IBM introduced the System 370, with three to five times the price-performance

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began to appear. IBM remedied this situation by standardizing the operating systems software and computer architecture for its System 360 line of computers that enabled the company to benefit from economies of scale in production and break new ground in lowering the cost of computing. As we shall see, this would create substantial constraints for IBM's competitors in the mainframe market.

of the older 360 machines (measured by the cost of processing one million instruction sets per second).

The intensity of competition precipitated a shake-out of the American computer industry by the early 1970s that would solidify IBM's dominant status on international markets. Shortly after IBM's announcement of the System 370, two major competitors in the international industry - General Electric (GE) and the Radio Corporation of America (RCA) - withdrew from the computer business citing their unwillingness to continue to invest in the high cost of development.(Sobel, 1986) With the departure of RCA and GE, IBM controlled 70% of the world market in 1971 while its nearest placed competitor in mainframe business computers, Honeywell, controlled just 8%. IBM continued to enlarge its world market share throughout the 1970s as other companies retreated from the general purpose mainframe business computer market, then the largest and most lucrative product segment of the market. By the mid-1970s, things had settled into a fairly stable pattern, with IBM dominating the mainstream of business computing and several well-established but smaller firms nibbling at the margins in emerging markets not covered by the umbrella of IBM's product line.[3]

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3. Companies such as Apple (micros), Digital Equipment Corporation (minis), and Cray (super computers) would establish themselves on the market before IBM could mount a response.

3.2: EVOLVING PARAMETERS OF COMPETITION IN THE INTERNATIONAL COMPUTER INDUSTRY.

Commercial applications of computer technology had been introduced on a limited scale in the 1950s, but because of the early emphasis on military and government procurement markets, it took almost twenty years for the economic fundamentals shaping competition in the commercial industry to become established, and at least another decade for these forces to work to full effect. In the 1950s and early 1960s, military and government users had paid premium prices for their technology, and cost considerations had been subordinated to performance considerations (OECD, 1985:18). As the technology improved by the mid-1960s, costs not only came down, but the business applications market began to supercede military and government procurement markets. As a result, the economic fundamentals shaping competition in the commercial industry also changed. The central player in this change was IBM. The following will discuss some of the constraints acting on competitors in the commercial computer industry during the late 1960s and 1970s.

THE TECHNOLOGY-DRIVEN NATURE OF COMPETITION

Competition in the computer industry requires competitors to at least match the quality and pace of innovation set by the industry leader IBM. Companies that emphasize a strategy of undercutting the price of IBM products on the market without keeping pace with IBM in technology would be repeatedly frustrated. IBM has countered with a continuous stream of technical improvements throughout the 1960s and 1970s related to new generations of products, and with large differentials in price-performance, that have rendered technologically less sophisticated products obsolete.[4] Furthermore, it is important to point out the *direction* of technological change and how this has affected the pattern of competition during the period of our investigation. The major advances in computer hardware has occurred in two areas: (1) improvements in computer architecture - how the parts of the system are designed, connected and controlled; and (2) the basic physical components with which the system is built. By the late 1960s, most of the "great ideas in computer design" for the standard von-Neuman serial processing architecture had been proposed; thereafter, companies that introduce innovative changes to the serial processing architecture would only lead to marginal improvements in the price-performance of computers (Flamm, 1988:12). Instead, semiconductor components came to be viewed as the crucial bottleneck for further advancement in computer hardware performance. Incorporating leading edge components into final systems

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4. The rapid pace of technological change has resulted in an average yearly decline of 25-30% in the real cost of computer hardware in relation to processing speed (Anderla & Dunning, 1987:16).

products became the *sine qua non* for competitive price-performance on the market.

TECHNOLOGY STANDARDS

The intimate relationship between computer software and the hardware for which it is designed (essentially an issue of "compatibility") has been a key technical link shaping competition in the computer industry. In the 1960s and 1970s, most software were written in codes specific to a manufacturer's system. The highly complementary nature of hardware and software makes it difficult and costly for computer users to transfer applications between systems based on different proprietary standards. Consequently a user's purchase of a particular system begins to resemble a life-time commitment; as the user's needs change, it is generally less costly to purchase new hardware and software based on the same proprietary standard rather than to switch to a new system based on a different standard. This fact has enabled IBM to use its proprietary technology standard as a competitive weapon to "lock-in" existing customers and to "lock-out" alternative suppliers over time.

ECONOMIES OF SCALE

The computer manufacturing industry is both R&D and capital intensive, where economies of scale become an important factor for shaping competition. The high and relatively fixed sums spent on R&D and capital equipment argues for reaching out to the largest possible market to reduce unit costs, and to rapidly amortize initial investments through volume sales for new product innovation.

In this respect, IBM enjoyed a major advantage over most of its competitors in the 1960s and 1970s. IBM, by virtue of its size and integrated world-wide strategy created for the System 360, was able to make its proprietary standard in mainframe architecture and operating systems software the *de facto* world industry standard by the early 1970s. The follow-on System 370 was fully compatible with the older 360 software and peripherals, as were subsequent generations of IBM machines. The enormous cost reductions in software and hardware achieved through standardization and economies of scale in marketing and production fed-back into an increasing demand for IBM computers throughout the 1970s (Flamm, 1988). IBM had found the formula for linking a user's information processing costs in the most direct possible way to the size of IBM's market. Success reinforced success such that by the early 1980s the world mainframe market became one of austere simplicity: IBM-compatible and non-IBM compatible. The non-IBM compatible share of the world market dropped from 34% in 1971 to just 15% by 1983 (Kuwahara, 1984:68). IBM controlled 90% of the IBM-compatible market.

Historically, the least effective strategy against IBM has been to offer a line of mainframe computers based on a unique proprietary standard because their much smaller market share in relation to IBM has driven up unit costs of both hardware and software.[5] Sperry Rand (UNIVAC) and Honeywell, for example, had to beat a retreat into military markets as their business users defected to the IBM camp throughout the 1970s. Many firms employing this strategy have failed and no firm has clearly succeeded in challenging IBM in its bread-and-butter business mainframe market.

EMERGING MARKETS AND STRATEGIES IN THE 1970s

Despite these daunting constraints, however, there were important developments during the same period that signalled potential opportunities for mainframe producers willing to work within the prevailing patterns of international competition.

First, anti-trust pressure led by the US Justice Department forced IBM to unbundle its sales of software from

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5. An important exception to the rule has been competition in the higher and lower end of the market not covered by IBM's System 360-370 product line (such as micro, mini, and supercomputers). In the late 1960s and 1970s, IBM's smaller computer systems were not compatible with its larger mainframes. This openned "niches" for non-IBM compatible makers to compete against IBM on a more level playing-field, and to establish themselves before a response was mounted.

hardware in the early 1970s. This openned a niche for IBM competitors to make so-called "plug-compatible-machines" (PCMs) that would be capable of functioning in a similar way to IBM machines when plugged into an IBM system. Ironically, the establishment of the IBM-standard as the *de facto* world industry standard has also made significant economies of scale available to other companies besides IBM. The PCM strategy has the advantage of allowing the producer to tap into IBM's large customer base without the costs and uncertainties of cultivating a new one. And to the extent that a PCM strategy renders heavy expenditure on independent software development unnecessary, more resources can be directed toward hardware improvements - especially superior components - to compete with IBM through superior price performance.[6] RCA made the first steps in this direction during the late 1960s, although its machines were not entirely compatible with IBM machines. RCA withdrew from the computer business in 1971, leaving the field to other enterprising companies, such as Amdahl (and later Fujitsu and Hitachi), to improve on the PCM strategy.

Secondly, it was known in the industry at the time that IBM was not particularly strong in the area of semiconductor

6. The potential savings from not having to develop software independently are quite substantial as software development costs had risen from 8% of computer manufacturer's total development expense to 40% in 1965 and 50% by 1970. Furthermore, the large existing stock of applications software written for IBM machines makes IBM-compatibility more attractive to users.

manufacturing technology, despite the fact that the company was (and remains) the world's single largest producer and consumer of semiconductor components (Flamm, 1988:233). Semiconductor manufacturing technology therefore represented a weakness for IBM which competitors could target during this period.

Third, computer, telecommunications, and semiconductor technologies began to converge by the late 1960s (especially with the introduction of time-sharing applications). This represented another specialized niche market for mainframe producers that are organized to exploit the increasing complementarity between these technologies. Computers specialized for telecommunications applications was a market niche in which IBM had been slow to exploit, perhaps because the company was deterred or constrained by the dominant presence of ATT and its large research arm, Bell Laboratories, in the US telecommunications market.

Finally, the convulsions in the international computer industry in the late 1960s and early 1970s left many small computer makers around the world vulnerable to the challenges from IBM. At the same time, however, this represented an opportunity for these companies to forge international alliances to exchange their relative advantages in specialized knowledge and resources to compete against the common threat. The complex "system" nature of computer technology suggests an intricate division of labour among many firms is possible. However, technology and economic considerations do not determine corporate strategies. As our case studies will show, the primary obstacles to this strategy in the 1960s and 1970s were political, as foreign alliances would contradict many national policies that had an explicit bias toward "indigenous" technology development.

In summary, IBM had fundamentally redefined the parameters of international competition by taking the lead early in the growth of business computing and drawing the boundaries of its large market around its proprietary technology standard. This created serious constraints for existing and potential competitors in the computer industry. Nonetheless, there was an identifiable range of strategies that competitors could pursue. There was more than one strategic response to IBM, but the range of viable responses was limited by IBM's hegemony on world computer markets.

3.3: THE PERSPECTIVE FROM JAPANESE AND FRENCH DOMESTIC MARKETS IN THE EARLY 1970s: A CRUCIAL CONJUNCTURE FOR POLICY DECISIONS.

Two major trends at the regional market level show Japanese and French computer producers were confronted with similar market opportunities and constraints. The first trend was the rapidly growing commercial market demand for computers in Japan and Europe that outstripped the rate of demand growth in the United States (Jequier, 1974:197). Projections at the time showed the Western European market would grow by 62% between 1973-76 as against 50% for Japan, and 37% for the United States. Equally significant, by 1973 the total value of computer installments in Europe had reached the same total ($6 billion) as that in the United States. The total number of mainframe and minicomputers in use in Japan and France would triple in the five year period between 1970-74 (Flamm, 1988:135). Thus, Japanese and French companies were presented with a potentially lucrative opportunity given the high demand growth rate for computers in their respective national markets.

The second major trend of the early 1970s, however, appeared rather bleak from the perspective of those same domestic companies. American multinationals launched a new commercial offensive in Japanese and French computer markets - spearheaded by IBM's announcement of the Systems 370 in 1970 - that began a steady erosion of domestic makers' share of the market throughout the first half of the 1970s (Flamm, 1988:135). This pattern was repeated in British and West German computer markets where national companies - at one time rivalling American companies for world leadership in technology - were now beating a hasty retreat. Far from taking the commercial offensive of their own, Japanese and

French companies were thinking more in terms of retrenchment and short-term survival.

The crucial policy questions in the early 1970s were *whether* to attempt to seize a portion of the rapidly growing market for domestic industry or to yield this market to the multinationals, and if the former choice is taken, *how* to do it given the weakness of domestic firms in relation to the multinationals.

From the perspective of national governments, the computer industry was important not only in its own right, but it became a symbol of a perceived lag in the nation's ability to produce the technology-intensive goods at the forefront of economic growth. Governments' desire for national autarky in computers has resulted in a bias toward "self-sufficiency" in technology development that would, at least in the short term, disregard prevailing patterns of international competition. National governments have been willing to sacrifice short-term national consumption opportunities ("static-efficiency" gains) through reliance on foreign technology in the gamble that resources diverted to national technology development would generate comparatively higher rates of return and growth for the nation's economy over time ("dynamic-efficiency" gains). The problem was that the governments' preferred strategy carried a high degree of uncertainty and risk that the domestic companies - the would-be instruments of government policy - were not always willing to accept.

From the perspective of business, the "national origin" of technology was less of a concern as long as that technology contributed to their narrower concerns of profiting from the rapidly expanding computer market. Corporate desire for commercial success has led to a preference for interdependence with foreign companies for both technology and markets as a solution to their competitive problems. There were several reasons for this: First, the increasing complexity of computer systems technology had, by the early 1970s, resulted in a situation where no single national market - let alone a single firm - has complete comparative advantage or expertise in producing the full range of components, sub-systems, and process technologies that contribute to final systems products. Acquiring technology from foreign sources became critical for their catch-up efforts. Secondly, the economics of investment characterized by high and relatively-fixed sums spent on R&D argued for reaching out to the largest possible market to lower unit costs and to achieve the greatest possible return on initial investments. This meant that a domestic and international strategy of competition had to be pursued simultaneously. Finally, superimposed on these conditions is the dominant presence of IBM, whose successful penetration of national markets and unified global business strategy reinforces the international orientation of corporate competition and end-user markets. The obstacles that prevented companies from pursuing an international strategy however were financial and political. In the early 1970s, Japanese and French firms needed large infusions of financial resources just to remain in the competitive race, resources that only the state would be willing to provide and which, if accepted by the companies, would subject them to the desiderata of national governments.

National governments and business therefore needed each other as instruments to realize their own particular objectives, but neither could initially agree on the appropriate strategy for development. The convulsive changes in the international computer industry, characterized by IBM dominance, presented substantial constraints as well as opportunities for competitors willing to work within those constraints. Fundamental changes in the terms of market competition provided the initial impetus for the transformation of the Japanese and French computer industries. But the *direction* of domestic change has been the product of a recurrent tension between government and business over the appropriate strategic response to these external challenges. We contend that this has been the primary tension behind industrial change in Japan and France. How this tension played out in the late 1960s and early 1970s, and the *modus vivendi* reached between national governments and business during this crucial conjuncture would have profound consequences for industrial organization, orientation of corporate strategy, and market outcomes in the decade that followed.

CHAPTER FOUR

THE JAPANESE COMPUTER INDUSTRY

4.1: MARKET STRUCTURE IN THE LATE 1960s AND PRELUDE TO CRISIS.

The Japanese computer market in the late 1960s was characterized by the implantation of American subsidiaries that dominated the most sophisticated product segments of the computer market, and a collection of medium to large sized domestic firms that grew to capture a share of the less sophisticated product segments with the help of licensed American technology and active intervention by the state. Among the American subsidiaries, by far the largest was IBM-Japan, which established itself in the Japanese market just one year before the enactment of the Foreign Capital Law (1950) that restricted foreign investment into the country. IBM-Japan began production of computers for the Japanese market in the early 1960s, capturing and maintaining the largest share of that market (approximately 30-40%) for close to two decades. Other American firms that came after IBM (such as GE, RCA, Honeywell, NCR, Sperry Rand, and Burroughs) captured an additional 10% of the Japanese market in the 1960s.

Among the Japanese companies, three major computer producers consisting of Fujitsu, Hitachi, and Nippon

Electric Corporation (NEC) controlled approximately 35-40% of the domestic market in the late 1960s. Three relatively minor producers - Tokyo Shibaura (Toshiba), Mitsubishi-Electric, and Oki - controlled another 15-20% of the domestic market. Like many of their European counterparts, these companies were vertically integrated into other manufacturing activities with varying degrees of specialization in computers. Unlike their European counterparts, however, Japanese computer producers were neither defence contractors nor business equipment makers; rather, they began as telecommunications, consumer electronics, and heavy electrical equipment producers.

Since the early 1960s, the Japanese government actively encouraged these firms to diversify into computer manufacturing. Primary responsibility for administrative oversight of the domestic computer industry was assigned to the Ministry of International Trade and Industry (MITI) under the 1957 "Electronics Industry Development Provisional Act", which targeted electronics as a priority for Japan. The government also permitted selective exemption from the Antimonopoly Law, allowing MITI, and later NTT (the national telecommunications monopoly), to establish R&D and production cartels. Between 1961-69, the Japanese government provided domestic computer firms with a total of $132 million (US) in direct subsidies and tax benefits, and $410 million (US) in government-backed loans. Much of these loans had come from "quasi-public banks" - especially the Long-term Credit Bank of Japan (LTCB) and the Industrial Bank of Japan (IBJ) - that received special priviledges in return for cooperation with government policy.[1] The total amount of public financial assistance was not particularly large in comparison to European or American government assistance to their computer industries. Nonetheless, it was equivalent to 188% of what the six Japanese companies had invested themselves in computer R&D, plant and equipment during the same period (Anchordoguy, 1989). Government procurement of domestic machines between 1961-69 amounted to about 25% of total production by domestic firms. In addition to these measures, the government actively promoted a policy of import-substitution by restricting the number of import licenses issued and pressuring Japanese computer users to purchase or rent domestic machines despite their comparative inferiority to foreign machines. Formal quotas and tariffs on imported computers remained in effect throughout the 1960s and early 1970s. However, these concerted efforts by the government did not appear to have

1. The LTCB and IBJ are permitted to hold up to 5% of a company's shares, which identifies them as "public-policy" banks. These banks receive other priviledges such as government permission to exceed the stipulated deposit reserve/lending ratio. The LTCB and IBJ have been key suppliers of capital to the two largest computer firms - Fujitsu and Hitachi - and for setting up MITI-sponsored institutions (such as the Japan Electronic Computer Company). The third largest computer maker NEC is a member of the Sumitomo *keiretsu* (business group) that has its own *keiretsu*-affiliated bank; Consequently, NEC has been less dependent on MITI and the quasi-public banks for capital (Anchordoguy, 1989).

affected Japan's large trade deficit in imports of the most advanced computer technology. In 1972, for example, Japan's imports of computer technology exceeded exports by eight fold.

Japanese computer companies remained technologically backward in the late 1960s despite a prior decade of government protectionism and promotion. Most relied heavily on technology that was licensed or copied from American multinationals. Hitachi linked up with RCA in 1961, NEC with Honeywell in 1962, Toshiba with General Electric in 1964, Mitsubishi-Electric with TRW in 1962, and Oki with Sperry Rand (Univac) in 1963 (Anchordoguy, 1989:25). The exception was Fujitsu, which made the earliest commitment to manufacture computers of its own design.[2] Many of the so-called "domestic" computers were Japanese name plates slapped onto equipment assembled from imported components and sub-assemblies (Flamm, 1988:184). Overall, this type of unilateral technology transfer had a negligible impact on the ability of domestic firms to narrow their technology gap with the multinationals during the 1960s. On the contrary, it may have constrained Japanese response times. The patents supplied by the multinationals seldom divulged technical information that was of strategic importance, and Japanese licensees were not permitted to introduce machines

2. Fujitsu would later abandon its independent effort by linking up with the American company Amdahl in 1972 to build IBM plug-compatible machines.

adopting the latest architecture developed by their American partners until well after the American partner had announced their new product lines (Flamm, 1988:181-2). Japanese licensees were not permitted to export their production under the terms of their licensing agreements, effectively confining five of the six Japanese companies to the national market. Moreover, the large number of foreign partnerships in the Japanese industry - and the large number of technologically incompatible standards that this entailed - severely hampered efforts to develop an effective national R&D strategy in the 1960s. Although MITI and NTT had sponsored national R&D projects during the 1960s in an effort to improve the technological capability of domestic firms, the diversity of technical standards employed by domestic firms had dispersed limited resources across too many applications to have been effective in competing against the large multinationals.

Nonetheless, a partial cartelization of domestic producers was achieved at the marketing/distribution-end through the creation of the Japan Electronic Computer Company (JECC) - a centralized leasing company jointly capitalized by government and the six private firms - that provided a single venue through which 65% of domestic machines were rented or leased between 1961-69. No similar institution exists in Western Europe or the United States. The JECC provided the single most important, albeit imperfect, vehicle for collective action in the domestic industry during the 1960s. In the late 1960s, 80% of Japanese computer users prefered to rent or lease rather than to buy computers (A.J. Harman, 1971:30). The JECC reduced transactions-costs of producers by directly purchasing their machines and leasing them to customers, thereby relieving producers from the burden of setting up their own separate distribution network and having to act as a banker to leasing customers. Producers eventually had to buy-back their machines from the JECC at the end of the leasing period (minus depreciation), but in the interim, they received a lump-sum cash payment in advance for their machines rather than smaller incremental payments over a period of time. This was important in the 1960s when firms operated under extremely tight margins and required quick returns on their investment to plow back into follow-on projects. Secondly, and perhaps more importantly, the JECC functioned as a price cartel that ensured domestic machines produced by the six firms would be priced some 40% below the product offerings of the multinationals (Anchordoguy, 1989). The rationale behind this strategy was that if domestic firms could not compete against the multinationals through superior technological innovation, then they would compete through lower prices. In essence, the JECC devised a common product pricing strategy for the domestic industry as a whole, to compensate for the lack of an effective national R&D strategy, in order to compete against the multinationals.[3] In this way, Japanese producers were able to increase their collective market share from 27% of total domestic installments in 1961 to 60% in 1970. The apparent success of this strategy is tempered by the fact that Japanese producers were concentrated in the less competitive, less sophisticated, and lower value product segments of the computer market. American multinationals continued to dominate the more sophisticated and higher-value end of the Japanese market well into the 1970s. As we shall see, even the modest market gains achieved by Japanese computer firms proved to be rather tenuous and difficult to maintain as a new wave of American technological innovation swept through the international computer industry by the early 1970s.

Very schematically then, the structure of the Japanese computer market in the late 1960s can be summarized as consisting of two distinct but technologically interrelated populations of computer producers. The first consisted of US-based multinationals, led by IBM, that was an integral part of a highly competitive and dynamic international industry. These foreign-based companies were concentrated in the most sophisticated and higher-value product segments of the Japanese market. The other consisted of domestic firms that were partially insulated by government from the

3. Japanese companies would gradually wean themselves from the JECC as they attained technological parity with the multinationals after the mid-1970s.

full brunt of international competition, but at the same time, remaining highly dependent on the international industry for transfers of technology. With government assistance, Japanese companies carved out a share of the domestic market using licenced technology that was at best second-rate; nonetheless, these companies had compensated for their technological weakness by formulating a collective pricing strategy (managed by the JECC) that made domestic machines "competitive" by pricing them well below the product offerings of the multinationals. This market arrangement lasted throughout the 1960s as part of a government-business strategy to establish a domestic presence in computer manufacturing, but attempts to maintain it became increasingly untenable by the early 1970s.

3.2: TECHNOLOGICAL CHANGE & MARKET UPHEAVAL: THE TURMOIL OF THE 1970s.

The two main commercial strategies adopted by the Japanese computer industry in the 1960s - an emphasis on low price competition to compensate for their technologically inferior products, and a heavy reliance on licensed technology from a diverse number of American partners - began to unravel by the early 1970s as a result of two developments in the international computer industry.

First, a new generation of computer technology with superior price performance, originating in the US industry, eroded any competitive advantages that the low-priced Japanese products may have previously enjoyed on the market. IBM was among the first American companies to introduce a "3.5 generation" line of general purpose computers, the System 370, that incorporated large-scale integrated circuits (LSI) for its processor, a main memory that also consisted of integrated circuits (instead of the then predominant magnetic coil technology) resulting in larger memory capacity and faster access times, and "time-sharing" applications that significantly reduced central processing unit idle times. Japanese computer producers did not have technological parity with IBM's *previous* generation of System 360 computers, let alone the more sophisticated System 370, which had three to five times the price performance of the System 360. Japanese computers were a full generation (4-6 years) behind this new technology in the early 1970s. After IBM's announcement of the System 370, the JECC became flooded with trade-ins of domestic machines as customers flocked to IBM machines that offered them significantly more computing power per yen spent. The problem was compounded by the sharp upward revaluation of the yen in the early 1970s which made domestic machines even less attractive compared to imports. Between 1970-75, Japanese computer makers would lose approximately 15% of their share of the domestic market to the multinationals, particularly to IBM. It was clear that Japanese computer technology had fallen behind to such an extent that lower product prices could no longer compensate for its inferior quality.

Secondly, the Japanese computer industry's heavy reliance on licenced technology from a diverse number of American partners had, by the late 1960s and early 1970s, exposed it to the market convulsions in the American industry that witnessed the departure of several American computer firms, resulting in a serious disruption of technology flows to their Japanese partners. Shortly after IBM announced its system 370, the American multinationals RCA and GE withdrew from the computer business, casting adrift their Japanese partners - Hitachi and Toshiba, respectively. The American firm Honeywell purchased GE's computer division and decided to switch to the GE standard for computer architecture and operating systems software. This would have been good news for GE's former partner Toshiba, except for the fact that Honeywell was already allied with Nippon Electric Corporation (NEC), a competitor to Toshiba. And as Honeywell had decided to switch to the GE standard, NEC also found itself with an orphaned technology. Mitsubishi-Electric's former source of technology, TRW, sold its computer business in the late 1960s, which led Mitsubishi scrambling for a new American partner. Fujitsu and Oki were not affected by the disruption in corporate alliances (the former relied on its own technology while the latter maintained ties with Sperry Rand), but they were equally threatened by the new generation of technology that swept through the industry.

Thus, the early 1970s was characterized by market confusion and retrenchment in the Japanese industry as companies groped to understand how to deal with the convulsive changes in the broader international market environment that also threw their own domestic market into turmoil. Despite the best efforts of the Japanese government and business, they had failed to hive-off the domestic industry from the pressures of international competition or to change the terms of competition to their advantage. Japanese computer producers were at their most vulnerable point in their historical development. However, a new policy alternative to deal with the rapidly changing technological and market situation was not immediately available. It would take another crisis, this time a political one, before a major revision of computer industry policy would occur.

4.3: THE CHANGING POLITICAL CONTEXT OF JAPANESE INDUSTRIAL POLICY PLANNING.

Coinciding with the computer market upheavals of the early 1970s were fundamental changes to the Japanese industrial policy-making system. New political tensions emerged in the broader institutions of industrial policy-planning and within the state administrative bureaucracy that would result in a major revision of government policy toward the computer industry, and alter the pattern of state-business relations that had characterized the previous decade.

THE UNBUNDLING OF "JAPAN INC."

By the late 1960s, Japan's centralized coordinated policy system of the high-growth period (roughly spanning 1955-70) came under increasing external and internal political pressures that precipitated its unbundling toward a more decentralized and fragmented structure after 1970 (T.J. Pempel, 1987; D. Okimoto, 1989). Ironically, many of the pressures that forced these changes were the direct outgrowth of the policy-system's very success in helping to transform Japan into a major industrial and trading nation. Japan's entry into the OECD and GATT in 1964, and its growing balance of trade surplus after 1968, led to increasing foreign (primarily American) pressures on the country to liberalize its domestic market to imports. Foreign lobbyists, both governmental and private, became more numerous and vociferous in the Japanese policy-process.

Domestically, the pressures for change were more complex. The rapid growth of the domestic economy had, by the late 1960s, freed many financially strong Japanese companies from the tight confines of administrative oversight and guidance from the Bank of Japan, Ministry of Finance, the city banks, and MITI. The ability of many Japanese companies to ring up large profits gave them increased flexibility to finance their operations through their own resources rather than to rely on government administered debt financing. Many companies would now balk at government's attempts to impose administrative guidance on their activities.[4] In addition, many Japanese companies - such as those in auto and consumer electronics manufacturing - also began exporting in large volumes to international markets; the prospect of foreign trade retaliation if Japan did not liberalize its markets would seriously hurt these companies. Consequently, Japan's internationally competitive export industries, along with their allies in the government and bureaucracy, sided with the foreign lobbyists in pushing for deregulation, freer trade, and rapid adjustment to international economic pressures. The problem, however, was that growth did not

4. For example, three of the six computer producers - Hitachi, Toshiba, and Mitsubishi-Electric - were giant consumer electronics and heavy electrical equipment makers with sales of five to ten billion US dollars per year in the 1970s. Computers accounted for less than 10% of their total sales. Fujitsu and NEC had sales of between two to three billion dollars per year. Computers accounted for approximately 65% of Fujitsu's sales and 25% of NEC's sales (Martin Fransman, 1990:295).

occur evenly across all industrial sectors. By the early 1970s, some industries underwent severe retrenchment as a result of the quadrupling of oil prices (for example, the aluminium smelting industry), competition from newly industrialized countries (textile and ship-building industries), and rapid technological change from abroad (computer and telecommunications equipment industries). Industries that suffered or would suffer from greater trade liberalization, and their allies in government and the bureaucracy, pushed for greater bureaucratic regulation, protectionism, and government assistance to ease the pain of adjustment.

Under these divergent pressures, it became clear that the computer industry policy of the 1960s, and the pattern of government-business relations it had engendered, could no longer be maintained in its existing form. The prime minister, certain factions within the governing Liberal Democratic Party, and parts of the national bureaucracy favoured the immediate liberalization of the domestic computer market (Anchordoguy, 1989). The Ministry of Finance found it politically difficult to justify continued public subsidies for the computer industry at a time when Japan was entering its most severe economic recession since the post-war period. Japanese banks were reluctant to continue to plow money into the domestic computer industry whose survival was uncertain in face of the renewed technological and commercial offensive launched by the multinationals. On the other hand, the prospect of liberalizing the market to computer imports, without any compensating aid to the domestic industry, would have been devastating to Japanese computer firms who were already retreating from competition with the multinationals under the existing protected market arrangement. The computer firms were reluctant to abandon their business built-up during the 1960s that market liberalization would imply, and to forego the opportunity to profit from the rapidly expanding domestic demand for computers. This feeling was shared within parts of the government bureaucracy - particularly among MITI, MPT, and the national telecommunications monopoly NTT - who recognized the broad future potential of this industry. Together with the domestic computer manufacturers, they lobbied against liberalizing the computer market.

After extensive consultations and negotiations that included business leaders, the government bureaucracy, and academics, a new national policy was devised in 1971 that reflected a delicate political compromise between the competing "pro-liberalization" and "protectionist" interests in the policy process, and at the same time, marked a major shift in Japanese industrial policy. Formal trade barriers that protected the domestic computer industry in the 1960s would be dismantled, with import quotas on computers to be eliminated by 1972, while tariffs on those same products would be gradually reduced over a five year period. The state would relinquish its role as "gate-keeper" to the domestic computer market by the end of 1975. At the same time, however, the policy reaffirmed government support for the computer industry with an emphasis on renewed government funding for national R&D projects. The justification for this government support was formalized in MITI's 1971 "Report on Industrial Policies in the 1970s", which envisioned the Japanese economy shifting away from "energy-intensive" industries and shifting into "knowledge-intensive" industries, with an indigenous capability in computer technology playing a central role in this transition.(Yamamura & Yasuba, 1987) The computer industry was recognized as promising not only in itself, but that it would play a prominent role in developing other industries at the leading-edge of economic growth. The quadrupling of oil prices in the early 1970s, and the resulting deep economic recession that witnessed the painful restructuring of the "energy-intensive" manufacturing sectors only made this argument more politically acceptable. In essence, the new policy linked the survival of the domestic computer industry to the future security and health of the nation's manufacturing economy as a way of achieving political consensus to support that industry.[5]

5. Evidence of the shift of government policy toward "knowledge-intensive" industries can be found in the spending priorities of government. From 1972-75, high-

Total subsidies and tax benefits to the computer industry during the first half of the 1970s reached an estimated US $632.4 million (Anchordoguy, 1989:102). This amount was equivalent to 56.7% of what the six computer firms were investing themselves in R&D and plant and equipment during the same period. When combined with the US $1.2 billion in government-backed loans, the $1.8 billion in total aid in this period was equivalent to 168% of what the firms were investing themselves in R&D and plant and equipment.

The problems did not end here, however, as there was little agreement as to what the policy would mean in operational terms. As we shall see, questions regarding how the computer industry should be structured, which government ministry should administer the the national R&D programs, and what should be the appropriate relationship between Japanese companies and foreign companies would not be fully worked-out until the policy implementation stage.

CHANGES IN THE ADMINISTRATION OF GOVERNMENT POLICY.

By the late 1960s, MITI would lose its monopoly for administrative oversight of the computer manufacturers as

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technology industries (including the computer industry) was the *only* category that increased as a percentage of total subsidies from 1972-75; In comparison, subsidies were slashed for coal and shipping industries and small and medium sized enterprises (Anchordoguy, 1989:102).

the Ministry of Post and Telecommunications (MPT), and especially NTT (the national telecommunications monopoly, a public corporation overseen by the MPT), began to take an active interest in those companies.

One major source of tension between MITI and NTT stems from the fact that the three principal computer manufacturers - Fujitsu, Hitachi, and NEC - (including the minor player Oki) also belonged to the "NTT-family" of telecommunications equipment suppliers. Rather than focusing on a vision of the broad needs of the computer industry, NTT has largely pursued its own agenda with telecommunications applications topping its priorities which sometimes conflicted with those of MITI.[6]

By the late 1960s, the increasing complementarity of computers, telecommunications, semiconductors, and software technology (now collectively known as the "information technology sector") resulted in greater overlap of administrative responsibilities between MITI and NTT, leading to jurisdictional battles for administrative

6. NTT's most important role after 1970 has been in the development of semiconductor technology. Its laboratories are considered by analysts in the US Office of Technology Assessment as one of the most important resource in Japanese semiconductor R&D (Flamm, 1988:199). Commercial products that have emerged from joint research by companies and NTT include 16K, 64K, and 256K memory chips. NTT has also been a big customer for, and influence on the development of large-scale computers oriented toward time-sharing applications through the NTT (or Dendenkosha) Information Processing System program (DIPS) that was initiated in 1968.

oversight of the same principal group of companies that straddle the telecommunications and computer manufacturing industries. Since 1968, every MITI-sponsored R&D project has been matched or exceeded by NTT, who finances R&D projects out of its own enormous budget that is separate from the government budget, and is therefore not subject to the restrictions and oversight of the tight-fisted Ministry of Finance (Samuels & Levy, 1991:137). In addition, NTT has been a major purchaser of equipment from its "family" of companies. NTT spent a total of $13.3 billion (US) on procurements from 1965-75 (Anchordoguy, 1989). Since 1968, 70% of NTT purchases were from Fujitsu, NEC, Hitachi, and Oki. NTT bought 60% of each of these firm's telecommunications production.

From the perspective of the companies, they were not only confronted with a divided administrative effort to guide them, but most crucially, they became less dependent on the resources and political discretion of any single public organization, despite the fact that their overall dependency on public funds remained high during this period.

4.4: REORGANIZATION AND RETRENCHMENT (1971-75).

Beginning in 1971, the Japanese government in conjunction with the six companies began the arduous process of restructuring the domestic industry. The government's response to the looming crisis in the computer industry was two fold. First, it would "rationalize" (consolidate) the industry by applying pressure on the six companies to merge their fragmented computer divisions into a unified national effort to compete against the foreign companies. Secondly, it would plow new money into a national R&D project - the "3.5 generation computer project" - in an effort to close the technology-gap with the multinationals. As we shall see, a consolidation of the domestic industry would be achieved and Japanese companies would attain technological parity with American computer companies by the mid-1970s. However, this was accomplished in a way that was very different from that intended by the government.

CONSOLIDATION THROUGH "CONTROLLED COMPETITION": ESTABLISHMENT OF A PRODUCER CARTEL.

At the beginning of the 1970s, three major computer makers - Fujitsu, Hitachi, and NEC - and three minor computer makers - Toshiba, Mitsubishi-Electric, and Oki - were dividing half a market that was a fraction of the size of the US market, with each firm attempting to produce a complete and competitive range of models based on incompatible proprietary standards. The government felt that this market fragmentation prevented the domestic industry's long-term survival. Both MITI and the Ministry of Finance wanted to use administrative guidance to merge the existing companies into two or three larger companies (Anchordoguy, 1989:105). Government pressure to merge these companies began in earnest in 1971.[7]

Almost immediately the firms decried MITI's efforts to merge their computer operations, and thereafter, a prolonged process of negotiations and bargaining between MITI and the firms ensued. It soon became clear to MITI and the MOF that the six companies were not willing to merge their computer operations, and that they were incapable of forcing the companies to do so.[8] In the end, the government pushed mergers never occurred. However, the companies were forced to compromise with MITI for several reasons: their deteriorating market position, the threat of impending market liberalization, the reluctance of private banks to plow more money into the domestic computer industry, and the desire of the companies to remain in the computer market had forced the companies into a dependency relationship with government. The $600 million (US) government aid package provided MITI with sufficient leverage to force the companies to the bargaining table and agree to a restructuring of the industry.

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7. MITI's and MOF's attempt to consolidate the computer industry through mergers was part of a general government strategy to increase corporate concentration in the manufacturing economy during the late 1960s and early 1970s.
8. Marie Anchordoguy (1989) suggests that the *keiretsu* (business-group) affiliations of these companies represented a major structural impediment to MITI's attempts to merge these firms.

The six producers reluctantly agreed to form three informal groupings from their fragmented computer divisions while maintaining their formal independence from each other. Each grouping, consisting of two firms, would focus on a line of compatible computers of a size and type that would not directly compete with the product lines of the other groupings. Furthermore, within each group, the partners initially agreed to divide the task of developing different sized models that would contribute to a full product line for the group, further reducing direct competition among domestic companies. This MITI-sponsored cartel, what the Japanese refer to as "controlled competition", essentially divided the market into specialized and imperfectly substitutable product segments that would, in theory at least, become the exclusive domain of each firm. Equally important, the product segments assigned to each firm were intended to be *complementary* with those assigned to the other firms; while no single firm would produce the entire range of machines, they would as a collective supply a "full product line". Thus, while competition was reduced among domestic companies, it was at the same time directed "outward" in a more or less unified way against the multinationals. This was the government's method of accomplishing its political goal of forging a unified national response to the foreign computer companies.

This producer cartel would be coordinated by MITI and supported by generous government funding through the "3.5 generation project" (1972-76) - so named because it was intended to provide a direct commercial response to the IBM System 370, a "3.5 generation" computer. Additional funding came from the NTT (Dendenkosha) Information Processing Systems (DIPS) project, which ran concurrently with MITI's "3.5 generation project". The machines to be developed for NTT's project were fundamentally the same as the "3.5 generation project" machines with some modifications for telecommunications applications (Anchordoguy, 1989:121). Through the DIPS project, NTT funnelled an additional $15 million (US) in research money to the top three Japanese companies (Fujitsu, Hitachi, and NEC), and equally important, promised large procurements from those same companies.

Fujitsu and Hitachi, the two largest and most technologically advanced companies, were consigned to build the largest and most sophisticated machines under the auspices of MITI's "3.5 generation computer project", an "M-series" of IBM plug-compatible machines (PCMs). Together, they received 45% of the public funds (Samuels & Levy, 1991). Initially, under MITI's insistence, Fujitsu and Hitachi agreed to a divide the "M-series" line of computers into different product segments to avoid direct competition with each other's products, the reason being they would together present a "full product line" of complementary products against IBM. Fujitsu would produce the largest and smallest models, and Hitachi would make two intermediate sized machines. The first machines were announced jointly in 1974, but cooperation thereafter did not last long as neither firm could resist the temptation to "cheat" on their production and marketing agreement. By 1975, both companies developed new models in direct competition with those that were supposed to be the exclusive province of the other (Flamm, 1988:195). These companies found it increasingly difficult to cooperate and eventually went their own separate ways.

The NEC-Toshiba team were assigned medium to small sized computers under MITI's project, and received 40% of government funds. They produced a line of computers using the "ACOS" operating system based on the Honeywell standard (which in turn was based on the old GE standard), but Toshiba chose to drop out of the mainframe business after the end of the project. NEC continued to develop new operating system and architecture. After the mid-1970s, it began to carve out a specialized niche emphasizing integration of telecommunications and computer applications.

The least technically advanced team consisting of Mitsubishi-Electric and Oki worked on a line of smaller computers, the "COSMOS" series (based on Sperry Rand's

UNIVAC architecture), and received 15% of government's funds allocated to the "3.5 generation computer project". Mitsubishi did commercialize a line of computers but it did not sell particularly well on the market. Oki failed to commercialize its results from the project, and because of this, it would be dropped from MITI's VLSI project. Both these companies would withdraw from the mainframe computer business and retreat to smaller and less sophisticated industrial control computers and peripherals.

STRATEGIC FOREIGN ALLIANCES: LINKING UP WITH IBM'S COMPETITORS FOR ADVANCED TECHNOLOGY.

A major goal of the government's "3.5 generation project" was to promote indigenous research within each informal corporate grouping. In practice, however, cooperation between the companies not only proved difficult, but it appears that the firms had continued to rely heavily on American technology rather than on indigenous innovation during the first half of the 1970s. Although total R&D spending by Japanese computer companies had tripled in the first half of the 1970s (Flamm, 1988:194), the closing of the technology-gap with American companies by the end of the "3.5 generation project" was largely achieved through strategic foreign alliances for technology, pursued independently by the companies, and to the dismay of MITI.

Contrary to MITI's expectations, the Japanese companies had reached out to American partners to help design their computer architecture and operating systems software. But in contrast to the 1960s where Japanese companies had arranged technology transfer through licensing agreements in which there had been little or no contact between the licensor and licensee, this time Japanese companies had forged strategic production and marketing agreements with American computer companies who saw IBM as their principal threat. For example, Honeywell - IBM's principal American rival in mainframe computers - provided substantial technical assistance to the NEC-Toshiba team in the design of their computers, and would eventually market NEC machines under its own nameplate. The "ACOS" series of computers developed by the NEC-Toshiba team shared very similar architecture and operating systems software with Honeywell's 60 series machines (Anchordoguy, 1989:117-8). Hitachi also received valuable information from its American partner RCA on how to build IBM-compatible machines before RCA left the computer business in 1971.

The most important international alliance in the first half of the 1970s was between Japan's top computer maker Fujitsu and the Amdahl Corporation of the United States. Amdahl Corporation was founded in 1970 by Gene Amdahl, a former chief computer designer for IBM. Amdahl was thoroughly knowledgeable about IBM's Systems 360 and 370 architecture and decided he could design and build a plug-compatible central processor (CPU) and attach it to peripherals that were already being manufactured by other plug-compatible manufacturers. Amdahl's entry onto the market was facilitated by IBM's decision to unbundle its sales of hardware from software as a result of anti-trust pressure in the United States. Thus, it was now possible to compete against IBM's bread-and-butter product lines by concentrating resources on the CPU development without having to make heavy investments to build all parts of the system - particularly the software, which by 1970 accounted for about 50% of the total cost of manufacturing a system.[9] Amdahl ran into financial difficulties in the early 1970s. He first approached Hitachi - which was previously allied with RCA for technology and thus knew something about manufacturing IBM-compatible machines - but Hitachi turned down his proposal. He then openned discussions with Fujitsu, Hitachi's rival. At the end of 1972, Fujitsu agreed to provide $54 million in exchange for 24% of equity in Amdahl and access to Amdahl technology.(Flamm, 1988:131-2) The R&D was mostly done at Amdahl's Silicon Valley facilities, while Fujitsu in Japan undertook the actual

9. According to Kenneth Flamm, the Amdahl strategy improved on RCA's flawed attempt at plug-compatibility by sticking exactly to the IBM design while following RCA's path in using leading-edge components to offer superior price performance to IBM. As we shall see, the Japanese companies would also adopt this strategy through the knowledge gained from the VLSI project in the late 1970s (Flamm, 1988:131).

manufacturing. The first Amdahl-Fujitsu system was installed in 1975 and became an immediate success.

MITI was not pleased with the Fujitsu-Amdahl venture because it deviated from the government's strategy of creating a computer industry based on indigenously-developed technology. Fujitsu had been favoured by the Japanese government in the past because it had been the only domestic company to have pursued its own independent efforts to design computers. Despite MITI's consternation, Fujitsu had the backing of NTT (Anchordoguy, 1989:111-2). NTT was important as an additional source of funding through its DIPS project that ran concurrently with MITI's "3.5 generation" project. NTT also purchased some 60% of the telecommunications equipment production from its "family" firms. The fact that Fujitsu was part of the "NTT family" of producers increased the probability that a return on its investments in Amdahl could be made rapidly through product sales to NTT.

In total Fujitsu received approximately $48 million (US) in subsidies for the "3.5 generation project"; during the same period, it received $24.4 million in direct subsidies and $279 million in loans through JECC.(Anchordoguy, 1989) With its after tax profits plunging from $41.5 million (US) in 1972 to $20.3 million in 1976, it is highly unlikely that Fujitsu could have afforded to invest a total of $54 million (US) in Amdahl without public financial support.

By the end of the "3.5 generation project", Japanese manufacturers gained technological parity in hardware with American firms (particularly in mainframe architecture design), but not in the manner intended by MITI. This was accomplished primarily through: (1) strategic foreign alliances with IBM's major American competitors - Amdahl, Honeywell, Sperry Rand (UNIVAC) - who taught the Japanese companies how to improve their computer architecture; and (2) "controlled competition" in the domestic industry through the creation of a producer cartel that restricted competition among Japanese companies and directed their competitive energies outward against foreign companies, particularly against IBM. When the dust finally settled in the mid-1970s, the Japanese computer industry consisted of three chief players. Fujitsu and Hitachi opted to build IBM plug-compatible machines (PCM) as their business strategy. The third, NEC, also adopted a PCM strategy but based on the Honeywell standard and with an emphasis on specialized processors for the telecommunications niche market - an application that Honeywell ignored and in which IBM has historically been weakest. NEC's strategy of specializing in the telecommunications niche market ensured the Japanese company a solid footing in the emergent information technology industry, even as its American partner, Honeywell, suffered a steady decline throughout the 1970s as its mainframe business computing customers defected to IBM.

In a sense, the PCM strategies and the search for new market niches had been thrust upon the Japanese companies as they began the decade far behind the American companies in technology. Impending market liberalization also pressured the companies to take the fastest route possible to achieve technological parity with the American industry, which meant linking-up with American partners for technology where ever possible, even if this meant foregoing technological leadership in final systems products. The initial commercial success of the PCM strategy may have muted government criticism for abandoning the goal of building wholly Japanese designed computers. Nonetheless, MITI persisted in pushing domestic companies to strive for technological leadership in the mid-1970s. In a dynamic, fast changing industry as computers, gaining technological parity with the market leader at one point in time is an ephemeral victory if there is no follow-on strategy.

4.5: THE TECHNOLOGICAL AND COMMERCIAL OFFENSIVE (1975-79)

In the latter half of the 1970s, the Japanese computer industry would take the PCM strategy further in two major ways: (1) Emphasizing innovation in *process technology* for semiconductor components to overcome their initial disadvantage as technology followers in the design of final systems products; and (2) expanding into foreign markets through strategic alliances with American and European "plug-compatible-machine" vendors to escape the limits of the national market to which they had been confined since the 1960s. These two strategies were complementary. On the one hand, success in the competitive US and European computer markets would not have been possible without significant advances in production technology to produce the quality components that give final systems products superior price-performance. On the other hand, the rising front-end R&D and capital equipment costs of developing new component technology encouraged producers to reach out beyond their single-country market to reduce unit costs, and to rapidly amortize initial investments for follow-on product innovations. The fact that leading edge research into component manufacturing technology even took place at all was due largely to government funding of the VLSI project that the companies would otherwise not have engaged in because of the high costs and risks involved. But once again, there would be conflict between MITI and the companies over the structure of funding and how R&D should be organized.

"DISTRIBUTED COOPERATION" IN VLSI RESEARCH.

In a major departure from the technology imitation strategies of the 1960s, NTT and MITI initiated R&D projects to strive for leadership in IC production technology.[10] From the perspective of business strategy, this enabled PCM makers to gain an edge over the market leader in price-performance of final systems products through higher quality components rather than through pure price competition. Cooperative research projects, essentially institutions of "backwardness", would now be adapted for leading-edge research.

NTT had organized a three year project in 1975 involving three of its "family" firms - Fujitsu, Hitachi, and NEC - to research VLSI aimed at producing 64K-bit RAM chips for use in telecommunications. This was perhaps NTT's most significant contribution to the Japanese computer industry's development. Even though NTT's vision had been much more narrowly focused on telecommunications applications, the growing complementarity between computer and telecommunications technologies, and the fact that its

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10. Despite the importance of integrated circuits (ICs) for computer technology advancement, Japanese companies only began IC production in 1966, long after the Americans and Europeans began their production. Even then, volumes were very small, and Japanese IC production was neither significant nor sophisticated until the latter half of the 1970s when NTT, and later MITI, sponsored national research projects into very-large-scale integrated circuits (VLSI).

"family" of suppliers included the three principal Japanese computer makers, ensured that the results of NTT's VLSI research project would be rapidly diffused among the Japanese computer companies and give them the technological edge they needed to make the PCM strategy a long-term success.[11]

Shortly after NTT announced its VLSI project, MITI initiated a larger and more ambitious VLSI research project that was to last four years (1976-79) with the aim of producing chips with up to one million bits. MITI was not happy with NTT's intrusion into its policy domain and had tried to merge its own program with NTT's. NTT refused but agreed to share technology informally. Six research themes were chosen for MITI's VLSI project: (Borrus, 1988:127)

1. Development of microfabrication methods to handle submicron lithography, especially electron beam lithography.
2. Development of low-defect, large-diameter silicon wafer substrates.
3. Development of improved computer-aided design technology.
4. Development of improved LSI microfabrication processing techniques and equipment.
5. Development of VLSI evaluation and testing techniques and equipment.
6. Definition of logic and memory devices that could utilize 1-5.

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11. NTT's President Yonezawa admitted that a visit to Bell Laboratories in the United States had convinced him that Japanese companies had to catch up in VLSI manufacturing technology after seeing Bell's experimental design of a machine that used electron beams instead of the standard photo-exposure systems for drawing smaller circuits on silicon wafers (Anchordoguy, 1989).

As the list suggests, much of the VLSI program was aimed at catching up to the US industry's capabilities in advanced IC production technology.

MITI initially insisted that all firms should pool their efforts and resources into a joint laboratory. However, the firms insisted on choosing the most important themes for their own "in-house" research under normal conditions of company secrecy. The reasons for companies' opposition to joint research in joint laboratories had to do with the fact that they were both actual and potential competitors in many product areas influenced by VLSI. Furthermore, they were afraid other partners would "free-ride" on their efforts while making it difficult for the innovating company to appropriate the benefits of R&D results. Ultimately, MITI and the five computer companies (Oki was not included in the project) settled on a compromise solution by taking a two pronged approach to research organization. Some research would be conducted in joint laboratories involving members from several firms, but the majority of research would be conducted according to what the Japanese refer to as "distributed-cooperation" among the companies (Martin Fransman, 1990:80-81).

Under "distributed-cooperation", researchers from different companies do not work together (Samuels & Levy, 1991:129). Instead, each participant company assumes responsibility for a specific task as part of a larger project. Research is performed independently in each firm's own labs with the patents then shared through prior agreement negotiated between the companies, MITI, and NTT. This practice of "distributed-cooperation" suggests an exchange of roughly comparable, independently produced, and complementary technologies rather than genuine collaboration among research personnel from different companies. There are important political attributes to this form of research organization. Since technologies are generated independently, it is very difficult for a partner to do nothing while hiding behind the efforts of its partners. Distributed cooperation helps assuage fears of being victimized by "free-riders". MITI typically acts as the external authority to reward cooperation and to punish recalcitrants that do not adhere to prior agreements.

There were also important technical attributes to this form of research organization. Each company performs a relatively simple research task in-house which then becomes part of a much more complex technology when the results are exchanged and combined with other research results at the institutional level of inter-firm relations. By dividing up a highly complex project into simpler tasks among the companies, this has the effect of reducing the magnitude of uncertainty confronting each individual firm. For the most complex research themes, such as electron-beam and X-ray lithography devices for etching microcircuitry onto silicon chips, three separate teams simultaneous pursued different approaches to solving the same technical problem. Indeed, the VLSI project members tried a total of seven different ways to get the electron beam to draw patterns on a silicon wafer (Anchordoguy, 1989). Equally important, four joint laboratories were established to provide extensive lateral connections between private company labs, MITI's Electro-technical lab, and NTT's lab to exchange information. This mode of research organization is similar to that proposed by Contingency theorists for effective management of complex technology, except these structures had evolved at the *institutional level* of inter-company and government-business relations rather than within a firm.

Finally, there were important economic attributes associated with "distributed-cooperation". When positive results are achieved, they are made available to other project participants through prior negotiated agreement (essentially to exchange "future values") and at a comparatively lower cost than if R&D information were purchased on the open market. In other words, it helped to reduce the transactions-costs of members. In the event that no solution can be found, the costs of failure are spread among the project members.

The total cost of the VLSI project was ¥ 73.7 billion (approximately US $360 million), of which 40% was subsidized by government.[12] Only between 15-20% of this amount is allocated to the joint laboratories. The remaining 80-85% of the funds was allocated to research done primarily inside the individual participating companies (Fransman, 1990:80).

Generally, joint laboratories did not contribute as much to knowledge-stock of VLSI program. This was reflected in data concerning patents filed. VLSI project resulted in some 1000 patents, 59% held by individuals, 25% by groups dominated by people from one company, and only 16% by groups consisting of several member firms. However, joint laboratories performed an important *coordinative function* at the institutional level of inter-firm and government-business relations. Joint laboratories provided the lateral connections to hold together an extremely complex project, and it did this at the institutional level.

The VLSI project resulted in significant advances in production technology. The project developed the world's first variable-rectangular electron beam system, making it possible to manufacture chips having a line width of 1

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12. The US government spent a similar amount ($200 million) on its Very High Speed Integrated Circuit project (VHSIC) between 1979-84. While the US project focused on technology for military applications, the Japanese projects were concerned solely with commercial applications (Langlois *et. al.*, 1988).

micron. It was more accurate and faster - 1/100th the time - than conventional electron beam devices in use at the time (Anchordoguy, 1989:143-4). By the end of the project, they were able to draw line widths between 0.1 to 1 micron. Research on silicon crystals resulted in new methods to reduce impurities, minimize warping, and to obtain a more even chemical composition on the silicon wafer to reduce overall defects during the manufacturing process. For testing and evaluation technology, they developed a laser scanning device for detecting defects on patterns drawn on wafers, and an evaluation technology for oxide and nitride layers using liquid crystals.

ENTERING THE INTERNATIONAL MERCHANT MARKET FOR IC's.

To recover the high costs of VLSI research and to lower unit costs of components, producers could not rely solely on the domestic market but had to sell on international markets. Japanese entry onto the merchant market for ICs was greatly facilitated by the superior price quality of their components, which reflected advances made during the VLSI project. Many consumers, including Hewlett Packard, rated Japanese-made ICs as more reliable than many US-made ICs. The international computer industry's switch from magnetic core memory technology to IC memories during the

1970s gave Japanese companies an additional opportunity to apply their competence in process technology.[13]

During the first two years of the VLSI project, the major Japanese firms led by NEC and Fujitsu rapidly built up a distribution system for ICs in the United States. NEC and Fujitsu each developed extensive ties to a large number of US distributors, which gave them access to most regions of the country (Borrus, 1988:129). When demand for IC memories in the US market began to take off in 1978, Japanese companies were well placed to take advantage of the situation. From supplying only 1% of US consumption of ICs in 1976, Japanese firms were supplying 8% by 1980. A similar situation was repeated in Europe, where the Japanese share of the semiconductor market increased from 2% in 1977 to 10% in 1983, and 15% by 1986 (Borrus, 1988:196).

STRATEGIC ALLIANCES WITH AMERICAN AND EUROPEAN PCM VENDORS.

The final ingredient in the offensive strategy had to do with strategic alliances with American and European PCM

13. Memory ICs are relatively uniform in design (consisting of rows upon rows of nearly identical circuits etched on a silicon wafer) compared to more complex logic circuits; they are therefore particularly amenable to high-volume, standardized production. Japanese companies' expertise in high-volume production technology for IC components, gained from the VLSI project, gave them the initial lead-time advantage over their competitors in the computer industry. By dramatically improving the price-quality of their IC components, Japanese companies also achieved better price performance in their final systems products compared to IBM.

vendors to market Japanese-made computers. This was also a shrewd assessment by Japanese companies of the tight restrictions of entry onto foreign markets where incumbents enjoy advantages over newcomers. Japanese entry onto foreign computer markets was largely accomplished through Original Equipment Manufacturer (OEM) agreements, whereby foreign PCM vendors would purchase Japanese machines and market them in their home countries under their own nameplates.

In contrast to the 1960s where international corporate alliances usually meant unilateral technology transfers among unequal partners through licensing agreements, corporate alliances with foreign firms after 1970 involved a greater degree of reciprocity in market benefits and two-way technology transfer among corporate partners. In the case of the Fujitsu-Amdahl alliance, the American company Amdahl designed the computer architecture for Fujitsu's IBM-compatible machines to reach technological parity with IBM; in return, Amdahl received not only much needed capital infusion in the early 1970s, but also low cost, high quality components for its machines by the latter half of the 1970s as the results of the Japanese VLSI project began to bear fruit. The American companies Itel and National Advanced Systems (a division of National Semiconductor) sold IBM plug-compatible machines manufactured by Hitachi in Japan. In Europe, Japanese-made mainframes shored up the market position of weaker European companies by filling out their product lines in the higher-end of the market. Fujitsu supplied IBM-compatible machines through OEM agreements to ICL (Britain) and Siemens (Germany). Hitachi signed OEM agreements to supply machines to BASF (Germany) and Olivetti (Italy). In France, NEC supplies large Honeywell-compatible machines to the French national champion Bull. With a full product line, European vendors were now able to offer customers a full array of compatible machines and therefore more likely to retain their customer loyalty over time as their customer's needs change. In return, Japanese companies gained entry into the lucrative European market without establishing their own distribution channels and cultivating a new customer base.

Since 1977, Japanese PCM makers have consistently matched every one of IBM's price reductions and introduced new IBM compatible and non-IBM compatible models. PCM vendors succeeded in taking 19% of the US market by the turn of the decade. As much as 90% of PCMs were supplied by Fujitsu and Hitachi in 1980 (Gregory, 1988:244). By 1985, $33 of every $100 earned by Japanese computer companies came from exports, compared to $11 for the European firms.

THE EFFECTS OF JAPANESE STRATEGIES ON COMPETITIVE PERFORMANCE IN THE JAPANESE DOMESTIC MARKET.

The cumulative effects of the PCM strategy, VLSI project, and export strategy on the Japanese industry's domestic market performance is best illustrated by comparing the period immediately before those strategies were developed and the period immediately afterward. During the period of restructuring (1972-74), Japanese companies grew by 14% as against 22.4% for foreign companies. Japanese companies' rate of growth actually fell behind the rate of demand growth in the domestic market (22.4%) for that period, and Japanese companies had lost approximately 13% of their share of the domestic market to foreign firms.(Anchordoguy, 1989) Foreign companies captured over 50% of the Japanese market by 1974. However, the situation was dramatically reversed after Japanese companies adopted the PCM strategy and as the results of the VLSI project began to come on stream in the latter half of the 1970s. Between 1976-80, Japanese exports of computers and related equipment experienced an annual increase of 41.5%. Exports as share of total production rose from 6.8% to 10.7% (Gregory, 1988:245). During the same period, Japanese companies' rate of growth on the domestic market rose to a remarkable 28% as against 9% for foreign-based companies, in a domestic market environment where total demand growth was approximately 20% (Anchordoguy, 1989). By 1980, Japanese companies had pushed back the multinationals by capturing 72.5% share of the domestic market representing an increase of more than 20% from 1974. In the same year, Japan gained the distinction as the only OECD country where IBM became dethroned as the number one firm by a nationally-based firm, Fujitsu. In the following year, Japan became a net exporter of computer technology for the first time.

4.6: SUMMARY OF JAPANESE COMPUTER DEVELOPMENT STRATEGIES.

It is our contention that while Japanese policy and development strategies did lead to a dramatic change in the competitive fortunes of national companies, this process developed fundamentally within the prevailing parameters of competition in the international computer industry. Japanese strategies and their consequences did not radically change the terms of international competition. Rather, Japanese strategies have been successful because they have been "market conforming" - not in the sense of conforming to "free" market principles underlying neo-classical economics - but in the sense that they have generally respected and worked within the market constraints imposed on industry followers by the world industry leader IBM. Of the three major Japanese computer producers, the two largest - Fujitsu and Hitachi - adopted IBM-compatibility as their business strategy. This strategy enabled the two "plug-compatible machine" makers to tap into enormous effective demand created by IBM's existing world-wide customer base. The third major Japanese company, NEC, also worked within the prevailing patterns of international competition by adopting the Honeywell standard and focusing on specialized telecommunications applications, a market segment that was largely ignored by IBM, but which was growing rapidly due to the increasing complementarity of computer and telecommunications technologies. Product specialization enabled NEC to survive and thrive in the mainframe computing business even as its American partner Honeywell had to abandon the general purpose business computer market as its customers defected to IBM throughout the 1970s.

The Japanese decision to focus R&D efforts on VLSI production technology also followed the pattern of competition in the American industry that emphasized superior component technology to improve price-performance of final systems products. The government sponsored VLSI project, however, did create comparative advantage for Japanese industry, particularly in process technology for high-volume, standardized semiconductor products (such as DRAMs). In this respect, Japanese "plug-compatible-machines" were not just imitative but embodied some domestic innovation. The proprietary technology in these machines is buried in the components and the manufacturing processes used to make them more cheaply and reliably, rather than in the system in which they are embedded. But we should stress that the Japanese do not have complete comparative advantage in the full range of components and intermediate technologies that contribute to final systems products. This accounts for the inter-firm technology exchanges between Japanese and American companies that continues to this day. Moreover, the Japanese experience with international alliances for technology and market development suggests that mutuality of benefits for foreign and domestic partners can be achieved - in spite of the explicitly nationalist orientation of government policy during this period.

The decision to adopt the PCM strategy and VLSI projects appears to be a shrewd assessment of market realities by government planners and business. But closer examination of policy process suggests that the collective strategy taken was not purely a product of rational-design, given the high degree of uncertainty and disagreement between government and business about the appropriate response to market challenges. Preceding each instance of collective action was a process of negotiation and bargaining whose purpose centred not so much on judging the technical or economic merits of policy alternatives, but rather to establish consensus among policy participants regarding their appropriate market domains and relationship to each other in the collective task. In this sense, industry reorganization, the formulation and implementation of national strategy, operated according to a "political logic" that reflected the relative bargaining power of each participant in relation to the others in the policy process. Furthermore, political conflict played an innovative role in reconfiguring the structure of inter-firm and government-business relations for advanced research during the VLSI project. The successful Japanese pattern of "distributed cooperation" in semiconductor research has since become a standard institutional model for cooperative research in other countries.[14] In the literature, politics is seen to affect the speed with which development strategies are adopted, but rarely seen to create new methods of industrial organization and strategies that could fundamentally change the *direction* of development. In Japan, however, there emerged out of the political struggles of the early 1970s creative solutions to market challenges that were unforseen by policy participants at the initial stage of policy formulation.

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14. For example, the European Esprit project and the American Sematech joint research corporation follows the organizational model developed under the Japanese VLSI project.

CHAPTER FIVE

THE FRENCH COMPUTER INDUSTRY

5.1: MARKET STRUCTURE IN THE FRENCH COMPUTER INDUSTRY: THE LATE 1960s.

Beginning in the early 1960s, a wave of foreign (primarily American) investment into France had resulted in the implantation of foreign subsidiaries and a sharp rise of computer imports that came to dominate the largest share and most sophisticated product segments of the French computer market. In response to this "American challenge", the French state actively intervened in the regroupment of the weaker French companies to form a defence, and supplied generous funding and procurements to maintain a French presence in the domestic computer industry. As in Japan, this resulted in the bifurcation of the French computer market into two distinct but coexisting business worlds. The first consisted of foreign subsidiaries that were a part of the highly competitive international computer market; the second consisted of domestic companies partially sheltered by the state from the full brunt of international competition and occupying a much smaller share of the domestic market, but remaining dependent on the international industry for transfers of the most advanced technology that they could not produce on their own.

By the late 1960s, three companies were manufacturing computers in France: IBM-France (a wholly-owned subsidiary of IBM's World Trade Corporation), GE-Bull (a "binational" American-French company with majority ownership held by General Electric of the United States), and Compagnie Internationale pour l'Informatique (CII), the wholly French-owned "national champion" in computers. In 1967, IBM-France accounted for about 43% of computer installments (but 63% by value of installments), GE-Bull 31%, and CII about 7% (Franco Malerba, 1985:126). Imports accounted for the rest - primarily from such American companies as Control Data, Honeywell, RCA, Burroughs, and Sperry Rand.

Of the foreign controlled companies, IBM had established a wholly owned subsidiary in France for many years before the postwar electronics revolution. In the 1960s, IBM-France manufactured computers for the French market, including specialized types of semiconductor components for all IBM computers in Europe and some for the United States, as part of the multinational's integrated global manufacturing strategy developed for the System 360 (A.J. Harmon, 1971:21). Despite the best efforts of IBM-France to appear as a "national" company (for example, it hired French nationals to senior executive positions, and was the largest employer of computer researchers, engineers, and technicians), the government has never considered this company to be "truly French".

The government's attitude was similar toward the "binational" company GE-Bull, the second largest computer manufacturer in France during the late 1960s. The American company General Electric entered the French market in 1964 by acquiring a controlling share of the French Compagnie des Machines Bull, when the latter ran into severe financial difficulties.[1] Significantly, when the government's plan to create a self-sufficient French computer capability was enacted, the binational GE-Bull was excluded from the group of firms put together to form a "national champion" despite the fact that the company was still partially owned by French capital (albeit a minority share) and had controlled over one third of the domestic market. Clearly a lot more was driving that policy than striving for simple economic gain.

Among the French computer producers, Compagnie Internationale pour l'Informatique (CII) had emerged through a series of government-encouraged mergers to become the French national champion in computers by 1966. CII was

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1. Prior to the take-over, Machines Bull had been the second largest computer manufacturer in France after IBM, and had represented a showcase for French technology. The take-over of Machines Bull by the American multinational GE sparked a minor political crisis for the de Gaulle government (J.A. Hart, 1992). According to several observers, the so-called *l'affaire Bull* was one of a series of significant events that led the French government to formulate the first *Plan Calcul* (1967-71) to stimulate an indigenous capability in computer technology development.

created from the smaller computer divisions of three large French electronics and electrical equipment conglomerates, each of whom retained formal ownership in the new company despite massive government subsidies to facilitate the merger.[2]

CII was a weak company both in terms of its technology and market position. The three computer divisions that formed the basis of CII were very small, collectively controlling about 7% of the French market and with combined sales of only $34 million (US) in 1966 (A.J. Harman, 1971:37). CII came out with its first computer in late 1968, the medium sized IRIS 50, largely based on technology transferred through its inherited licensing arrangement with Scientific Data Systems (SDS), an American company that had been allied to one of the partners that formed CII (A.J. Harman, 1971:37). The licensing agreement with SDS was extended through to 1975, and later computers designed by CII would continue to rely heavily on technology from this American company. Although CII had developed some computers based on its own design under the auspices of the *Plan Calcul*, the net result was an incompatible product line that

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2. At its formation, CII's major corporate owners were the Compagnie G┼n┼rale de t┼l┼graphe sans fils (CSF), Compagnie G┼n┼rale d' ■lectricit┼ (CGE), and the Schneider group. By 1968, Schneider dropped out of the joint venture, and CSF merged with Thomson (also a large electronics conglomerate), with the result that there were now three major owners of CII: Thomson, CGE, and the French government.

limited the company's ability to achieve any significant scale economies.

Total subsidies from the French government during the first *Plan Calcul* (1967-71) amounted to approximately $120 million, with the majority of this amount channelled to CII. The expressed aim of CII was to recapture 30% of the French market from the multinationals. However, at the beginning of 1973, the national champion's share of the French market was not significantly higher than that of the original firms in 1966 (less than 10%), and its exports, mainly to non-competitive Eastern European and Third World markets, were very modest. The French government consistently spent more on an average yearly basis in support of civilian R&D in computers in comparison with UK and Germany from 1966-70, but continued to lag behind those same countries that it outspent (Jequier, 1974:220). Nonetheless, the government persisted in heavily subsidizing this venture throughout the 1970s. Clearly, the economic performance of CII was not the only consideration for French government support of this venture.

5.2: THE POLITICAL CONTEXT OF FRENCH INDUSTRIAL PLANNING AND CONSEQUENCES FOR COMPUTER INDUSTRY POLICY IN THE LATE-1960s TO THE MID-1970s.

French policy toward the computer industry cannot be adequately understood apart from the broader political and institutional context of French industrial planning. Since the Fifth Plan (1965-70), there has been a principal shift in emphasis of state planning toward the micro-economic level. Termed *la nouvelle politique industrielle*, the dominant feature of the new program involved a principal shift from state support for an entire industrial sector toward more focused state support for particular firms as part of a general strategy of improving the international competitiveness of French industry (Hall, 1986:149). The primary objective of industrial policy, in the words of the Fifth Plan was:

> The establishment or reinforcement...of a small number of firms or groups of international size...in most industrial sectors (aluminum, steel, mechanical and electrical engineering, electronics, motor cars, aircraft, chemicals, pharmaceutical products, etc.). The number of these groups should be very small, often even reduced to one or two. (*Commissariat General du Plan*, 1965:68)

This policy endeavoured to create "national champions", firms groomed to compete in the international economy as flagships of French industry. From the beginning, the *Plan Calcul* (1967-71) was part of a larger French strategy for global competitiveness, as outlined in the Fifth Plan. The shift in emphasis of state policy away from promotion of an *entire sector* toward promotion of *specific firms* has entailed changes both in the structure of policy planning within the state bureaucracy, and in the structure of relations between individual businesses and the government. We will discuss these changes in turn.

CHANGES IN STATE INSTITUTIONS FOR INDUSTRIAL PLANNING.

Within state institutions, power and responsibility were shifted away from organizations with sectoral responsibility - such as trade associations and the Ministry of Industry and Scientific Research - toward administrations such as the Planning Commission (part of the Prime Minister's staff) and the Ministry of Finance (Zysman, 1977:63).

There were political as well as administrative reasons for these changes. For example, an industrial policy intended to encourage competitiveness of *particular* firms requires direct communication between businessmen and civil servants. The trade association, as an intermediary between the government and an entire manufacturing sector, stood in the way of such a relationship and has been increasingly by-passed through devices such as the coordinating committees of the National Economic Plan (Zysman, 1977:63).

Furthermore, the implantation of American firms who then join the associations makes trade associations thoroughly inappropriate for national planning. Similarly, the Ministry of Industry also waned in importance when planning shifted to targeting specific firms. This ministry was divided into seven sectoral administrations, each with a specific tutelary responsibility for maintaining "harmonious development of a particular sector as a whole" (Ibid.). It is primarily concerned with the even-handed and impersonal mechanisms of state support or programs which permit only small benefits to be widely distributed. Thus, the Ministry of Industry was a poor conduit for funnelling large concentrated benefits to particular firms, and has correspondingly diminished in importance as industrial planning shifted to promoting "national champions".

The elaboration of an industrial policy using financial incentives to promote specific firms has on the other hand increased the importance of the political executive, particularly the Prime Minister with his technical staff, which includes the Planning Commission, and the Ministry of Finance, which has control of the budget and "an iron grip on all expenditures through the network of finance inspectors." (Zysman, 1977:64) It is the Prime Minister and his staff who are responsible for drawing up the long-term plans of the government, but the Ministry of Finance has the greatest influence in their implementation. Thus, the planning and coordination of industrial policy after 1965 became increasingly centralized in the hands of the political executive.[3]

The centralization of industrial policy planning and coordination in the political executive is reflected in the specific organizations for administering policy in the computer industry. For example, the *Plan Calcul*, which established the specific target for data processing technology, was directed by a newly created organization - the *Délégation à l'Informatique* - that was responsible for overseeing the expenditure of government funds and to direct the activities of companies that would be the instrument of government policy (Zysman, 1977:74-5). In the Planning Commission (an office of the Prime minister) there was another group, COPEP, the permanent electronics commission which concerned itself with the broader electronics industry as a whole.[4] Although separate organizations were formally charged with separate responsibilities, in practice, the two policies over-lapped each other and the same actors within

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3. According to Peter Hall (1986), the changes brought by the Fifth Plan (1965-70) reinforces a trend that began in 1958 with the advent of the Fifth Republic, when changes in the Constitution conferred substantial new powers on the political executive. Since that time, successive governments started to take an active interest in the Plan, giving it a high political profile as a united Gaullist party under a strong president began to enjoy some continuity in office (Hall, 1986:150).
4. COPEP was the only permanently constituted industry group at the Planning Commission, which reveals the French government's obsession with that industry.

the state and in the industry were involved in each case. The head of COPEP in fact became second in command at the *Délégation à l'Informatique*. The formulation of the *Plan Calcul* was therefore heavily influenced by the political executive. This centralized coordination of industrial policy resulted in line authority relations that emanated directly from the political executive. Consequently, the content of state policy also reflected the political orientation of that executive. This contrasts sharply with Japan where the policy system evolved toward a more decentralized and fragmented structure during the same period.

RELATIONS BETWEEN THE STATE AND BUSINESS: THE POLITICS OF POLICY FORMULATION AND IMPLEMENTATION DURING THE FIRST PLAN CALCUL (1967-71).

The process behind the formulation of the first *Plan Calcul* (1967-71) reveals the general weakness of French companies in relation to the state planners. In contrast to the Japanese experience, the French process of restructuring the computer industry in the late 1960s involved less open conflict between the state and private companies; or more precisely, private companies have tended to defer to state administrative guidance. There were two reasons for this. First, the French companies that participated in the *Plan Calcul* have generally been more dependent on state resources for their operations than their Japanese counterparts. Second, the French state administrative bureaucracy has been characterized by a greater degree of centralized coordination of policy and a greater unity of purpose among bureaucrats compared to the situation in Japan (particularly after 1970). The differences between the Japanese and French pattern of restructuring the computer industry is most starkly revealed in the formulation and implementation of the first *Plan Calcul* (1967-71), to which we will now turn.

Broadly speaking, two decisions had to be made during the formulation of the first *Plan Calcul*: (1) What would be the substantive goals of a computer policy; and (2) what would they mean in operational terms? With respect to the first question, the political executive that dominated the policy formulation process decided that an "independent" computer industry consisting of firms controlled by French capital and not dependent on American technology was required for the future well-being of the French economy. According to one government committee:

The importance of electronics is not measured solely by the production of sales figures of the branch, which only represent 1.5 percent of the Gross National Product, nor by the number of employees, which only represents 0.6 percent of the active population....In fact our country cannot give up an electronics industry, and a complete electronics industry, without entering onto the road of underdevelopment. (Quoted in and translated by John Zysman, 1977:74)

The second question necessarily involve the issues of who in the state and private sector would control the direction of policy, and who would become the instrument of policy and recipient of state assistance. With respect to these issues, there was no apparent consensus between government and business. The computer subsidiary of Schneider (then independent from the Thomson group) and an independent consulting firm urged a strategy of aggressively exploiting competence in particular market niches, but they did not find much support in the government bureaucracy (Ibid:76). Certain holding companies also urged an entirely different solution - some kind of agreement or technological tie-up with GE-Bull the second largest computer maker in France after IBM - to assure a profitable but not independent French presence. Since French technological independence was a major objective of the Plan, this was rejected by the bureaucrats (Ibid:76).

Policy choices were finally formulated by the head of the Planning Commission (Ibid:76). The question of business strategy was addressed only after the different purposes each government agency urged on the government were defined.

The instruments of achieving the policy goals would take three forms: (1) The fusion of the existing small firms and the creation of a "national champion" in computers; (2) the support of French exports in semi-competitive markets aimed at Eastern European and Third World markets; and (3) the creation of internally protected markets (primarily through public procurements) for the national champion and other privileged firms, and the outright subsidy of these firms.

In April 1967, the agreement between the companies and the state was signed. The existing French computer companies, and the banks that supported them, would pool their collective resources into a single national champion in computers. There was some dissention within the state bureaucracy and the military regarding the formation of a single national champion in computers. For example, the PTT (postal, telephone and telegraph services - a public corporation) and the military did not support efforts at a fusion that would saddle them with a single supplier and thereby limit their price-quality negotiating power (Zysman, 1977:77). However, because Prime Minister Pompidou and the minister of finance are said to have taken an active role in policy formulation, dissent was effectively squashed and coordination achieved.

The new environment created by the *Plan Calcul* led to the so-called "non-aggression" pact in 1969 between the two major corporate owners of the national champion CII - Thomson and CGE - in which the two firms temporarily called a halt to competition in heavy electrical equipment, telecommunications equipment, and consumer electronics (Hart, 1992:125). Despite the appearance of good faith, Thomson and CGE remained suspicious of each other. Often the objectives of CGE and Thomson were to prevent the other from expanding into their own business domain rather than to pursue their own expansion and the expansion of the jointly owned CII (Ibid.). Furthermore, Thomson's and CGE's motives for participating in the *Plan Calcul* appear to have little in common with the state's motives. For instance, Jublin and Quatrepointe (1976) observed that when the establishment of CII in computers was set as a national priority by the government, the new entity was considered by CGE and Thomson as "an unwanted child to be sent to the orphanage as soon as possible" (Recounted in Dosi, 1981:97). For Thomson and CGE, participation in the *Plan Calcul* provided them with an easy solution to the competitive problems suffered by their computer divisions; their computer divisions were small and weak to begin with, and merging them together (and receiving government funding in the process) was a better alternative than to let them wither and die on the competitive market.[5]

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5. The situation was similar for the government's *Plan Composants* (semiconductor components) - devised in 1968 as a companion to the *Plan Calcul* - that led to the creation of SESCOSEM for semiconductors. CGE had already sold its semiconductor division to Philips of Holland in 1968, and Thomson was going to sell its division to the American firm General Electric. But because the government's goal under

There were additional reasons why CGE and Thomson cooperated with the state. The state, with its control of the large French public sector, was a principal purchaser of heavy electrical and other electronic equipment from Thomson and CGE (Zysman, 1977:83-4). Thus, cooperation with the state in the *Plan Calcul* ensures that these two companies would remain in the state's circle of favourites when it came to public procurements. By contrast, Japan has a comparatively small public sector, and Japanese companies such as Hitachi, Mitsubishi-Electric, and Toshiba have been less dependent on state purchases of their non-computer related products. Consequently, there has been less of an incentive for these Japanese companies to bow to government pressures.

The national champion CII was given the task of producing a full product line of general purpose mainframe computers competitive but not compatible with those already being produced by IBM. French state planners specified the production of a central processing unit based on a proprietary standard of a uniquely French design. This meant that CII found itself in direct competition with the bread-and-butter product lines of IBM. The government heavily subsidized CII's R&D investments and ensured that

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the *Plan Calcul* was national self-sufficiency in computer technology, Thomson's decision to merge its semiconductor division (SESCO) with CSF's semiconductor division (COSEM) in 1968 was largely due to the urging of state industry planners.

large computers would be purchased for government laboratories. The competition with American firms, particularly with IBM, proved to be a major commercial blunder. CII's development of a line of computers based on its own proprietary standard had dispersed the company's limited development funds over too many applications which could only be sold on the limited national market. In any case, CII's most successful computers that were eventually commercialized were not of its own design, but smaller machines based largely on technology developed by the American company Scientific Data Systems. Thus, some of the technological know-how of the "all French" series of computers were still based on American expertise. Initially, CII stated the objective of recapturing 30% of the French market from American-controlled firms. Despite massive government subsidies, in 1973 CII controlled roughly the same share of the French market that its constituent elements had commanded in 1966, and prospects for the future looked gloomy.

Export strategy in the late 1960s and early 1970s consisted of active government promotion for exports to Eastern Bloc and Third World countries where competition has been more political rather than commercial and technical. These include negotiations with the Hungarian government in 1969 over licensing agreements for CII's 10010 computer (which was based on technology developed by the American company SDS, see Harman, 1970:37). In practical terms, this had the effect of reducing pressure on the national champion to match the international development pace or to develop its own competitively based export policy. Whereas a strategy emphasizing export to advanced industrial markets would have forced the national champion to develop an economically based commercial strategy, Eastern Bloc and Third World exports, at the same time that they reduce competitive pressures, permit the continuation of a bias toward "technological self-sufficiency". National self-sufficiency in technology proved to be an illusory goal. The technology lag between the French national champion and its American counterparts has been so great that technology transfers remained an important tool for French firm to regain its competitiveness.

5.3: SEMICONDUCTOR POLICY IN FRANCE: 1960s - LATE 1970s.

In France, direct foreign (primarily American) investment in semiconductor manufacturing began in the early 1960s as a way for foreign firms to escape the high tariffs imposed on electronic imports, and to tap into government procurement markets.[6] The French government always tried to

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6. Motorola established a plant in 1964 and Westinghouse transferred it wafer diffusion operations to France in 1967. Texas Instruments also set up operations during the late 1960s to supply semiconductor devices to IBM-France as well as to the national champion firm CII. Throughout the 1960s and 1970s, American companies entirely dominated the most

bargain access to its market against some technology transfer (for example, it encouraged the establishment of local R&D facilities) and increase import substitution and export capabilities of foreign subsidiaries (Dosi, 1981:31). Despite a 17% *ad valorem* tariff on computer component imports - among the highest in the industrialized countries, and which remained in place throughout the 1960s and 1970s - this did not appear to have affected import flows of the most advanced semiconductor devices.

French government assistance to the domestic semiconductor industry first began in 1968 through the *Plan des Composants*, devised as a companion to the first *Plan Calcul* which aimed at French self-sufficiency in computer technology.(Ibid) Under the *Plan des Composants* (1967-70), approximately FF 91.6 million (about US $18 million) in government funds were channelled mainly to SESCOSEM, a French company created through government encouraged mergers. As a "late-comer" to semiconductor manufacturing, SESCOSEM was a technologically weak company. Most of this government financial assistance went to the creation of SESCOSEM and for covering this firm's losses rather than for R&D (OECD, 1985).

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sophisticated product segments of this market (OECD, 1985:73).

The French government's policy toward the computer and semiconductor industries has been criticized for its lack of coherence. For example, SESCOSEM was supposed to supply CII, the national champion in computers, with components despite its technological weakness. But CII's mandate to design computers that would be competitive with American computers required the computer company to incorporate the most advanced components that were available. The weakness of SESCOSEM led CII to design its products around components made by the American firm Texas instruments. Nonetheless, given the government's goal of technological "self-sufficiency", SESCOSEM was obliged to develop and maintain the catalogue of Texas Instruments products to ensure a French "second-source". SESCOSEM was relegated to this role by government decree, and must develop products for which it was not even the primary source. Thus, because SESCOSEM was weak, it could not guarantee a market, but because it must guarantee production for the state's political goal of technological self-sufficiency, it became impossible for it to develop a sound business strategy.

The costs of government subsidies for SESCOSEM continued to mount thoughout the first half of the 1970s and an endless downward spiral ensued. SESCOSEM eventually failed in 1977 and was absorbed by the French electronics conglomerate Thomson as part of a larger restructuring of the French semiconductor industry.

After the failure of SESCOSEM in 1977, the French government recognized belatedly that its semiconductor policy was not working. In addition, the increasingly large requirements of the PTT (the Postal, Telephone, and Telegraph services - a public corporation) for integrated circuits to develop its rapidly expanding telecommunications system led the government to initiate a new five year plan, dubbed the *Plan Circuits Intégrés* in 1978. The new Plan would last four years and had a budget of FF 600 million (about US $130 million, see OECD, 1985:73-4) These figures do not include the large government-backed long-term loans supplied by the Cr┼dit Nationale.

In contrast to past policies, "self-sufficiency" in technology and markets were no longer the aim (Dosi, 1981:29). R&D and production no longer focused on a single national champion, nor would the project be restricted to French nationals. It was also envisaged that half of the production would be exported. Research "contracts" between the state and business were fanned out to three main groups: (1) EFIS, a joint venture between Thomson and the Commissariat a l'Energie Atomique, with licensing agreements with the American company Motorola; (2) Eurotechnique, a joint venture between the French company Saint Gobain and the American company National Semiconductor; and (3) Matra-Harris, a joint venture between the French firm Matra and the American firm Harris (OECD, 1985:74). There were interesting parallels with the Japanese mode of research organization under the VLSI program in the sense that project work was divided among several participating groups. Unlike the Japanese pattern, however, there were no joint laboratories to facilitate lateral communication and coordination among the research groups. This may have been due to the structure of French government financing for this project.

The structure of government financing for the *Plan Circuits Integres* was centralized, as in the past, and aimed at meeting the specific requirements of the PTT and the military through various "contrats d'etudes" signed between the relevant ministries and the companies. In conjunction with the centralized financing of R&D, the government also encouraged use of procurements to forge close links between firms and the main public procurement markets - the military and the PTT.[7] This structure of financing may have discouraged lateral communication between project groups, and may have led to a less effective mode of research organization.

The *Plan Circuits Intégrés*, and a subsequent *Plan filière electronique* launched by the Mitterrand government

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7. Public procurements were important by the end of the project. For example, public sector consumption of ICs for telecommunications applications alone accounted for 21% of domestic consumption (OECD, 1985:93, n88).

in the early 1980s, did help French companies narrow their technology gap with the leaders in the international industry (Langlois *et. al.*, 1988). However, French companies never managed to gain technological leadership in this area nor have they come close to being the transnational equivalents of American and Japanese companies on export markets.

5.4: EUROPEAN COOPERATION: THE UNIDATA PROJECT (1973-75).

As early as 1968, CII attempting to free itself from the constraints imposed by its French political and corporate masters, went in search of a "European solution" by soliciting the headquarters of Siemens (Germany), Philips (Holland), Olivetti (Italy), and ICL (Britain). However, the idea of a cooperative effort that transcended national boundaries was not seriously considered until the early 1970s, when a shake-out of the international computer industry left many computer companies around the world scrambling for new strategies to compete in the new market environment. General Electric withdrew from the computer business in the spring of 1970 and sold all its computer facilities, including GE-Bull, to Honeywell. Despite CII's efforts to persuade the French government to purchase Bull and to merge it with CII, the government permitted Bull's transfer to Honeywell. Siemens of Germany was left stranded when RCA, its American partner, dropped out of the computer business in August 1971. Philips of the Netherlands was also looking for European partners so that it could enter the rapidly growing computer business.

CII's efforts to link up with other European companies finally culminated in UNIDATA, a joint venture between CII, Siemens, and Philips in July 1973. The UNIDATA project required each of the three participants to build part of a complementary IBM-compatible line of computers.(Kenneth Flamm, 1988:157) In this respect, the UNIDATA project shared many similarities with the Japanese "3.5 generation" computer project that aimed at formulating a direct commercial response to IBM through the development of IBM plug-compatible-machines. Siemens' previous alliance with the American company RCA may have influenced the decision to adopt an IBM-compatible strategy. The least experienced Philips team was assigned to build the smallest model; Siemens would design two medium machines; and CII would produce three medium and larger models. By 1974, the smaller models in this series had been developed, but development of the larger machines by CII lagged. Rivalries between these three partners soon emerged over control and marketing responsibilities, and overlapping and duplication in development soon emerged. These rivalries, however, need not have been fatal to the cooperative venture, as the Japanese experience in cooperative R&D and market development demonstrates. But unlike the Japanese experience, UNIDATA lacked strong external institutional support to arbitrate disputes and to stabilize cooperation between the partners.

CII's French corporate owners had also actively worked to undermine the joint venture. For example, the UNIDATA venture came under fire almost immediately after its conception from CGE (then, a partner with Thomson in CII) and Honeywell-Bull. CGE was concerned that Philips would enter the French minicomputer market through its connections with CII in UNIDATA, and was also concerned that Thomson would acquire entry into French telecommunications markets. Honeywell-Bull perceived the threat to be mainly to its French computer markets, as Honeywell was the major competitor to IBM and IBM-compatible machines in the 1970s. Ambroise Roux of CGE and Jean-Pierre Brule of Honeywell-Bull worked together to sabotage Unidata by promoting a merger between CII and Honeywell-Bull (J.A. Hart, 1992:126).

When Giscard d'Estaing took office in 1974, CII and the D┼l┼gation ╚ l'Informatique favoured the UNIDATA approach because it avoided a linkage with an American firm, whereas Michel D'Ornano, Giscard's new minister of industry, favoured the CII-Honeywell-Bull merger because CII would gain access to larger American markets. The French government, faced with ever mounting subsidies required to float the *Plan Calcul* and the unwillingness of CGE to increase its capital investments, moved to change the state's commitments and arrange the merger of CII with Honeywell-Bull (Zysman, 1977:139). In the fall of 1974, the D┼l┼gation ╚ l'Informatique was dissolved by the French government. It was announced on May 12, 1975, that CII would be merged with Honeywell-Bull, effectively ending the first European cooperative effort, and marking a shift in government policy toward an alliance with an American company.[8]

After CII left UNIDATA, Philips withdrew from general purpose mainframe computers.[9] Siemens, after withdrawing from much of its computer activities, eventually replaced the missing part of its IBM-compatible line that was to have been manufactured by CII with large-scale mainframes supplied by Japanese PCM maker Fujitsu.

The causes of UNIDATA's failure were largely political, that involved the costs of upsetting the political equilibrium among CII's corporate owners (CGE and Thomson), and the weak commitment of the French government toward the first joint European venture in computers. From the outset,

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8. According to J.A. Hart: "Philips and Siemens remembered the incident for a long time. It would return to haunt the French when they sought cooperation with the Dutch and Germans in the late 1980s in the development of new semiconductor technologies." (Hart, 1992:126-7)
9. Angeline Pantages, Nancy Foy, and Andrew Loyd, "Western Europe's Computer Industry", Datamation, vol.22 (Sept. 1976) p.68

the aims of transnational cooperation contradicted the government's aim to cultivate a "national champion" in computers. The lack of external institutional support has meant that UNIDATA was an inherently unstable venture to begin with.

5.5: THE CII-HONEYWELL-BULL VENTURE: THE THIRD PLAN CALCUL (1976-81).

The merger of CII with the American subsidiary Honeywell-Bull did not mean that the French government had abandoned its goal of cultivating a national champion in computers, as the French retained a controlling share over the new company. The French share of the reworked national champion CII-Honeywell-Bull was 53%; Honeywell owned 47% of the company. Furthermore, the state's informal procurement preference for the national champion in place since the first *Plan Calcul* was now made into an explicit guaranteed procurement as a major element of the third *Plan*. The French government had hoped that by linking up with Honeywell, IBM's principal rival in mainframe computers, this would ensure a more secure future on the market for CII. However, the fortunes of the reworked champion, renamed CII-Honeywell-Bull, had fallen with its American partner Honeywell's decline in world markets throughout the 1970s.

The French government had gambled on the wrong partner to help its national champion, and a closer examination of Honeywell's business strategy reveals why. Historically, Honeywell's computer operations had been salvaged from the failures of would-be competitors (for example, Ratheon's computer division in 1957, Computer Control Corporation in 1966, GE's computer division in 1970, and Xerox's computer division in 1975; see Flamm, 1988:114-15) These acquisitions propelled Honeywell to the number two spot on world markets by 1971 (8% share of the world market) - albeit a distant second to IBM. However, because of its growth through acquisition, Honeywell had also put together several different and incompatible lines of machines, limiting possibilities of achieving any sort of scale economies in supporting this hardware and developing newer models. Many of the products Honeywell had inherited were competing in the same broad, general purpose business markets controlled by IBM. Honeywell did not fare well during the remainder of the 1970s, and by the early 1980s, its position in the market had slipped badly.[10] Honeywell's business strategy had gone against the prevailing patterns

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10. Honeywell retreated to military markets by the late 1970s. Finally, in 1986, Honeywell gave up on computers and its commercial computer operations were sold to Japan's NEC and France's Bull. Today, Honeywell only markets commercial computer products made by others - primarily NEC. NEC outlasted its US partner by focusing on specialized telecommunications equipment niche market. It is unclear why CII-Honeywell-Bull did not do the same as the Japanese company NEC.

of international competition in the computer industry that also dragged-down its French partner CII-Honeywell-Bull.

Things changed again in 1981 toward a more nationalist development stance when CII-Honeywell-Bull was nationalized as part of restructuring carried out by the Mitterrand government. The now renamed Groupe Bull became one of twelve nationalized sectors of the French economy, but this had done little to set a clear course for the national champion.

In the fifteen years following 1967, France pumped more than one billion (US) dollars into its national computer champion, but the company showed a true profit (i.e. before subsidies were taken into account) in only two of those years, 1979 and 1980 (Richard DeLamarter, 1986). In 1978, a report prepared for President Giscard d'Estaing found that US suppliers still dominated the French market. National firms satisfied only 20% of domestic needs in office computers and 40% in terminals and minicomputers. A worse blow to government planners, US companies had done better in France than in other industrialized nations with an explicit policy to promote national computer firms. In 1975 American companies supplied 45% of computer installments in Japan, 60.5% in the UK, 75% in Germany, and 83.5% in France.

In 1980 CII-HB accounted for 31% of French computer installations compared to IBM's 52%. But the company remained essentially weak. During the same year, the national champion not only earned less profits in France than IBM-France, but it employed fewer people: only 16,120 compared with IBM-France's payroll of 20,596. In 1982, with total revenues of $1.49 billion (US), CII-Honeywell-Bull showed a net loss of $249 million, despite close to $200 million in government subsidies that year (Delamarter, 1986:298). Compared to the 1970s, CII-HB and other European national champions increased their shares of data processing business in their government and state-owned enterprises. But CII-HB, now known simply as Groupe Bull, is hardly competitive outside the public sector, let alone internationally. In 1983, French manufacturers (mainly Bull) provided 63% of the civil service's computer installations, whereas they only served 45% of the private market (Rob Van Tulder & Gerde Junne, 1988:40). Regionally, in 1985, Bull ranked fifth in the EC market (4.2% market share) behind the Italian company Olivetti (4.6%), the American company Digital Equipment Corporation (5.4%), the German company Siemens (6.9%), and IBM (33.5%). Hundreds of millions of dollars in government subsidies have been required each year to just keep the company afloat.

Finally, the French trade deficit in computer technology has not decreased in the slightest as a result of

Bull's efforts: it grew from $19 million (US) in 1976 to $386 million in 1981. Nevertheless, French policy persevered throughout the 1980s. A five year electronics plan (1982-1987) pumped a total of $26 billion (US) in electronics, a major part of which went for computer equipment. Honeywell's departure from computer manufacturing in 1986 has resulted in Bull teaming up with NEC of Japan. NEC manufactures the larger and more sophisticated mainframe computers for its French partner Bull to sell under its own nameplate on the French market through "Original Equipment Manufacturer" (OEM) agreements. French policy since the mid-1980s has ostensibly shifted once again from national self-reliance to greater international cooperation. Nonetheless, the chairman of Bull has criticized the sale of ICL (of Britain) to Fujitsu in 1990 and has objected to the Japanese company's participation, via ICL, in government-financed European research projects. "As a fundamental principle, I wouldn't be in favour of having Japanese competitiveness increased by the European taxpayer," he says (Economist, October 6, 1990:79). The French never seemed to have dealt with their policy ambivalence regarding international cooperation in technology development.

5.6: SUMMARY OF FRENCH COMPUTER INDUSTRY POLICY.

In the fifteen years spanning the first and the third *Plan Calcul* (1967-81), the French quest for a successful strategy in computer technology development has vacillated between the extremes of national self-reliance, to interdependence with foreign companies, and back to an emphasis on national self-reliance in technology development.

During the first *Plan Calcul* (1967-71), French planners encouraged the national champion CII to develop and market general purpose mainframe computers based on its own proprietary design and in direct competition with the heart of IBM's business product line. This strategy proved to be a costly commercial blunder, and was effectively buried in 1973 when CII, under its own initiative, entered into a joint venture with Siemens (the largest German electronics firm) and Philips (the Dutch electronics giant) to develop a line of IBM-compatible computers in the UNIDATA project. These three European companies were essentially following the path first taken by RCA, and later by Amdahl, Fujitsu and Hitachi. However, this first European joint effort was cut short by the lack of external institutional support from CII's political and corporate masters, particularly from the French government that had been ambivalent about supporting a transnational effort at the same time that it was seeking to cultivate a national champion, and by CII's corporate owners (Thomson and CGE) who feared an alliance with the German and Dutch companies would undermine their own positions on the French market. In 1975, one year after a change in the French government, CII was merged with Honeywell-Bull (a subsidiary of the American firm Honeywell but with French majority ownership) in the hope that an alliance with IBM's principal American rival in mainframe computers would ensure the company a more secure future in international competition. The government also redirected its efforts toward inter-firm and international cooperation to develop semiconductor components, a crucial input to computers, by financing a research project (the *Plan Circuits Intégrés*, 1978-82) involving several French and American companies, reminiscent of the pattern of "distributed-cooperation" found in the Japanese VLSI project. This research project, and subsequent projects, did help the French attain technological (but not commercial) parity with American and Japanese companies in semiconductor components. But the fortunes of CII-Honeywell-Bull, the reworked champion in computers, sunk further with the decline of Honeywell in world markets as mainframe business computer customers defected to IBM machines throughout the 1970s. Once again, French policy makers had run-up against the constraints of international competition which they could not change. The nationalizations of the early 1980s under the Socialist

Mitterrand government shifted French policy back to a more strictly nationalist orientation in technology and market development, but had done little to set a viable course for the national champion in computers, now known simply as Bull.

This shifting policy pattern partly reflects the French frustration at their inability to find a viable long-term commercial strategy for computers. French strategies of computer technology development have, for the most part, struggled against the prevailing terms of international competition by competing head-to-head with IBM. Throughout the 1970s, the French have introduced a similar but non-compatible range of products aimed at IBM's core market of business mainframe computer users. Unlike the Japanese, neither IBM-compatibility nor the pursuit of new applications in niche markets emerged as a stable focal point for the French. Consequently, French strategies have foundered against the market constraints imposed on industry followers by the industry leader IBM. However, the lukewarm approach of French policy towards working within international market constraints is partly a political choice. The centralized coordination of French policy that concentrated decision-making in the political executive, and the corresponding weak bargaining position of business vis-a-vis the state, has resulted in a bias in favour of state preferences for national autarky in technology development that was incompatible with prevailing patterns of international competition. French policy has been characterized by a profound ambivalence between the desire for "national self-sufficiency" in technology through promotion of a national champion, and the desire to make the national champion commercially competitive, which requires interdependence with foreign companies for technology and markets.

Japanese policy toward the computer industry was characterized by a similar ambivalence throughout the 1960s. The Japanese seem to have resolved this problem by the early 1970s, not entirely through superior foresight and planning, but through political bargaining between private firms and government. The results of that bargaining operated according to a political logic. The fact that Japanese companies did not adopt a policy biased toward "self-sufficiency" in technology reflects the relative weakness rather than strength of MITI vis-a-vis private firms in contrast to the comparatively strong French government agencies that were able to impose their own agenda on the national champion. Moreover, MITI's failure to merge the six companies into one or two national champions may have ironically led to a more diversified Japanese strategy of technology development that proved to be more effective than the French strategy of placing all bets on a single national champion.

CHAPTER SIX

CONCLUSIONS

6.1: CONTINGENT GENERALIZATIONS AND PATTERNED VARIATIONS IN JAPANESE AND FRENCH COMPUTER INDUSTRY DEVELOPMENT.

The preceding analysis has examined the historically-parallel transformation of two groups of "industrial followers" - the Japanese and French populations of computer companies - in an effort to shed light on relevant issues of strategic importance: How do we account for the rapid ascendency of the Japanese computer industry to international competitiveness whereas other national computer development efforts have been forestalled? To what extent is the Japanese pattern of computer development unique, and to what extent does it conform to the prevailing pattern of international competition? In our comparison of the "deviant" Japanese case with the "control" French case, the operative questions have been: What combinations of conditions could account for patterned variations in (1) aggregate domestic industry outcomes; and (2) the trajectory or path of domestic industrial change over time? The conclusions fall into three categories: the parameters of international competition, patterned variations in domestic competitive outcomes, and patterned variations in national trajectories of development.

1. THE PARAMETERS OF INTERNATIONAL MARKET COMPETITION.

The industry leader IBM defined the parameters of international market competition throughout the period of our investigation. IBM seized the technological leadership early in the growth of business computing when it introduced the revolutionary System 360 in 1964. Thereafter, the company cemented its leadership for the following decades through continuous investments for product innovation, and drawing the boundaries of its large market around its proprietary technology standard. By the early 1970s, IBM controlled 70% of the world market for computers. In this IBM-dominated market environment, three major and interrelated factors defined the parameters of competition: continuous technology innovation, technology standards, and economies of scale.

(1) *Continuous technological innovation.* The minimum requirement for market survival requires competitors to at least match the market leader's quality and pace of technological innovation. Technology imitators or "free-riders" who base their strategy on price competition without adequate attention to innovation can be repeatedly undermined by the rapid pace of technological change, and by the large price-performance differentials between old and new generations of products. It is also important to emphasize the direction of technological change in the

industry at large and how this affected the pattern of competition. By the late 1960s, most of the "great ideas in computer design" for improving the standard von-Neuman serial processing architecture had been proposed; thereafter, novel improvements to the serial processing architecture, however clever, would only lead to marginal improvements in price-performance of computer systems. Instead, the emphasis shifted to improving the quality and reliability of *semiconductor components* for superior price-performance in final systems products.

(2) *Technical standards.* The intimate interrelation between computer software and the hardware for which it is designed (essentially an issue "compatibility") became a crucial technical link shaping competition in the industry. In the 1960s and 1970s, most software applications were written in codes specific to a manufacturer's hardware, making it difficult and costly for the user to interchange software and hardware based on different proprietary standards. This fact enabled IBM to use its proprietary technology standard as a competitive weapon to "lock-in" customers and to "lock-out" alternative (non-IBM compatible) suppliers over time. IBM, by virtue of its overwhelming share of the world computer market in the 1960s, was able to turn its internal company standard into the *de facto* industry standard.

(3) *Economies of scale.* Computer manufacturing is both R&D and capital intensive where economies of scale - both the static and dynamic aspects - are important for shaping the pattern of competition. The high and relatively fixed front-end investments required for R&D and capital equipment argues for reaching out to the largest possible market to reduce unit costs, and for rapidly amortizing initial investments through volume sales for new product innovation. In this respect, IBM enjoyed an early advantage over most competitors as it had already established world-wide operations for its punch-card machines in the late 1940s. By the mid-1960s, all aspects of IBM's computer operations were geared toward a single global market with the boundaries of that market drawn according to its proprietary technology standard. Other companies that focus on single-country markets, and producing a similar range of products aimed at the same business market segments as IBM, were now severely disadvantaged because their much smaller market made it difficult to lower unit costs and to amortize front-end investments for new product innovation.

These factors in combination created severe constraints for existing and potential competitors in the computer industry. Nonetheless, IBM's unified global business practices - concentrated mainly in the general purpose mainframe market - had established a fairly stable and identifiable pattern on international markets to which industry followers could adapt themselves for survival. The analysis in chapter three suggests that there was more than one development strategy for industry followers, but the range of viable strategies was circumscribed by the dominant position of IBM on international markets.

2. PATTERNED VARIATION IN DOMESTIC COMPETITIVE OUTCOMES.

The case studies suggest Japanese and French domestic competitive outcomes fell within the existing parameters of international competition. Different national strategies were important in determining just where domestic industry outcomes lie within the parameters of international competition i.e. they account for the *variance* in domestic competitive outcomes. National strategies, however, were not able to *change* those parameters.

The Japanese computer industry's competitive success in its domestic market is attributable to "market-conforming" strategies - particularly those adopted *after* market liberalization in the 1970s - that generally respected and worked within the existing terms of international competition as defined by the industry leader IBM. Of the three major Japanese computer producers, the two largest - Fujitsu and Hitachi - adopted an IBM "plug-compatible-machine" (PCM) strategy that essentially entails building a cheaper, higher performance version of a standardized product.[1] To the extent that a PCM strategy renders independent software development unnecessary, this enabled Fujitsu and Hitachi to plow more resources into hardware development. At the same time, it enabled the two PCM makers to tap into enormous effective demand created by IBM's existing world-wide customer base. The third major Japanese computer company, NEC, adopted the Honeywell standard, but directed its efforts towards specialized telecommunications applications - a market niche in which Honeywell and IBM had been slow to exploit. Product specialization enabled NEC to thrive in the rapidly growing telecommunications applications market, even as its American partner Honeywell had to abandon mainframe computer manufacturing as its business customers defected to IBM throughout the 1970s. The Japanese decision to focus R&D efforts on VLSI production technology also enabled Japanese computer companies to manufacture high-quality components to improve the price-performance of final systems products. In this sense, Japanese-made "plug-compatible-machines" were not just imitative of American designs, but embodied important domestic innovations that are embedded in the components and the manufacturing processes used to make them more cheaply and reliably. Process innovation enabled Japanese companies to overcome their initial disadvantage as technology followers in the design of final systems

1. Ironically, the establishment of the IBM standard as the *de facto* industry standard has also made significant economies of scale available to Japanese PCM producers.

products, and has allowed those companies to remain competitive with the market leader over time. Finally, the Japanese case suggests that competitive success on domestic markets depends on the speed and effectiveness with which the broader international market is developed. In the late 1970s, this was accomplished through strategic market alliances with American and European PCM vendors to sell Japanese-made products under foreign name plates. Japanese computer exports accounted for about one third of Japanese companies' revenues in the mid-1980s. By expanding their sales abroad beyond the confines of their national market, it became easier for Japanese companies to lower their unit costs, and to rapidly amortize the high costs of R&D and capital investments for new product development. Therefore they could compete effectively against IBM.

French strategies, for the most part, have tried to defy the prevailing terms of international market competition. The French national champion in computers, CII, has tried to compete head-to-head against IBM by introducing a similar range of products that competed in the same business market segments as IBM. This strategy failed miserably, and interestingly enough, was abandoned at about the same time that Fujitsu of Japan also abandoned its independent efforts. The national champion's much smaller market share has made it difficult to lower unit costs and to amortize initial investments for new product innovation.

Apart from modest exports to semi-competitive Eastern block and Third World countries, the national champion made no significant sales outside of France. In the mid-1970s, CII's hopes of gaining market share through its partnership with the American company Honeywell - then the second largest computer company on world markets - were dashed as Honeywell's competitive fortunes in the business mainframe market sank throughout the 1970s. Unlike the Japanese companies, neither IBM-compatibility nor targeting specialized product niches emerged as a stable strategy for the French. Consequently, French strategies have failed to advance the competitiveness of domestic industry beyond the narrow confines of government-protected procurement markets.

3. PATTERNED VARIATION IN NATIONAL TRAJECTORIES OF DEVELOPMENT.

The path of industrial change in Japan and France since the 1960s has been non-linear (or multi-linear) and contingent on the interplay between two major factors: (1) The structure of power relations between state organizations and domestic companies in the policy process; and (2) Response from the broader international market. In the short term, different power structures of state-business relations account for the divergent pattern of collective action on the market; In the long term, however, market feed back had a decisive, if indirect, influence on the partial convergence of collective action on the market. The following will elaborate on each factor and their interaction over time.

First, the case studies confirm the strategic developmental orientation of Japanese and French computer industry policy. Policy, however, did not respond deterministically to pressures of technological and economic change, nor were they purely the product of rational-design by state industry planners. In both countries, the policy process was driven by a fundamentally similar tension between the state and business over the appropriate strategic response to market challenges originating in the international market.[2] National governments and business needed each other as instruments to realize their own particular objectives, but neither side could initially agree on the appropriate strategy for development. Different power structures of state-business relations determined the degree to which state and business actors were able to bring pressure to bear on policy. State power was relative to the needs that companies have for the financial resources that it could command, compared to other

2. As argued in chapter three, state planners preferred mercantilist strategies emphasizing "national self-sufficiency" in technology development in the belief that this would enable the domestic economy to capture the dynamic gains of innovation. Business, on the other hand, preferred a strategy of linking up with foreign companies, in the belief that this would serve their more immediate and narrower concerns of profiting from a rapidly expanding market.

sources in the economy. The Japanese state had less power over the targeted domestic companies compared to the French state, resulting in a *negotiated* pattern of industrial development in Japan, in contrast to the predominantly *state-led* pattern in France. Consequently, the pattern of French computer industry development was characterized by a distinct bias toward "national self-sufficiency" in technology and market development that reflected the preference of state industry planners. The national champion CII was encouraged by state industry planners to build a uniquely French-designed computer system. By contrast, the Japanese approach embodied a compromise between the state's preference for domestic innovation and private companies' preference for imitation of foreign technology. The Japanese imitated American technology in the design of their final systems products, but stressed domestic innovation in manufacturing process technology for components that contribute to final products. This accounts for the *divergence* in the orientation of collective action in each country.

Secondly, the cases suggest that response from the international market had a decisive, if indirect, effect on national strategies and the orientation of collective action over time. Market response had its most immediate and visible impact on the profitability and sales of domestic companies. In both Japan and France, national policies were only able to advance the competitiveness of domestic industry when they operated within the terms of market competition as defined by the industry leader IBM. When national policies ignored or attempted to challenge head-on the prevailing terms of global competition, their strategic efforts failed, forcing a revision of national policy and a reorientation of collective action on the market. This pattern was observed in both Japan and France, and we believe, accounts for the *partial convergence* in national development trajectories over the period of our study. In the late 1960s, for example, Japan emphasized imitation of American technology and price competition with the multinationals, whereas France emphasized domestic innovation to create a uniquely French-designed computer system. Both these policies failed by the early to mid-1970s as it became evident that the technological and cost factors of market competition had changed dramatically against their favour. By the mid-1970s, Japan still imitated American technology in the design of their final systems products, but engaged in domestic innovation for components through the VLSI project. The French abandoned their independent technology effort (which was never truly independent anyway) and, like the Japanese, decided to imitate American designs (through Honeywell) for their final systems products, but also engaged in a renewed national effort to develop semiconductor technology through the *Plan Circuits Intégrés*. In the end, the French national champion's partnership with Honeywell did not work out as planned, and the *Plan Circuits Intégrés* did not achieve the same dramatic results as the Japanese VLSI project. However, the point remains that international market pressures did in fact contribute to a *partial convergence* in the development path of these two national industries over time. We have argued that those pressures were the direct result of IBM's activities on international markets, affirming the industry leader's role in defining the first order constraints on the development path of industry followers.

SUMMARY

The computer industry leader IBM defined the parameters of international market competition for at least two decades following the mid 1960s. Japanese and French domestic industry outcomes fell within those parameters. Different national strategies determined just where within the parameters domestic outcomes lie; that is, they account for the variance in Japanese and French outcomes. National strategies, however, did not change those parameters. The competitive success of Japanese industry in its domestic market is attributable to "market-conforming" strategies adopted after 1970 that respected and worked within the prevailing terms of international market competition as defined by IBM. French strategies, for the most part, have struggled against the terms of international competition and have subsequently failed to advance the competitiveness of domestic industry. Finally, comparison of Japan and France suggests the path of national computer industry change over time has been non-linear (or multi-linear) and contingent on the interplay between the domestic structure of state-business power relations, on the one hand, and on the other hand, response from the broader international market. In the short term, different power structures of state-business relations account for the divergence in national trajectories of development. In the long-term, however, response from the broader international market had a decisive, if indirect, influence on the partial convergence of national development trajectories.

6.2: IMPLICATIONS FOR THEORIES OF INDUSTRIAL CHANGE.

This final section will evaluate the theories of industrial change first presented in chapter two in light of the findings from comparison of the Japanese and French computer industry.

1. MARKET COMPETITION (SCHUMPETERIAN) EXPLANATIONS.

This study supports the Schumpeterian contention that market competition through continuous technological innovation is crucial to understanding the dynamics of industrial change. However, Schumpeterian conceptions of market competition tend to be one-sided; they highlight the profit and power motives of private actors, but are largely silent about the considerable degree of public involvement in technology development. In both national cases, computer technology development was imbued with larger political significance because of the perception by national governments that such technology could generate broad social returns for the national economy over time, beyond the more immediate and narrow profit concerns of private firms. It was this perception that led national governments to actively intervene in the affairs of domestic industry to promote technological innovation. In the process of doing so, national governments changed the pattern of corporate strategy and behaviour on the market. Consequently, an adequate explanation of industrial change must include a broader analysis of the network of political-market relations in which the firm is embedded.

2. MARKET FAILURE AND ADMINISTRATIVE GUIDANCE EXPLANATIONS.

The market failure analysis guards against the simplistic position that resource allocation guided by the free market is in any way "optimal". Many of the market problems identified in the theoretical literature - such as the public goods nature of R&D, imperfect information in growth industries, and the transactions costs of systems producers - seem to have been borne out by the empirical cases. However, the case studies also suggest that finding the "socially-optimal" solution to market deficiencies is neither an easy nor a politically-neutral task. In Japan and France, the state had actively intervened in technology development using similar kinds of instruments, but with very different results. The indeterminate effects of state intervention on industry development suggests that either the theories of state intervention are not doing what we think they should be doing, or that our conceptual understanding of industrial change needs to be enlarged.

Market failure explanations may be guilty of juxtaposing an idealized conception of market behaviour with institutionally-nuanced views of government intervention. They portray government as a *deus ex machina*, capable of devising and implementing the appropriate policies to save market actors from themselves in the nick of time. The case studies shows that government-business relations in the industrial policy process is more complex. In the first place, the content of policy depends, among other things, on the organization of interest representation that aggregate the preferences of many actors in particular ways (Katzenstein, 1978; Hall, 1986). For example, the increasingly fragmented Japanese policy system (particularly after 1970) suggests that there had been a greater degree of pluralism, bargaining and compromise in formulating policy compared to the highly centralized French policy system that concentrated decision-making in the hands of the political executive. Furthermore, the choice of policy goals do not determine *instrument choices*, although the two are often made concurrently (Weaver, 1987). The Japanese and French cases show that there had been considerable disagreement between the state and private companies as to how the domestic industry should be structured, and whether foreign participation should be encouraged. Disagreements over instrument choices have not been simply a reflection of underlying conflict over policy goals; In Japan and France, the defence of particular policy instruments itself became an objective of policy by which state and business actors hoped to maintain or to enlarge control over their respective domains of market activity. Finally, the ability of government to *implement* its chosen policy depends as much on the character of its links with the target population of companies as it does on the organization of government (Zysman, 1983; Hall, 1986). If we adopt the view that state power is relative to the needs that domestic companies have for the resources that it could command, compared to other sources in the economy, this might help explain the different patterns of industrial development in Japan and France. The empirical cases suggest that Japanese companies have been *less dependent* on government financing and procurements for their business compared to their French counterparts. This also suggests that the Japanese state had less power over their domestic computer companies compared to the French state. We believe this national difference in state-business power relations accounts for the *negotiated* pattern of industrial restructuring in Japan, compared to the predominantly *state-led* pattern in France. Thus, an accurate depiction of industrial change would require a more explicit institutionally-embedded view of government-business relations.

3. TECHNOLOGY AND ORGANIZATION OF PRODUCTION SYSTEMS: CONTINGENCY EXPLANATIONS.

Contingency theorists argue that the characteristics of technology - particularly its degree of complexity and interdependence - are associated with the characteristics of the structures devised to organize the firm - for example, the extent of its differentiation, decentralization, and modes of coordination. They offer the promise of explaining competitive performance by examining the degree to which organizational structures "match" the imperatives of technology. However, most literature attempting to link various modes of corporate organization with technology have been characterized by a fundamentally *internal* focus, with the single firm as the unit of analysis (Pfeffer, 1987). Most corporate organization research do not implicate the structure of relations among organizations, or the embedded, situational character of relations among units in their analysis.

Comparison of Japan and France suggests that the individual company's ability to effectively manage the complexities of technological development is significantly affected by the organization of collective efforts at the institutional level of inter-firm and government-business relations. If we move the level of analysis up from the individual firm to the institutional level of inter-firm relations, and examine how the two different organizational levels complement each other, this may help to explain cross-national variations in corporate behaviour and industrial performance outcomes. For example, an individual firm may carry out a few specialized tasks as part of a larger and more complex R&D program when viewed at the institutional level of inter-firm relations. The Japanese method of "distributed cooperation" under the VLSI project of the mid-1970s conforms to this pattern of industrial organization. Conversely, a single firm may be faced with the full complexity of performing a large number of specialized tasks within a comparatively simple policy system - as had been the case with SESCOSEM, the French "national champion" in semiconductors. When these two modes of industrial organization are compared, it becomes clear that the degree of complexity at two adjacent organizational levels, and the magnitude of contingency demands placed on the individual firm, have varied dramatically between the Japanese and French contexts. If a crucial aspect of organizational design is to determine how best to manage the complexities of technology, then our empirical cases suggest that the Japanese mode of industrial organization is much more effective than the French. This requires the analyst to move concerns from internal adjustments and responses of the individual firm to attempts by many firms and government to collectively manage, structure, and in other ways to *create* a negotiated environment that complements efforts at the firm level.

4. INSTITUTIONAL EXPLANATIONS.

A crucial insight of the institutional perspective is that domestic structures are *authoritative* for guiding collective action on the market. However, most comparative studies of industrial competitiveness confine themselves to analysis of how domestic policies and structures affect patterns of competition at the international level - such as patterns of national specialization in trade and comparative advantage (See for example, J.A. Hart, 1992). Only rarely and recently have scholars examined how international patterns of competition affect domestic policies and structures of a specific industry, or the *dynamic interaction* between them over time. Of the few studies that do examine the interaction of international pressures and domestic response, most have focused on the less dynamic and/or depressed industrial sectors, rather than on the more dynamic high-growth sectors (Calder, 1989). Consequently, we believe that many of the broad conclusions about state-societal relations derived from the predominantly static comparisons can be highly misleading when applied to the more dynamic industrial sectors.

A dynamic comparison of the Japanese and French computer industry suggests that international patterns of competition are not just the *consequence* of domestic policies and structures, but are also an important *cause* of them (*contra* Katzenstein, 1978). We cannot systematically link domestic policies and structures to competitive performance or to the path of industrial change over time without combining an understanding of the parameters of market competition influencing a particular instance of industrial development. Domestic policies produce *outputs* in collective action on the market; but as our study suggests, competitive outcomes and the path of industrial change over time are contingent on the broader market environment's response to those policy outputs. Market response has its most immediate impact on the profitability, sales, and market share of companies targeted by policy. In capitalist economies, these types of market indicators are also authoritative for directing policy and the path of collective action over time.

These observations caution us against sweeping generalizations about national capacities and trajectories of industrial development applied across a broad range of industry sectors. They also point to the need for incorporating explicit arguments about the nature of technology and market operations into the study of industrial change. If we are to understand industrial change, the analytic distinction between politics, technology, and economics must be bridged. They simply instruct us about different dimensions of the same phenomenon.

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