terpersonal one, will be a heavy one. The more potent the drug, the more sustained its use, the more likely is there to be an increase in side effects, the unanticipated and unwanted consequences of drug use.

Drug giving and drug taking represent all too brittle and undiscriminating responses, and ultimately, in our view, they will breed only more frustration and more alienation. Changing the human environment is a monumental undertaking. While seeking to change cognitive shapes through chemical means is more convenient and economical, the drug solution has already become another technological Trojan horse.

The ultimate task is to alter the shapes of human relatedness and social arrangements that determine the context and the substance of our existence. To maintain, as do significant groups within the pharmaceutical industry, the medical profession, and the youth culture, that this can be accomplished merely through chemical means is indeed to have fallen victim to mystification.

References and Notes

1. The concept of "mystification" originally described by Marx has recently been adapted to the study of family dynamics by R. D. Laing and others. For Laing, mystification "entails the substitution of false for true construction of what is being experienced, being done (praxis), or going on (process), and the substitution of false issues for the actual issues" [R. D. Laing, "Mystification, confusion and conflict," in *Intensive Family Therapy*, I. Boszormanyi-Nagy and J. Framo, Eds. (Hoeber Medical Division, New York, 1965)]. It seems to us that the concept of mystification, in the above sense, is applicable to the process by which psychoactive drug action is often presented and defined for those to whom these drugs are administered.
2. We should emphasize that we do not wish to minimize research and clinical observations pointing to the usefulness of psychoactive agents, especially of the major tranquilizers in the management of severe psychiatric disorders. There is, however, an immense difference between psychopharmacological intervention for this patient group with strikingly troublesome symptomatology and the advocacy of the use of psychoactive agents to treat *la condition humaine*, that is, the emotional challenges of daily living.
3. *Journal of the American College Health Association* **17**, No. 5 (June 1969).
4. *American Journal of Diseases of Children* **118**, No. 2 (Aug. 1969).
5. Professional sample, *Geigy Pharmaceutical*, insert dated 15 August 1968.
6. R. C. Pillard, statement before Subcommittee on Monopoly of the Select Committee on Small Business, 30 July 1969 (U.S. Government Printing Office, Washington, D.C., 1969), p. 5408.
7. "If we picture an organism as infected by a certain species of bacterium, it will obviously be easy to effect a cure if substances have been discovered which have an exclusive affinity for these bacteria and act deleteriously or lethally on these and on these alone, while at the same time, they possess no affinity whatever for the normal constituents of the body and cannot therefore have the least harmful, or other effect on that body. Such substances would then be able to exert their final action exclusively on the parasite harboured within the organism, and would represent, so to speak, *magic bullets* which seek their target of their own accord. . . ."—P. Ehrlich's address delivered at the dedication of the Georg-Speyer-Haus, 6 September 1906, in *The Collected Papers of Paul Ehrlich*, F. Himmelweit, Ed. (Pergamon Press, London, 1960), vol. 3.
8. R. Dubos, "On the present limitation of drug research," in *Drugs in Our Society*, P. Talalay, Ed. (Johns Hopkins Press, Baltimore, 1964).
9. H. Laborit and P. Huegenard, *J. Chir.* **67**, 631 (1951).
10. A. Hordern, in *Psychopharmacology*, C. R. B. Joyce, Ed. (Lippincott, Philadelphia, 1968).
11. S. Schachter, in *Psychobiological Approaches to Social Behavior*, P. H. Leiderman and D. Shapiro, Eds. (Stanford Univ. Press, Stanford, California, 1964), pp. 138–173.
12. We are aware of the fact that the validity of this proposition is dose-related.
13. *Medical Newsletter* **11**, No. 20 (3 October 1969), pp. 81–84.
14. We do not wish to minimize the considerable differences between legal and illegal drugs in terms of dose standardization and purity of the chemical compound. However, we are not addressing ourselves to the issue of physical risks in this paper, though it is an important one.
15. This point is developed in more detail in part IV of our paper "Drug giving and drug taking," given at American College of Neuropsychopharmacology, San Diego, February 1970 (mimeographed).

Technological Strategies and National Purpose

Domestic and foreign developments necessitate a new relationship.

Robert Gilpin

Since the end of World War II, the world economy has undergone a major transformation. Many varied factors underlie the changed international economy, but the effects of the contemporary technological revolution upon economic and commercial activities have been of primary importance. Of present-day technological developments and their economic effects, the most noteworthy are advances in air and sea transportation, which have decreased transportation costs and travel time between continents; improvements in radio, telephone, and television communications, which in conjunction with advances in transportation have facilitated the emergence of a global market; and, most significant of all, the unprecedented innovation of new products and of cost-reducing industrial processes, which has profoundly altered the relationship between technology and economics.

Three major interrelated economic consequences have flowed from these developments. The first, as Cooper has pointed out, is the increased interdependence among national economies and the consequent greater "sensitivity of foreign trade to changes in economic conditions" (*1*). The second is the enhanced role of technological innovation in economic growth and competition. The third is the rapid expansion abroad of the corporations, primarily American, that are best equipped to take advantage of the new conditions of the world economy. These developments have in turn produced in all major industrial nations a concern that they will be left behind and that they must formulate appropriate strategies to adapt their economies to the imperatives of economic growth and competition. One English writer has expressed the problem in this way (*2*):

> The major problem now is seen as securing greater mobility of resources in order to take advantage of more rapid technological change. The old fear of the law of diminishing returns has been replaced by the fear that we shall be unable to take advantage of increasing technological opportunity.

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There has also been a significant economic transformation at the domestic level during the past several decades. The population explosion and the revolution of rising expectations have made economic growth a major goal of governmental policy in both the industrialized and the lesser developed nations. For the poorer nations of the world, expansion of the gross national product is necessary to survival; for the developed nations it has become the primary means of ensuring full employment and of alleviating domestic discontent. Underlying the success of the contemporary welfare state is the fact that intergroup conflict over the just distribution of wealth has been displaced to a considerable degree by intergroup cooperation in the achievement of a higher growth rate. This substitution of a politics of growth for one of distribution has considerably changed the role of the state in economic affairs.

These international and domestic developments have forced the world's industrial nations and especially the major trading nations to give ever closer attention to their scientific and technological capabilities. The result in many countries has been a series of moves designed to improve both the training of scientists and engineers and the organization of science and technology and to make more efficient allocation of resources for research and development. The technological revolution that has engulfed the industrial world is indeed requiring nations to develop conscious and systematic scientific and technological strategies.

To advance or even to maintain its position as an economic power in the world today, a nation must formulate long-range technological strategies to deal with certain unavoidable problems. In the first place, very considerable funds are frequently required to develop even the most elementary scientific and technological capabilities, and, of course, the investments required to develop certain areas of technology are enormous. Even the most wealthy nations must select for support specific fields of science and technology instead of attempting to compete across the board. Second, the long lead time between the conception of a new technology and the production stage means long-range planning and commitments (*3*). Third, the rapidly growing appreciation of the impact of technology on human welfare and the physical environment is forcing governments to assess and to attempt to control the consequences of technological advance (*4*).

Economists are now reluctantly acknowledging that differential rates of technological innovation and diffusion of new knowledge are major determinants of the patterns of international trade. As a result of this fact, the theory of international trade is undergoing a reorientation as dynamic elements displace the older emphasis on static factor endowments—land, labor, and capital (*5*). The international economy has become characterized by the increasingly rapid obsolescence of technologies and the undermining of traditional comparative advantages. As industry becomes more science-based and innovation-oriented, the tradition and experience of a firm, or indeed of a nation, are of decreasing utility in the maintenance of a competitive position. Even the possession of raw materials confers less of an advantage than in the past, owing to the rapid decline in the cost of marine transportation. In fact, today a country deficient in raw materials, like Japan, can become a major industrial power, whereas a country like Sweden must worry over the declining importance of its iron ore resources.

Three Strategies

A nation can follow one of three basic technological strategies in response to the challenge of this new international economy. The first is to support scientific and technological development across the broadest front possible. A nation following this broad-front strategy seeks to maintain a position in all the advanced fields considered to be of military, economic, and political importance—especially atomic energy, computers, and aerospace. This strategy is, of course, the one followed by the two great powers, the United States and the Soviet Union. It is also the strategy that Great Britain attempted to follow until the early 1960's and that France pursued under the leadership of President Charles de Gaulle (*6*). As shall be shown below, this strategy is undergoing a critical review in France at the beginning of the 1970's.

The second strategy is scientific and technological specialization. The essence of this strategy is to select for support specific areas of science and technology, usually of commercial utility, and to concentrate one's resources upon them. In the selected areas an innovative policy is required at every stage, from basic research through technological development. Among the countries that have most successfully followed this strategy are Sweden, the Netherlands, Switzerland, and, increasingly, Great Britain.

In contrast to the first two strategies, which are innovative, the third is an importation strategy. Emphasis is placed on importing foreign technology by the purchase of licenses; in the period since World War II, imported technology has most frequently been American. Although this strategy, like the second, implies specialization, it differs in that relatively little basic research is carried out. Instead, indigenous scientific and technological resources are concentrated on improving and redesigning imported technologies, especially for subsequent export. The country that has perfected this strategy is, of course, Japan (*7*). In addition, West Germany has also relied heavily upon the importation of American technology in advanced fields such as computers, atomic energy, and aviation.

A nation's choice of strategy reflects its social, economic, and security circumstances and objectives; therefore, the choice of strategy cannot be separated from the nation's broader domestic and foreign policies. Differing national strategies can be identified, but it must be noted that they are not exclusive strategies but rather characterize the major emphasis of a country's scientific and technological policies. For instance, the United States obviously cannot do everything; Sweden does imitate in some areas; and Japanese firms, for their part, do innovate. Furthermore, each strategy entails its own peculiar risks and opportunities, and, as the cases of France and Japan attest, the consequences of choosing the right or wrong strategy can be momentous. Indeed, a nation's strategy may change as its circumstances, capabilities, and objectives change over time.

An analysis of the strategies followed by four countries—France, the United States, Sweden, and Japan—illustrates the alternatives and emphasizes the significance of choosing the correct strategy. The experience of these four countries also illustrates the effects of changing circumstances on national

strategies. France and the United States are examples of countries that selected the broad-front strategy; the United States has found it rather successful, but for France it has proven to be a nearly unmitigated failure. Sweden exemplifies an exceptionally successful pursuit of the second strategy of specialization, and Japan has broken all economic records in perfecting the strategy of importing foreign technologies. However, contemporary developments are forcing changes; in Japan, for example, a shift to a strategy of innovative specialization and perhaps even to the broad-front strategy can be discerned.

French Strategy

The basic motif of French technological policy under both the Fourth and Fifth Republics has been economic, political, and military independence. More than any other European nation, France has given systematic thought to the implications of the contemporary technological revolution for its future and has sought to develop a national policy to improve its scientific and technical capabilities. The French effort to develop independent French capabilities in the modern fields of science and technology began as early as 1945. With the coming to power of Charles de Gaulle in 1958, these efforts were intensified, and a decision was made to exploit these capabilities for the creation of a nuclear striking force.

To decrease its dependence upon the United States and to balance German industrial power, the French have sought to establish a French capacity in all the sciences and technologies believed to be important for military power and economic competition: atomic energy, computers, electronics, high-performance aircraft, space technology, and so forth. Where it was unable by itself to develop the necessary technologies, such as rocket launchers and telecommunications satellites, France has taken the lead in promoting European technological cooperation. In short, the French sought to compete against the two superpowers across the broad front of science and advanced technology.

However, threats to this policy existed in certain fundamental but generally unappreciated weaknesses of the French scientific and technological position. When the student and worker uprisings convulsed France in the spring of 1968, these weaknesses were exposed, and the French scientific-technological effort was thrown into what must be described as its present state of crisis.

A fundamental threat to the French strategy of scientific and technological independence lay in the scarcity of the resources necessary to progress on so broad a front of research and development. It is relatively obvious that resources that could have been concentrated on potentially new scientific and technical fields were virtually wasted in duplicating American or other foreign efforts. Less obvious before France's present crisis was the fact that the programs were necessarily operating on an extremely narrow margin, a margin too narrow to withstand any serious financial or technical setbacks. Thus, as a result of the inflationary spiral set off by workers' wage demands and of the government's subsequent stabilization program, many of these projects and programs have had to be abandoned completely or severely cut back.

The retrenchment that has taken place has affected the overall level of support for science and technology as well as the fate of important programs. Canceled or at least seriously retarded were projects in high-energy physics, aviation, space research computers, biomedical sciences, and nuclear weapons development. The optimistic growth projections of the Fifth Plan (1966–70) were shattered, and, given the effects of inflation and devaluation of the purchasing power of the franc, the consequences for French scientific ambitions will be severe (*8*).

The crisis of French science and technology provoked by the current austerity program has been compounded by general disappointment in the fruits of the national research and development effort. Aside from the remarkable successes of Marcel Dassault in high-performance aircraft (that is, the Mystère and the Mirage), there are few if any indigenous innovations in advanced technology to which the French can point with pride. Large development projects upon which the French have placed so much hope have suffered drastic setbacks for technical or economic reasons. The atomic power program based on natural uranium reactors has had to be abandoned. The huge investment of funds in space has led to no significant scientific or commercial results; the preponderance of these funds has gone into the establishment of large ground facilities such as the Guyana base, whose utility has yet to be proven. The French color television system (SECAM) has failed to be adopted outside France except in such as yet unpromising markets as the Soviet bloc and the underdeveloped countries; moreover, a large and probably wasted investment has been made to solve technical difficulties of the television tube. And as for the "Plan Calcul," the French are beginning to realize that the task of making an indigenous computer is going to be many times more difficult than they had initially anticipated (*9*). The Concorde remains as a technical achievement that can gratify French pride, but its eventual commercial success is far from assured.

These setbacks illustrate another danger in the strategy of scientific and technological independence chosen by France: the tendency toward the premature translation of research programs into the development and production stages. To create independent French technologies rather than to depend upon proven foreign technologies, France undertook a number of grave risks which now appear to have been unwise. Technological innovation is an extremely hazardous business at best, and for a relatively small country the risks involved in costly advanced technologies can be extremely great indeed.

The United States has had two important advantages over France with respect to successful innovation: first, the superiority of American resources in science, technology, and capital; and, secondly, its managerial superiority. Whereas the French must select one option (or at least a very small number of options) fairly early in the research and development cycle and, thus, when uncertainty is greatest, the United States with its greater resources can pursue several lines of inquiry until the uncertainties have been greatly reduced and a particular technology appears to be quite definitely superior; the shift to prototype development and production can then be undertaken with a greater assurance of success. Of course, this more cautious strategy has not always been applied in the area of armaments, and here the United States, locked in its arms race with the Soviet Union, has wasted immense resources upon fruitless projects such as the nuclear-powered aircraft, controlled fusion, and

missile development (*10*). But, again, America's wealth has given it a large margin for error.

Furthermore, superiority in technological management has been a vital element in America's technological strategy. As Layton has pointed out in seeking to explain why "Europe's innovations have often been overtaken by American rivals," American firms tend to emphasize basic and applied research until development and exploitation appear to be ripe (*11*). There follows a concentration of effort which, in the area of advanced technology, involves the cooperation of private industry, the government, and, frequently, the university. It is this capacity for concerted effort rather than any specific managerial techniques that accounts for the relatively shorter lead time in the United States as compared with France between new knowledge and technological exploitation. However, to maximize their independence from the United States, the French have gone from the research stage to development or even production relatively early in the evolution of the state of the art. This method is always a risky business, and the French have also lacked the managerial competence to permit rapid perfection and exploitation of these technologies before their eventual obsolescence due to scientific and technological advances. This situation is responsible for a number of the technological defeats that the French have suffered.

Perhaps the best illustration of the several weaknesses in France's technological strategy comes from the area of nuclear power development. In the early 1950's France decided to base its nuclear power industry on natural uranium. There were technical as well as historical reasons for this decision, but primarily it was based on political considerations. In the first place, a nuclear power industry based on natural uranium would be independent of the United States for its supply of fuel. Second, the "plutonium way," as it was called, would provide the fissionable material for future nuclear power weapons programs. Thus, at a rather early date in the evolution of nuclear power technology, France in a very real sense cast its other possible options aside and concentrated its efforts on the development of the so-called graphite gas, natural uranium reactor.

In contrast, the United States pursued a more cautious approach. It sowed, as it were, many kinds of seeds and allowed many flowers to bloom before settling on a preference. Thus its decision with respect to which type or types of reactors to exploit for commercial purposes was made at a much later stage of development. Because the reasons for these contrasting policies tell us a great deal about the differing contexts of French and American technological policies in this specific case and in general, it is worthwhile to analyze them.

First, the United States (unlike France) had an indigenous supply of enriched uranium because of its nuclear weapons program; therefore, both the natural and enriched uranium options were readily available to it. Second, France saw in nuclear power the opportunity to overcome immediately the historic shortage of fossil fuels, which in the past had stunted French industrialization; the United States, on the other hand, possesses great resources of oil and coal. Third, and perhaps of greatest importance, French nuclear power development was dominated by the Atomic Energy Commission (CEA), whose leadership (largely owing to its participation during World War II in the Canadian phase of the atomic bomb project) was committed to a particular type of reactor; the one customer in France for nuclear power reactors, the nationalized French Electricity (EDF) had, in turn, to accept what its one supplier could supply. In the United States, the Atomic Energy Commission enjoyed no such unchallenged position in the councils of government; nor did any such unanimity exist on the best type of reactor to develop. Congress, fossil fuel interests, and the several laboratories of the Commission waged a battle for one type or another. And, on the consumer side, private industry brought its own ideas and interests into the debate over reactor development. As a consequence, the United States postponed until much later than did the French its decision on the types of reactors to be developed for commercial purposes.

Whereas French nuclear power policy was motivated largely by political considerations, commercial criteria dominated American policy in the last analysis. The choice of two types of light water, enriched uranium-fueled reactors for America's first generation nuclear power plants was based on their lower cost relative to other types of reactor systems and fossil fuel plants. Once these decisions were made, American industry in cooperation with government quickly brought these types of reactors from the development stage to the production line.

In contrast to the seemingly disorganized but commercially more successful American nuclear policy, France's apparently more logical policy has had a much less happy outcome. Despite its technical success, the graphite gas, natural uranium reactor is much more costly and is therefore simply not competitive with the smaller, enriched uranium reactors. For this reason, by 1969 the French government had capitulated to the policy of "buying American." Future nuclear power stations in France will be American in design and will be fueled by enriched uranium bought from the United States (*12*). Thus, having made the wrong decision much too early in the development of the first generation of power reactors, France can only hope that its candidate in the second generation competition (the fast breeder) will be more successful.

An analysis of the European cooperative arrangements, in which France has been a leading participant and through which it has sought to complement its national program, also reveals a series of failures. Intended to enhance independence from the United States, these projects display comparable patterns of obstacles to effective cooperation. The principle of the "just return," by which each nation receives a percentage of contracts equal to its financial contribution to the overall project, prevents the development of an effective division of labor, the concentration of effort, and the efficient utilization of resources. In every area of importance each nation seeks to maximize its self-sufficiency and its advantage at the expense of the common program. As a consequence Euratom, the European Launcher Development Organization (ELDO), and the European Satellite Research Organization (ESRO) are in jeopardy. Even the high-water mark of European scientific cooperation, the European Organization for Nuclear Research (CERN), is in serious difficulty as it plans for the next generation of nuclear particle accelerators. Nor has scientific and technical cooperation with the Russians proven to be the great boon that de Gaulle thought it would be. The combination of secrecy and inferiority in many areas of advanced technology has made the Soviet Union

a poor counterweight to the United States.

Amid the wreckage of their technological strategy, the French ask themselves where to turn now. As this debate over future direction takes form, it has been put in terms of stark, undoubtedly exaggerated, yet revealing alternatives: "Having failed in our pursuit of independence, do we make our technological alliance with the Germans or the Americans? Which potential ally presents the greater opportunity? Which poses the greater threat?" On the one hand, there is Jean-Jacques Servan-Schreiber, author of *The American Challenge*, who calls for a French-German industrial alliance against the United States (*13*). On the other, there is the government of Georges Pompidou, which reversed de Gaulle's policy against permitting the entry of Ford into France and received Henry Ford with all the pomp and circumstance due a head of state. For Pompidou, the lesser evil is to bring in the giant corporations of the New World to balance the threat of German industrial hegemony in the Old.

American Strategy

In turning to a consideration of American technological strategy, the first question that arises is whether such a strategy actually exists. Obviously, American corporations and governmental departments, especially the Defense Department, have technological strategies. But does the U.S. government as such, with its resistance to national planning, have a strategy in the same sense that France does? Indeed, it is possible to discern a pattern of practices and objectives which amounts to a strategy and which has had great importance in the advancement and character of American technology. Three central practices (all of which are generally absent or underdeveloped in France) may be identified.

First, one must note the frequent initiation by the U.S. government of technological projects considered to be of public interest but neglected by private enterprise for one reason or another. There are several types of technological developments where this has occurred:

1) Developments in which the scale of investment or of risk is too great for private enterprise—for instance, atomic power and supersonic transport.

2) Other developments with potential military or political significance—for instance, computers and space technology.

3) Still other areas are hampered by the absence of profit incentive—for instance, pollution control technology, housing technology, mass transportation, ship building, and the electric automobile.

The second common practice is a maximization of the involvement of private enterprise in technological advance, especially through the extensive employment of the contract mechanism. The extent of this practice is revealed by the fact that, although the national government finances two-thirds of the national research effort, two-thirds of it is executed by private enterprise. Perhaps of even greater importance in stimulating private enterprise in its research efforts, however, is the role of government as the primary consumer of advanced technology and the consequent creation of an immense public market and strong demand. These policies maximize the commercial spin-off of government programs and stimulate American industry across a broad front of technological advance.

In Europe, however, although national governments also play an important economic role as a customer for advanced technologies and although in aggregate the public market is equal to that of the United States, the market is fragmented. Each nation pursues separate and independent research and purchasing policies, and, as a consequence, there is little to stimulate the rise of large European corporations equivalent in scale to their American competitors. Instead, the effect of governmental policies is to foster relatively smaller national industries. Especially in advanced technology but in many areas of traditional technologies as well, there is a tendency toward national self-sufficiency. Europe is thus handicapped in areas of modern technology that call for the creation of large markets and corporations.

Furthermore, as P. M. S. Blackett argues in a critique of British scientific and technological policies, the tendency of Great Britain (and, one could add, of other European countries as well) to rely on government laboratories and arsenals for military and other projects rather than to contract with private enterprise has been a major error (*14*). As a result of this practice, many programs divert resources from rather than into the productive sectors of the economy. Although this analysis is an oversimplification of the situation on both sides of the Atlantic, the contrast is in general valid. In this connection, recent Soviet delegations to the United States have been extremely interested in the contract mechanism as a possible solution to certain of their organizational problems with respect to technological development; in particular, the Russians want to integrate their civil and military technological efforts and thereby use their scarce resources more efficiently. In effect, what the Russians are seeking is the secret behind the success of the American "military-industrial complex."

The study of American science policy by the Organization for Economic Cooperation and Development brought out that the American government's role as contractor has had a profound influence on the development of advanced technology in the United States. In more traditional technologies, as illustrated below, the government's involvement has been much less (*15*):

Areas of extensive government assistance are atomic energy industry; space technology; new materials, such as special plastics and steels; electronic components; and computers, especially in early phase.

Areas of slight to moderate government assistance are power engineering other than atomic energy; pharmaceuticals; and bulk chemicals.

An area of negligible government assistance is the automotive industry.

The third common practice in the United States is the functioning of the government to bring a new technology to the point of commercial exploitation and then turning it over to private enterprise to reap the profits. This desire to give private firms as large a role as possible is seen most clearly in the area of atomic power. The government has removed itself successfully from different aspects of the industry as private enterprise has shown itself capable of taking over efficiently and economically. From reactor development and production through the processing of irradiated fuels, the government's role has receded and has become primarily that of regulator.

The policies of American governmental agencies are not uniform, but the overall tendency of contracting, purchasing, and patent policies has been to make private enterprises the beneficiaries of public undertakings. Though the propriety of this practice is ques-

tionable, the issue of public versus private ownership does not concern us here. Rather the point is that governmental policy has assisted and has stimulated technological developments of commercial importance and has given American corporations a comparative advantage over their foreign competitors in many areas of advanced technology.

Although this American strategy has been relatively successful in military, space, and commercial technologies, it is coming under increasing criticism. In the first place, even America does not have the economic and technical resources to support all projects of importance; it too must choose. Second, a high proportion of the limited resources has gone into military and military-related projects, while pressing social and economic needs of the society have been neglected. Third, the devastating consequence of technological advance for the environment has suddenly emerged as a major national concern that has forced even a conservative President to stress the elimination of environmental pollution as a major national goal.

In response to these American developments, there is a growing belief that the United States must give greater attention to the formulation of a more explicit technological strategy designed to increase the social return of its immense investment in science and technology and to minimize its negative environmental effects. If this means, as it might, a slackening of economic growth, a cutback on military research, and a decline in commercially relevant innovations, the consequences for America's domestic politics, military posture, and international trade position would be significant. For this reason, the direction of America's technological strategy will become an increasingly important political issue.

Sweden's Strategy

In contrast to the broad-front strategies of France and the United States, Sweden and Japan have chosen to specialize in particular commercial technologies. The two latter countries differ in three important respects, however. Whereas Sweden's strategy has been innovative, Japan has rebuilt its industry with technology imported primarily from the United States. Second, Sweden's technological strategy has been wholly in the hands of its private sector with relatively little government intervention. In Japan, however, the government's control over the pace and direction of technological development has been extremely important. Third, whereas Sweden's policy of armed neutrality has been accompanied by an impressive weapons development program, Japan has placed its security in the hands of the United States and has expended relatively little on military research and development.

Sweden's successful strategy of specialization in such industrial technologies as shipbuilding, high-quality steel, and ball bearings has been developed in a highly favorable environment. Sweden's industrialists and her socialist government have had an implicit understanding of noninterference in each others' affairs; the capitalists foreswore interference in general political affairs and accepted high taxes to support the welfare state in exchange for a free hand in building their industrial empires and in competing effectively in world markets (*16*). The immense concentration of industrial and financial power in the hands of a few families and banks has given decision-making with respect to technology a coherence and direction (*17*) that is lacking in the more decentralized society of France. With a few exceptions, there is a concentration of technological development and production of a particular product in one or, at the most, two companies, and thus specialization and decreasing price competition are enhanced among Swedish firms. Further, the long reign of the moderate wing of the Social Democrats under Premier Tag Erlander fostered a pragmatic approach to public policy questions and, consequently, the lodging of governmental decision-making to an extraordinary degree in the hands of high civil servants (*18*).

The replacement of Erlander by Olof Palme as premier is symptomatic of impending changes in the conditions that have influenced Sweden's technological strategy; it suggests that the content of that strategy will itself be altered in the future. Although there will be no shift from Sweden's emphasis on specialization, there may be different priorities. The new mood in Sweden is one of ideological reengagement. Is a high standard of living and a successful export trade all that socialism means, ask the intellectuals of the Social Democratic party. Government, they believe, should play a more important part in controlling business enterprise and should prevent immoral actions like trade with Rhodesia. With respect to technology, greater resources should be devoted to improving the quality of life, to solving such social problems as pollution, and to reducing the inequities of Swedish society. With the aim of fostering the development of socially relevant technologies, the government has established new agencies such as the Ministry of Industry and the Board of Technical Development. To lessen class differences, education is being reformed at the expense, some fear, of the types of scientists and engineers who have given Swedish industry its traditional excellence and competitive edge. In a small (population of 8 million) and high-wage society such as Sweden, continued prowess in technological innovations and marketing has an importance unparalleled in larger and less affluent societies.

There is, however, an equally important international challenge to Sweden's traditional technological strategy. Sweden has prospered and succeeded as a trading nation because of the relatively free international market. Her superior performance and competitive prices have been sufficient to maintain her strong position in world markets. But as international commerce becomes more and more controlled by large multinational corporations, as government purchasing policies increasingly create the markets for advanced technologies, and as international trade becomes more regionalized as a result of institutions like the European Common Market, the position of a neutralist trading nation like Sweden becomes ever more difficult. In place of the free market, corporations and governments are entering into long-term cooperative arrangements to develop and to market modern technologies, especially those of large scale. Only through such international cooperation can a sufficiently large and guaranteed market and resource base be created to achieve economies of scale. And for Sweden, this situation may threaten retention of her traditional political neutrality in the face of the imperative need to cooperate economically and technologically with her neighbors and especially with the countries of the Common Market, including her greatest trading partner, West Germany.

Japan's Strategy

Japan's technological strategy has best been characterized as one that exploits a variety of "technological niches." Under the heavy-handed guidance of the Ministry of International Trade and Industry and with careful analyses of potential export markets, the Japanese have purchased from abroad the technologies through which they have achieved their impressive rate of economic growth and export trade. To achieve their economic conquests, they have, in effect, employed the same techniques of close government-industrial cooperation, individual discipline, and unswerving dedication to the objective that once enabled their military conquests (*19*).

It is now necessary to ask if Japan's technological strategy can be maintained indefinitely into the future, and, if it is changed (or perhaps even if it is not), to ask what the implications of Japan's strategy are for the world economy and the technological strategies of other nations.

There can be little doubt that Japan, for all its economic success, is undergoing severe internal difficulties. The student riots are symptomatic of deeper problems: neglect of social investment to improve the quality of Japanese life; the callous disregard for the physical environment; resentment over Japan's subordinate position with respect to the United States; and discontent with a national purpose defined in terms of doubling the gross national product. Other more tangible factors also suggest that Japan's strategy will shift in the direction of more innovative research and eventually to the broad-front strategy identified with great power status.

The first reason to expect more innovative research on the part of the Japanese is the decreasing utility to her of foreign technology. The gap between Japanese and Western technology caused by prewar embargoes and World War II is rapidly disappearing at the same time that Japan faces a growing labor shortage. As a consequence, two elements of Japan's formula for competitive success—cheap labor and foreign technology—are disappearing (*20*). Whereas in the past Japan has had the best of both worlds, increasingly Japan is finding itself caught between its low-cost Asian neighbors (mainly the overseas Chinese communities of Taiwan, Hong Kong, and Singapore) and high-technology Western economies. Although the danger of this squeeze remains on the distant horizon, the Japanese are giving it increased attention. It will become acute when mainland China, with its almost unlimited labor supply, completes its present effort to reequip its industry with Western technology and reenters the world economy.

This situation poses a serious dilemma for the Japanese. Density of population and consequent intense pressures on the environment have forced the Japanese to curtail population growth drastically. At the same time, an intense labor shortage and consequent acceleration of wage rates threaten to undermine Japan's competitive position in world markets. As a result, there is growing pressure on the part of Japanese industrialists to reverse the policy of demographic restraint and to increase the birth rate in order to recreate a pool of cheap labor (*21*). This clash between social welfare and economic competitiveness will become a dominant theme of Japanese politics, and of the politics of all other industrialized states for that matter. The solution of this dilemma, if one is possible, will be found in cost-reducing processes, new products, and more socially beneficial technologies, and thus greater emphasis will have to be placed on technological innovation.

The second factor moving Japan toward an innovative strategy is the policy of American and other foreign firms of writing more restrictive clauses, including prohibitions against exports, into licensing agreements. In the future what will be important for Japanese firms is not licensing but the establishment of cooperative arrangements with foreign firms; these long-term corporate alliances will involve cross-licensing, capital participation, and joint ventures. In order to enter such arrangements on equal terms and to enhance their bargaining positions, Japanese firms must have their own technology to contribute.

Furthermore, American pressures for liberalization of the Japanese economy with respect to imports and especially for permission for direct capital investment are forcing the Japanese to shift to an innovative strategy. One of the preconditions for Japan's imitative strategy has been the ability of the Japanese government to protect the home market as the exclusive domain of Japanese industry and thereby to make licensing the primary mode of access for foreign firms to Japan's market of 100 million population. In addition, by interposing itself between powerful American corporations and intensely competitive Japanese firms, the government was also able to protect the Japanese from making unfavorable agreements in order to obtain American technology and to best their local competitors (*22*). (Such tactics have been unavailable to Western Europe because of the Common Market and the competition among governments for American investment.)

The Japanese fear that, if American corporations with their superior capital and technical resources can export freely into the Japanese home market and can build production facilities there, their smaller firms dependent upon American technology will be at a disadvantage (*23*). But to reject American demands would lead to retaliation and would deny to the Japanese the exceptionally lucrative American market. Currently, the trade balance is approximately $1.5 billion annually in the Japanese favor, which provides them with the surplus to finance extensive imports of raw materials (*24*). Loss of the American market and the consequent severing of Japanese-American ties would force a drastic reorientation of Japanese economic, foreign, and security policies. A more independent policy in all these areas would necessitate a much greater reliance upon indigenous technology. Thus, whatever the outcome of American demands for liberalization, the Japanese will be forced to produce more of their own technology.

The most important reason to expect a more innovative Japanese strategy—one that may eventually place Japan in the broad front of technological advance—is a combination of political and military factors. Japan desires to be in the front rank politically, and, to achieve this status, a nation must be capable of producing its own technology. Moreover, in an uncertain world and in her particular geographic position, Japan can be expected to be strong in the technologies upon which economic and military power rests today. This relationship between technological independence and national power is one that de Gaulle understood well, but the Japanese appear to have

the resources and the managerial skills to succeed where France failed.

What the Japanese seek to become is the industrial equal of the United States. It is not clear, however, whether Japan with its expansive and dynamic economy will be America's major economic partner in the world or its greatest competitor. It is certainly the hope and the policy of the United States, as expressed by the Nixon Doctrine, to help Japan become an even more powerful industrial power to counterbalance China and Russia in Asia (*25*). Indicative of this policy was the important American-Japanese Agreement of 31 July 1969 for the transfer of much of American aerospace technology to the Japanese (*26*). Extremely lucrative for American aerospace firms (approximately $300 million) and giving them a strong position in the Japanese economy, the agreement provides the Japanese with technology that the United States has refused its European partners, and in the short run it binds the Japanese more closely to the United States.

However, the seeds of discontent and future difficulties are embedded in the agreement. The Japanese are forbidden to use the technology for military purposes, a difficult distinction to make with respect to aerospace technology. The Japanese must adhere to the International Telecommunications System (Intelsat), an organization controlled by the United States. And, most important of all, the Japanese may not export the technology to third countries, whereas their American partners presumably may do so.

In the light of developments of such magnitude, the future relationship of Japan and the United States will be of immense importance for the rest of the world. Although the alternatives should not be oversimplified as being only to become partners or to become competitors, the general character of the relationship will be one of the most important factors that shape future international economic relations and one that other nations must take into account in devising their own technological strategies for the next one or two decades.

Conclusion

It would be presumptuous to suggest that economic and technological forces will determine the course of domestic or international affairs. In the last analysis, passions rule the world. Nonetheless, to a degree perhaps unparalleled in the past, economic and technological considerations will shape the ways in which political interests and conflicts seek their expression and work themselves out. In a world where nuclear weaponry has inhibited the use of military power and where social and economic demands play an inordinate role in political life, the choice, success, or failure of a nation's technological strategy will influence in large measure its place in the international pecking order and its capacity to solve its domestic problems.

References and Notes

1. R. N. Cooper, *The Economics of Interdependence* (McGraw-Hill, New York, 1968), chap. 3.
2. R. Bailey, *Problems of the World Economy* (Pelican, New Orleans, 1967), p. 124.
3. The best empirical study of lead times known to me is *Technology in Retrospect and Critical Events in Science*, prepared and published for the National Science Foundation by the Illinois Institute of Technology Research Institute (Chicago, 1968, 2 vols.).
4. See *Technology: Processes of Assessment and Choice* (National Academy of Sciences, Washington, D.C., 1969).
5. The current status of the field is discussed by H. G. Johnson, in *Comparative Cost and Commercial Policy Theory for a Developing World Economy* (Almqvist & Wiksell, Stockholm, 1968).
6. See R. G. Gilpin, *France in the Age of the Scientific State* (Princeton Univ. Press, Princeton, N.J., 1968).
7. For a more detailed analysis of Japan's strategy, see P. B. Stone, *Japan Surges Ahead: Japan's Economic Rebirth* (Weidenfeld & Nicolson, London, 1969).
8. For a stark and frank appraisal of the situation by the French government itself, see *Journal Officiel, Assemblée Nationale* (Commission de la production et échanges, Séance du 10 Octobre 1968, Annexe 360), p. 587.
9. See N. Vichney, in *Le Monde* (8 July 1969), p. 6.
10. The wasted expenditure on nuclear powered flight has been estimated to be as high as $1.5 billion.
11. C. Layton, *European Advanced Technology* (Allen & Unwin, London, 1969), p. 236.
12. The difficult situation now facing the French atomic power industry is discussed by N. Vichney in *Le Monde* (18 October 1969), p. 5.
13. J.-J. Servan-Schreiber, *The American Challenge* (Atheneum, New York, 1968).
14. See J. Walsh, *Science* **155**, 1656 (1967).
15. *Reviews of National Science Policy: The United States* (Organization for Economic Cooperation and Development, Paris, 1968), pp. 423–424.
16. K. Samuelson, *From Great Power to Welfare State; 300 Years of Swedish Social Development* (Allen & Unwin, London, 1968).
17. A fascinating analysis of the Swedish structure is provided in a special survey by *The Economist* (28 October to 3 November 1967).
18. See I. Dörfer, *Public Policy* (Harvard Univ. Press, Cambridge, 1968), vol. 17, pp. 201–229.
19. The literature on the Japanese miracle is rather extensive, but three recent studies are especially relevant: M. E. Dimock, *The Japanese Technocracy* (Walker, New York, 1968); R. Guillain, *Japon Troisième Grand* (Editions du Seuil, Paris, 1969); H. Brochier, *Le Miracle Economique Japonais* (Calmann-Levy, Paris, 1965).
20. This is the conclusion of the excellent study of Japanese science and technology by the Organization for Economic Cooperation and Development, *Reviews of National Science Policy—Japan* (1967), p. 16.
21. P. M. Boffey, *Science* **167**, 960 (1970).
22. S. Okito and T. Miki, in *Capital Movements and Economic Development*, J. Adler and P. W. Kuznets, Eds. (Macmillan, London, 1967), pp. 166–167.
23. M. Y. Yoshino, *Japan's Managerial System* (M.I.T. Press, Cambridge, 1968), chap. 6.
24. Partial loss of this market may occur in any case as American firms become more concerned over Japanese imports.
25. R. Nixon, *Foreign Affairs* **46**, 111 (1967).
26. Reported in *Business Week* (13 September 1969), p. 52.