2/The Dynamics of Technology

Technology, far from being an inert deposit of practical knowledge, is itself a rapidly evolving system operating within larger systems also undergoing dynamic transformation. The radical instability which characterizes technology's matrix, modern societies, perfectly embodies the imagery made famous by Heraclitus—"all things flow." The very texture of life in such societies is swift, perpetual, and ineluctable change. Pervasive change creates expectations of further change and conditions people to view innovation as a value for its own sake, quite apart from considerations of intrinsic merit. No more congenial setting could be found for the development and continued growth of technology.

Technology has become, for moderns, the functional equivalent of nature for primitives. The present chapter briefly explores how technology is a kind of "second nature" and identifies various sources of technological dynamism. These include the competitive structures operative in the developed world, capitalist and socialist; the interaction among basic value choices in any society, its preferred development strategies, and its approach to technology; and the "sequence of dependency" which marks relations between rich and poor countries in arenas of international exchange.

Technology as Second Nature

In 1954 Ellul wrote that "no social,. . .human, or spiritual fact is so important as the fact of technique in the modern world."[1] Ellul's term *technique* is roughly synonymous with *technology* as used in the present work. Moreover, one central assertion made herein parallels a major theme of Ellul's, namely, *that technology has replaced nature as the context of societal perceptions and decisions.* For modern societies as for transnational societies now facing its challenge, technology, not nature, is the boundary against which possibilities must be measured.

In earlier ages humans experienced and interpreted reality against the backdrop provided by nature; indeed, a dominant part of the reality they perceived was nature itself. Their plans for survival and physical activity depended on the regularities or caprices of natural forces—heat, cold, wind, rain, seasonal cycles. That artificial sunlight called electricity did not yet exist; neither did the man-made bird called airplane, the artificial eye known as camera, or the surrogate mountains and forests we call skyscrapers and cities. Both in perceptual time and in importance nature was primary. The events which most dramatically influenced individual lives were natural: rainfall, droughts, floods, storms, and good weather were woven into the tissue of births, puberty rites, and deaths. Compared to natural forces, whatever an individual, family, tribe, or village might affect seemed puny. One planted and weeded, of course, but crop success depended above all on the weather. Society mobilized young males for hunting, but a sudden storm could chase the game out of reach. One built houses, but torrential rains could bring them down in an instant. Rivers were benevolent or destructive, winds capricious, the seasons themselves uncertain. Economic outcomes, no less than social harmony, depended largely on how nature behaved. Inevitably, all societies felt bound to render prodigal ritualistic homage to nature's supremacy through symbols, festivals, and personal obligations. More significantly, norms prescribing social behavior were designed to respect limits set by nature.

In modern societies technology has displaced nature from center stage. This is also the case in premodern societies increasingly caught up in processes of change. The impersonal forces to which society must now relate are those created by technology: electricity and other forms of artificial energy; machines able not only to perform myriad tasks but to design them as well; and decisional techniques which interpret and manipulate human life at every level. Such technological events as building roads, operating large factories, administering new cities, and disseminating radios or contraceptives *en masse* leave people feeling far more powerless than do such natural happenings as lightning, storms, or floods. The only "natural" world which a growing number of the world's inhabitants directly experience comprises the artificial mountains, streams, and forests built by technology: skyscrapers, faucets, pipelines, and cities.

Technology has become, for many people, the significant reference point against which possibilities and constraints must be measured. Therefore, moderns pay their ritualistic homage to technology instead of to nature. Within "developed" cultures it has now become mandatory to praise technology and to endow it with esthetic legitimacy (formerly reserved to nature and to gods) by glorifying it in art, music, and worship. Beyond ritualistic tribute, however, moderns must guide their actions by what technology can do, should do, and perhaps even impersonally wants them to do.

To probe the full implications of technology as second nature, particularly its penetration deep into modern psyches, would require writing an ambitious, albeit an exciting, book. My present task lies elsewhere, however: the metaphor of "technology as second nature" is invoked here solely to set the stage for a discussion of those systemic properties of technology which are germane to development. Of central importance is the ambiguity inherent in technology both as social reality and as artificial nature. To what extent does technology determine development images, strategies, and accomplishments? In one important respect technology is unlike nature, for it changes very rapidly. Its mutations are recorded in years and decades, not centuries or millennia. Is it, ultimately, the potent dynamism inherent in technology which explains its dual impact on human values, simultaneously destroying and creating them? But does technological progress necessarily presuppose speedy change within the larger society? One cannot answer this question without first understanding how technology propels, and is in turn propelled by, the engines of economic competition. It is no exaggeration to regard technology itself as the key to the "competitive edge."

The Competitive Edge

In 1705, a full seventy-one years before the appearance of Adam Smith's treatise *The Wealth of Nations*, Bernard Mandeville wrote *The Fable of the Bees.*[2] Since then the notion of progress in the West has been associated with quantitative, and particularly with economic, growth in a framework of socially sanctioned competition. More recently the cult of growth has extended to technology. Technology is presumed to progress or improve if it grows—in size, influence, areas of penetration, and number of new products it creates.

During interviews I have often asked corporate managers and research directors: "Why are research and development (R&D) so important to you? Do its benefits justify such huge expenditures?" Almost uniformly their answer has been: "We have to keep up because technology is always changing. And it changes constantly because it gives those who possess it a competitive edge which confers a decisive advantage over others in arenas of economic competition." A similar assumption is made by many government officials in Third World countries: namely, that technology must keep growing if it is to serve the cause of development. This twin legitimation—on grounds that corporations need technology in order to remain competitive and that poor countries need it in order to develop—decisively affects thousands of corporate investment decisions and governmental choices regarding R&D. These decisions, taken cumulatively as a systemic whole, transform technology into a compulsive growth industry. Champions of technological expansion rarely pause to ask whether quantitative growth is better than steady state (qualitatively distinct from stagnation) or whether their chosen pace of acceleration does not render the affected social systems unmanageable.

Within industrialized countries social critics now bemoan the absence, in expert policy-makers, of wisdom to match their science. Perhaps one reason why wisdom is so scarce is that technological applications of science have been made to grow compulsively in order to serve the cause of competition regardless of social costs, tangible and intangible. The notion of "competitive edge" merits further analysis because it goes to the heart of the evolutionary dynamism of technology itself.

Certain development writings imply that science and technology are the common patrimony of mankind and that the Third World enjoys advantages in being a latecomer on the scene of technological modernization. The Third World, we are told, can take technological shortcuts. Yet technology is not a free, but an economic, good sold dearly to those who can pay for it, not to those who need it most. As Lord Ritchie-Calder explains:

> It is true that one does not have to re-invent the wheel in order to ride a bicycle. It is true that each country that undertakes the modernization of its economy relies partly on the heritage of others. It is also true that there is a great deal of knowledge and know-how freely available for transmission from one country to another but many of the less developed countries do not know how to go shopping in the supermarket of science (Nobel laureate Patrick Blackett's phrase) nor how to get the free samples of generally available technology. The term "transfer" in this sense is a euphemism because technology and know-how is being bought and sold like a commodity, but there is no world market nor a world exchange nor world prices for technology. The "latecomers" in this case are like spectators arriving at the last moment at a cup final and having to buy tickets from speculators at excessive prices.[3]

Technology may be the most vital of economic goods because it can generate new wealth faster than other productive assets—capital, labor, natural resources, or favorable location. If new wealth is the golden egg, technology is the hen that lays it. The institutional capacity to generate technology permanently and in self-sustaining fashion constitutes a priceless asset. A research and development laboratory is but a special kind of factory which produces an important capital good known as technology. Neither the factory itself, not its output, technology, is a free good or the common patrimony of mankind.

Unless exchanges are subsidized, technology must be paid for by the buyer. The proper arena for its circulation is some local, regional, national, transnational, or global market. Although much of it is proprietary knowledge, technology tends to circulate faster and easier than most other capital goods, indeed, than many consumer goods themselves. This greater mobility is explained by the relatively intangible nature even of technologies which are incorporated in a "package" of goods or services. What is worth noting here is that technology circulates, if at all, within arenas of economic competition in the production and provision of goods, products, and services. Thus is technology caught up in the dynamics of competition. This fact leads directly to a question: To which stimulus does competition itself respond in modern economies?

Competition is fueled by incentive structures which reward those who are the first on the list at meeting effective purchasing power and its equivalents. Goods are produced and supplied by various enterprises—private, public, or mixed. Their supply role is meaningless, however, unless matched by a vigorously exercised parallel demand function. Whether producers are decisively stimulated by the lure of moneys held by purchasers or by the rewards that come from those who wield effective power to set targets, competition remains the basic ground rule of economic activity. Within capitalism, competition as response to effective buying power enjoys priority as the motor force of mobilization for production. Under socialism, on the other hand, competition—or "emulation," as it is more generally termed—responds to motivations based on political, ideological, and bureaucratic interests. Even state-owned enterprises must compete among themselves to be awarded contracts, to gain access to sources of material inputs indispensable to production, and to meet targeted quotas in time to avoid punitive measures. Under both systems, it is competition in the arena of production which dictates the behavior of individual production units, even though these units respond to diverse stimuli which play the role of inducing and rewarding production in a competitive mode. Thus, although considerable differences separate the two systems, both place the quest for a competitive edge at the center of enterprise planning. Yet why, one may legitimately ask, are enterprises so important?

Not only are enterprises the main producers and consumers of technology, but they also rely heavily on their technological abilities to gain or preserve any competitive edge they may enjoy. Nonetheless, significant differences among them are discernible in arenas of competition. Where enterprises, be they private corporations or state agencies, function as monopolies or oligopolies, they can indulge in the luxury, at least for a time, of being indifferent to those marketable "qualities" of their output best supplied by technology, packaging, or advertising. In theory, the very monopoly held by such firms would render them immune to the challenge of competitors did not practical constraints dictate otherwise. But after all, even state monopolies must meet production goals, quality standards, and minimum general-performance levels; if enterprise managers fail, the government planners—who are their masters—pass judgment on them on the basis of the performance of *comparable* enterprises in other countries or in other sectors of the same national economy. And as long as some competitive sector exists in which winning or keeping an edge is important, competitiveness rules the arena within which enterprises play out their roles as producers of goods. In the Soviet Union and other socialist national economies, a broader domain of competition prevails—that between the respective abilities of capitalist and socialist economies to "deliver the goods"—and competition creates pressures even upon monopoly enterprises in the socialist sector to gain a competitive edge founded largely on technology. Within capitalist economies, in contrast, monopoly positions are ephemeral and precarious by definition, and oligopoly advantages are even more so.

To summarize, in uncontrolled classical "free" markets, the competitive edge is essential to the survival and prosperity of enterprises. In controlled markets (monopoly and oligopoly situations), although the competitive edge is *relatively* less crucial on purely economic grounds, external considerations dictate some degree of competitiveness. What results is a universalized drive to "keep oneself competitive" by keeping abreast of technological innovations.

For purposes of this book it is worth recalling that most exchanges take place in market arenas, because even "nonmarket" transfers prove, upon examination, to be disguised market exchanges between a seller and a purchaser subsidized by some third partner. Because the competitive arena remains dominant, individual providers of goods feel obliged to seek some kind of "competitive edge." Consequently, even enterprises enjoying monopoly or oligopoly advantages constantly experiment with new technologies, new products, new packaging, and cheaper production processes. They seek two goals: to protect their position from encroachment by outsiders and to prepare themselves to enter other arenas where they do not (yet) enjoy control or dominance over the market. Indeed market conjunctures change quickly, and even monopolies are vulnerable to shifts in product life cycles and altered demand structures.[4] Other sources of change likewise affect control over markets: the pressure of governments and political militants on monopolists; shifts in buying power (either quantitative changes in monetary power or compositional shifts in consumer markets); and competition from enterprises eager to "break" the monopoly or share in the advantages of oligopoly. One lesson stands out: Complacency kills privilege. Accordingly, what business theorists term a "defensive" posture aimed at avoiding losses of privilege turns out, upon closer examination, to be no less direct a stimulus of competition than is an offensive stance aimed at gaining profit or privilege. Great latitude for aggressiveness is found whether firms pursue absolute profit gains or relative gains in their "share of the market."

One question—What provides the competitive edge?—has long puzzled theorists of the corporation. Frederick Knickerbocker traces it to a firm's oligopoly position.[5] But whence comes the oligopoly position itself? Its ultimate source is some competitive advantage expressed as a new product, better packaging, cheaper production processes, higher or more standardized quality, the ability to use alternative materials, or favorable access to special market slices. All these advantages, except the latter, are traceable to technology, which enables one firm to achieve these relative gains over others. Technology also enables competitors to wipe out the "edge" others enjoy and themselves become "competitive."

Yet one must not suppose that all technologies are equally stable. A few examples may prove helpful. Technologies used by shipbuilders[6] or dredge constructors change more slowly and less drastically than those utilized by makers of precision instruments or computers. Similarly, technologies acceptable to firms extracting minerals evolve more slowly than those utilized by manufacturers of carbon black or processors of petrochemicals, or even by those who refine or otherwise process extracted ores.

To the important question, "Why can certain activities remain competitive through the utilization of relatively stable technologies whereas others require ever-changing technologies?" several partial answers suggest themselves.

(a) *Scale constraints* explain some differences. In any activity requiring huge sums of capital and large basic infrastructures, actual and potential competitors cannot enter the arena quickly. Even assuming that competitors possessed superior technologies, they would lack other requisites for quickly translating their superiority into actual competing enterprises. Not surprisingly, the large size of the investment made by the initial firm in the arena makes it itself cautious about altering its equipment and/or processes before amortization has been effected. Although size alone does not *impede* rapid technological dynamism, it *slows down* the rate of change.

(b) *The nature of the product* also affects the relative stability of the technology used. If, for example, relative to the very nature of the materials used, fabrication is unsafe, materials are awkward to handle or transport, expensive or difficult to package, then a powerful stimulus exists to induce actual and potential competitors to make technological changes, for the reason that technological breakthroughs on these fronts confer immediate marketable advantages. On the other hand, if materials or processes are safe and easily handled, lesser inducements exist to concentrate R&D in search of improvements. Even when such improvements are made in laboratories, they cannot quickly be translated into sizable market advantages. In contrast, in domains where concerns for assuring health and safety are paramount—pharmaceuticals, chemicals, medical products, volatile or inflammable materials—technologies are highly unstable.

(c) *Luxury goods* and their equivalents also are biased toward rapidly changing technologies.[7] Demand for these categories of goods depends heavily on subjective factors easily manipulated by advertising. Design, shape, color, model variations, and packaging take on great importance in determining the size and location of the market for such goods. A powerful incentive exists for enterprises to engage in R&D because, by definition, potential buyers are conditioned to desire frequent changes. By applying this criterion to diverse technologies, one understands why bread-baking technologies tend to be less varied and more stable than those used in making cookies and those used to make screwdrivers more stable than those for electric lawnmowers, power saws, or phonograph records.

(d) *The state of scientific knowledge* also affects the relative stability of technologies. For long years it seemed impossible to "break the sound barrier" in airborne vehicles. Yet once scientists broke the barrier, new instabilities quickly made their way into the technologies for manufacturing even subsonic planes.

Technology is correctly viewed as a universe because it is a system of its own whose field of influence is the entire globe. Major technological changes such as the miniaturization of computer circuits quickly spread throughout the world, even in places where no autonomous technological innovation takes place. Indeed in such locales a competitive edge based on technology can most easily be established. Transnational corporations (TNCs) also know intuitively that a competitive edge which has been lost or diluted in "mature" markets can be regained in less mature markets. The history of TNC investment attests to the profitability of technologies and derived products in Third World sites long after the competitive edge, or even basic marketability, has been lost in original industrial sites.

TNC marketing practices also suggest an interesting gloss on the basic theses of Latin American dependency theorists.[8] This added dimension may be called the "sequence of dependency." (Chapter 4 of this book discusses in greater detail the role of transnational corporations in technology transfers. At this point it suffices to mention the elements of the "dependency sequence.") The sequence is initiated when the dependency of purchasers is expressed in their need for a varying spectrum of goods provided by outside sellers. Initially, public and private firms in less-developed countries depend on outside suppliers for *capital*. This need leads them to offer inducements to direct investment and other forms of supplying capital, such as loans or grants. After pressing capital needs have been met, however, or at least mitigated, the most pressing demand felt in underdeveloped economies is to import *technology*. Once again, varied incentives are held out to those who can satisfy this demand.

But what can transnational corporations offer to poorer countries once the latter have met their needs for capital and for technology? Many firms whose capital or technology is no longer sought or welcomed are courted for their *managerial expertise*. But in one sense, managerial expertise is simply a particularly intangible kind of decisional technology, special in that it can be gained only after long years of experience.[9] Moreover, it is usually enterprise- or firm-specific (not industry-specific) or general.[10] Thus a firm lacking managerial expertise can acquire it only by an ongoing transfer process which must be contractually negotiated.

The final component—after capital, technology, and managerial expertise have been obtained (hypothetically, of course) by less-developed purchasers—is *access to markets*. Prerequisites of access are an existing network of contacts, specialized legal and bureaucratic skills, and rapid information-processing abilities without which final products would not move fast enough or far enough to amortize the high production-input costs of capital, technology, and managerial expertise. Again is illustrated how tightly technology is bound to the dynamics of competition. (To make this relation explicit is necessary because many writings treat technology as though it were some good transferable independently of competitive laws.)

The four-step dependency sequence just outlined grows in importance even as increasing numbers of Third World countries reduce their dependence on imported capital, because they remain dependent, nevertheless, on outside suppliers of technology. Venezuela is an illustrative case; now that the country is self-sufficient in capital, it has launched an ambitious program aimed at reaching a high degree of technological self-sufficiency.[11] Arab oil-producing countries and Iran likewise no longer need capital from industrial centers; yet they still need technology. And corporate sellers of technology are quick to understand that the locus of their present "competitive edge" may shift once again. For this reason they strive to transfer their technology in ways which disassociate it from their managerial expertise. And why? Because such expertise is the next asset down the line which assures competitiveness to its possessors.

Is the technological universe, therefore, blindly condemned to grow in present modes, or can technological maturation be reached within patterns of steady state?[12] The question is whether qualitative improvement can replace quantitative growth as the driving force of the evolutionary dynamism of technology.

Unlimited Growth or Steady State?

Business leaders throughout the world speak glowingly of the benefits of growth. A typical encomium appears in the annual report of one corporation in these words:

> Whether or not it is expressed in words, there is a philosophy that guides the destiny of every corporation. The philosophy under which Koppers operates consists of a number of tenets. One of those tenets emphasizes the need for growth.
>
> To the public eye, growth becomes visible through rises in

> sales and earnings. Underlying those statistical gains is a recognition that the corporation has been successful in fulfilling its primary mission: to upgrade resources in order to provide the abundance demanded by society in its efforts to improve the human condition. . . .
>
> Growth can provide the opportunity for new challenge and relief from routine.[13]

For the managers of Koppers, as for their peers in other companies, growth "improves the human condition." To questions regarding equity and social justice, they reply that distributing new benefits can simultaneously right old wrongs and satisfy new needs. This conventional wisdom also asserts that competition is legitimate because it powerfully stimulates growth. Nevertheless, competition can be disassociated from growth paradigms, and technology itself can be viewed as competitive beyond the confines of standard, purely quantitative images of growth.

Technology does not itself create or cause competition in arenas of exchange; on the contrary, it is competitive because the arena in which it circulates responds competitively to market stimuli. Thus, technology could conceivably cease being the source of a marketable "competitive edge" if the incentive systems governing exchanges were altered. Such a change does not necessarily imply making technology static, however, inasmuch as various other stimuli can propel or elicit technological improvements: status emulation, the desire to solve problems, the drive to know more, or the urge to improve the quality or to increase the durability of present tools. Implied here is the belief that *qualitative technological growth* is fully compatible with nonmonetary models of competition. Recent theorists use terms such as *steady state* for models of economic progress or stress the need for "organic" instead of disjointed growth.[14] Indeed technological maturation may prove more essential to the success of these efforts than it is to present growth models. The key and unavoidable questions remain, however: What is technology for? Which values, politically arbitrated and ethically confirmed, should command technological choices? Arbitration is necessary because, as Victor Ferkiss writes,

> now that technology has given us the power to destroy these life processes and to alter the nature of the human species, *every decision is intrinsically political.*[15]

Borremans and Illich make the same point and conclude that "what is necessary today is the political control of the technological characteristics of industrial products."[16]

Some government planners define technology's role in harmony with an "organic growth" model of development. In order to create a decision-making system which could integrate and balance social, economic, and environmental processes, they devise a conceptual guidance system for making budgetary and programmatic decisions. What is germane here is simply the recognition by planning teams that only a "highly technical discipline" can enable them to control and redirect growth toward humane ends.[17]

The need to innovate qualitatively is salient in diverse approaches to "appropriate" or "intermediate" technologies. The priority goal sought by all is sound human development which shatters both the market determinism of capitalist growth and the rigidities of centralized, socialist planning. Serious advocates of "steady state," "organic," or "human scale" development acknowledge that their own goals cannot be reached without technology—hence their quest for alternative models of technological maturation, placing special emphasis on "self-help technology" which aims primarily at helping the rural poor develop their own economies. Criteria for self-help technologies are labor intensity, low cost, maximum utilization of local materials and skills, the protection of resources and environment, and easily managed scales of operations. E.F. Schumacher judges that "donor countries and agencies do not at present possess the necessary organized knowledge of adapted technologies and communications to be able to assist effectively in rural development on the scale required."[18] Were "adapted technologies" available, therefore, they would enjoy a "competitive edge" in meeting important unsatisfied needs not presently met. The experience of Schumacher's Intermediate Technology Group[19] attests to the need for new and better (but cheaper and simpler) technologies in the Third World, particularly in food-growing, water-harnessing, machinery design, health services, and housing-construction.

Most discussions of alternative technologies—called, variously, *radical, soft, intermediate,* or *appropriate* technologies—center on rural questions. Nevertheless, they raise issues germane to urban living and to industry, in short, to "developed" countries. This relevance is emphasized by the Community Technology Group in Washington, D.C.[20] Even US city-dwellers, argues the group's founder, Karl Hess, need to develop high degrees of self-sufficiency and achieve mastery over small-scale technologies.

My argument can be summarized in a series of related propositions and questions:

(1) *Technological expansion, as presently conducted, is highly wasteful of resources. If, therefore, resource and ecosphere conservation become priority goals, should technology be allowed to keep expanding?*

The answer is yes, provided that expansion takes place in a different mode. Conscious efforts need to be made to achieve qualitative maturation of technologies overtly designed to assure ecological integrity, more manageable scale, and greater accessibility to poor people.

(2) *If untrammeled wasteful growth is undesirable, is stagnation the only alternative?*

No. In "organic" or "steady state" growth models, quantitative gains are not eliminated but subordinated to qualitative improvements, to the mode in which the growth is realized, and to considerations of social-costs paid to achieve it. Growth, in short, is sought in ways which foster a cluster of stipulated values.

(3) *Can technological evolution adapt itself to the requirements of such growth?*

Yes, on condition that the basic value options, development strategies, and technological-development policy of a society are clearly defined and coherently pursued. (The "vital nexus" among the three is discussed at length in later pages.)

(4) *What other changes must occur before such an altered course in the direction of technological evolution can become possible?*

Many prior changes are required. First, widespread value transformation must wean people away from their infatuation with mass consumption and endlessly wasteful changes in design, shape, packaging, and color. The vision of a good life [21] must center on "sufficiency for all" defined in a dynamic way which balances quantitative growth against other values. Consequently, broad political agreement needs to be reached as to the desirability of placing some ceiling on the scale of technologies and on kinds of production. Furthermore, the education of engineers, designers, and planners must be revolutionized to release them from their servitude to the technological imperative.[22] This may clearly be the most difficult task of all.

At the conclusion of this work I shall return to these issues and discuss technology assessment and the revitalization of culture in the face of technology's standardizing influences. I must first, however, examine a relationship which both explains and obscures the dynamism peculiar to technology as a social system. This is the "vital nexus" which links any society's basic value choices to its preferred development strategies and to its attitude toward technology expressed in policy.

The Vital Nexus: Value Choices, Development Strategy, Technology Policy

As stated above, technology is both a system of its own and a component of larger social systems. One must, accordingly, analyze its workings by alternatively probing technology's inner dynamics and its links to broader social processes. It is particularly useful to analyze the link which binds society's basic value options to its preferred development strategies and to its technology policy. This "vital nexus" of the three is well illustrated in the case of the world's largest poor country, the People's Republic of China.

Mainland China openly affirms the central importance of value transformation on its road to development.[23] And a growing body of scholarly literature is now available describing China's approach to technology.[24] It lies beyond the scope of the present book to analyze or even to summarize China's technology policy. So as to illustrate the importance of the "vital nexus," however, it is worth recalling the importance attached by the Chinese to coherence among basic value options of their society, their road to development, and their technology policy. Huge problems faced China when Mao acceded to power in 1948: society had to be reconstructed from the ruins of war and foreign occupation and mobilized, along new ideological lines, to produce more abundantly and efficiently. Countless institutional problems identical to those faced by other nations in quest of "development" had to be solved. Among these were the creation of a universal educational system founded on social merit and participation instead of on hierarchy and privilege, the provision of health services to a population which remained largely rural and suspicious of "Western" medicine, and gaining effective access to foreign technologies. By all accounts, China's monumental efforts in these domains have brought relative success (whatever be one's final judgment as to the social and political "costs" incurred). Of special interest, however, is the explanation offered by the Chinese themselves as constituting the key to success.[25] One must, say the Chinese, center efforts on overall incentive systems operative in society and base these on values consonant with revolutionary objectives. One common formulation of the approach reads: "Values command politics, politics commands economics, and economics commands technique." Central values adopted and disseminated are:

(a) *the need to acquire "revolutionary consciousness"*

Developing this consciousness requires a new reading of China's historical past, which explains the causes of its subjection to foreigners and the perpetuation of indigenous privileged classes. This study also highlights the historical potential the nation presently possesses for creating a new society now and in the future.

(b) *a vision of "austerity" as preferable to a model of affluence*

Austerity is here understood to mean "sufficiency for all" obtained by "strenuous striving" to increase production and productivity. In pursuit of that sufficiency, all must make optimum use of every resource and struggle mightily, not only against the acquisitive spirit but also against "alienating" oneself in the desire for future goods. One pedagogical theme repeatedly stressed is the primacy of moral, over material, incentives. This primacy, it is stated, is the pillar upon which must be built the edifice of solidarity and the "serve the people" ethic. Austerity, therefore, is viewed not as a necessary evil to be tolerated in times of scarcity or initial poverty but as a permanent component of authentic socialist humanism. The assumption underlying this belief is that people are as deeply "infected" by the virus of acquisitiveness in their desire for future goods as they are by clinging to goods already possessed.

(c) *a commitment to high degrees of equality and participation*

The endless struggle against differential expropriation of benefits and against elitism are a social and institutional expression of this value choice.

(d) *a strong affirmation that the single most important resource for development is human will, collectively and responsibly mobilized*

This insistence leads to an attitude of thinking that no problem is insoluble, even in the absence of what are considered to be "normal" resource requirements of a material or a technological sort.

If, therefore, a society were to make these value choices (although no society can perfectly, or with full consistency, practice them!) and if, furthermore, it were to try overtly to formulate a "road to development" (or a development strategy) which coherently promotes these values, then obviously different criteria for policy will emerge than would otherwise be the case. It would become essential, for example, to decentralize productive investment, to institutionalize maximum self-reliance in local units, to combat tendencies which create or perpetuate chasms between intellectual and manual labor, etcetera.

The choice of initial values also has its impact on the precise formulation of technology policies. There is no need to review Chinese technology policy in detail here; nevertheless, one notes that great care is taken to allow at important sectors of production (the manufacture of consumer goods, agricultural production, and the provision of basic services) for grassroots technological innovation and shared research responsibility.

Although a worthy example of how the "vital nexus" may work, China is not perfect; it is no social paradise but an historical experience fraught with contradiction. Yet few societies strive so mightily and so explicitly to design development strategies and technology policies in accord with prior value choices. What is more, few nations attempt to formulate these choices so clearly and so vigorously.

My contention is that a direct correlation exists between the degree of linkage among the three component elements of the "vital nexus" and the quality of technology policy itself. Thus one can frame satisfactory technology policies—on the international, regional, and national levels—only to the extent that one is clear and firm regarding basic social values and development strategies consistent with these values. Many country planners and politicians, it is true, do articulate goals, albeit in purely rhetorical fashion (emphasizing, let us say, "developmental equity" or "relative technological autonomy"), and yet they refrain from adopting the strategies and policies which would render these goals feasible. In contrast, what China's example brings into sharp focus is an important lesson in how development can be guided by values and how value transformation can indeed become the main road to development.

In an earlier work I have argued that development decisions are not primarily economic, technical, or even political in nature.[26] Rather they are moral options around three vital issues: the criteria of the good life (the relations between the "fullness of good" and the abundance of "goods"), the basis for just relations in society, and the principles for adopting a proper stance toward the forces of nature and of that "second nature" we call technology. What renders these choices specifically developmental is the modern setting, characterized by the massive scale of operations; technical complexity and its attendant division of labor; multiple interdependencies which bind each part to the whole and the whole to each part; and the ever-narrowing time lag between the impingement of social changes proposed or imposed and the responses societies must make to assure survival, identity, or creative assimilation of change. Hence the development strategy any nation adopts and, *a fortiori,* its policy in more limited domains such as technology are necessarily linked to its value options.

Specialists usually discuss development strategies in terms of relative priorities: investment in industry over agriculture, in human resources over infrastructure, tax incentives to foreign firms over increased credit to native firms, and so on. Although planners rarely advert explicitly to the nexus between values and strategic priorities, its existence is undeniable. Thus if one adheres to the value of greater egalitarianism, one will tend to favor improvements in agriculture over industry, small technology over mass-scale techniques, subsidies to local firms over tax holidays to transnational corporations, and popular decision-making over exclusive reliance on experts. The same interdependence between strategy and values exists at the level of ideology. If one chooses capitalism, with its implied effort to integrate into the world market, values such as self-reliance and local innovation are relegated to the background. If, conversely, one adopts a communitarian socialist strategy of development, one will prefer gains in economic independence to pure efficiency and one will attach greater weight to social justice (in the land-tenure system, for example) than increased output. In a word, *value choices and development strategies are tightly linked.* When one introduces a third element into the equation, namely, technology policy, the nexus tightens still more.

What is to guide technology policy if not basic values and the strategies derived therefrom? Surely not mere considerations of technical self-sufficiency, uncritical aspirations for technological modernity, or imitation of technological pioneers. If technology policy is to have the consistency of sound decision-making, it should flow from the basic value choices underlying the selected development strategy.

Many national-technology policy-makers appear oblivious to this link; yet no technology policy can succeed if it is not expressly designed to reinforce the social values pursued, in some scale of priorities, by the development strategy adopted. Certain approaches to technology are evidently more congenial than others to this unity. To illustrate, if Tanzania's commitment to self-reliant development which builds on the communal values of its largely rural communities is a serious objective, one would expect its technology policy to assign a wide role to "soft" technologies aimed at increasing productivity through optimal use of local resources. Or, as one reflects on Algeria's declared goal of achieving the full range of industrial capacity for internal and export markets, different technological measures recommend themselves. Among these are: importing foreign technologies to build up competitive capabilities, training nationals in order to limit dependency to the briefest possible period, and achieving a coordinated bargaining posture so as to avoid outside exploitation.

To affirm the existence of a "vital nexus" among value choices, development strategy, and technology policy is not to state that all technology policy-makers in the Third World derive their policy from the other two elements. But it does mean that they *should* do so if they are to avoid two dangers. The first is falling into contradictions between basic development goals and technological choices. The second is becoming imprisoned by the greater or lesser degrees of determinisms which are inherent in technology itself or which flow from the uncritical acceptance of conventional technology transfers. Therefore, the best way to design policy is to advert explicitly to the "vital nexus"; it cannot be ignored with impunity.

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Part One of this work has described the technological universe. Technology has been called a two-edged sword because it is ambivalent, promoting certain values while threatening others and creating new servitudes as it frees its users from old constraints. Because the technological universe is not static, I have also described its dynamics, focusing on technology as a kind of artificial nature constantly evolving at a quicker pace and with greater unpredictability than nature itself. This mutability of technology was then placed in the context of economic competition, a major stimulus to social change. Also delineated was a "sequence of dependency" which less-developed nations might envisage breaking by progressively reducing their reliance on outsiders for capital at a first stage, then technology, later managerial expertise, and finally, access to markets. A further dimension of technological dynamism is its vital linkage to broad value choices constantly being made within changing societies and to preferred development strategies.

One central premise of this book is that value conflicts in international technology transfers are traceable to two distinct sources: the value ambiguities of technology itself (even in its matrix of origin) and the specific channels and mechanisms by which technology flows from rich to poor countries. The first of these has been examined in Part One. It is now time to examine how technology is transferred from "developed" to "less-developed" countries (LDCs). This exercise is conducted not for its own sake but to shed light on one crucial question: Do such transfers impede or aid genuine development for all? This question is now addressed in Part Two.