Soft Technologies, Hard Choices

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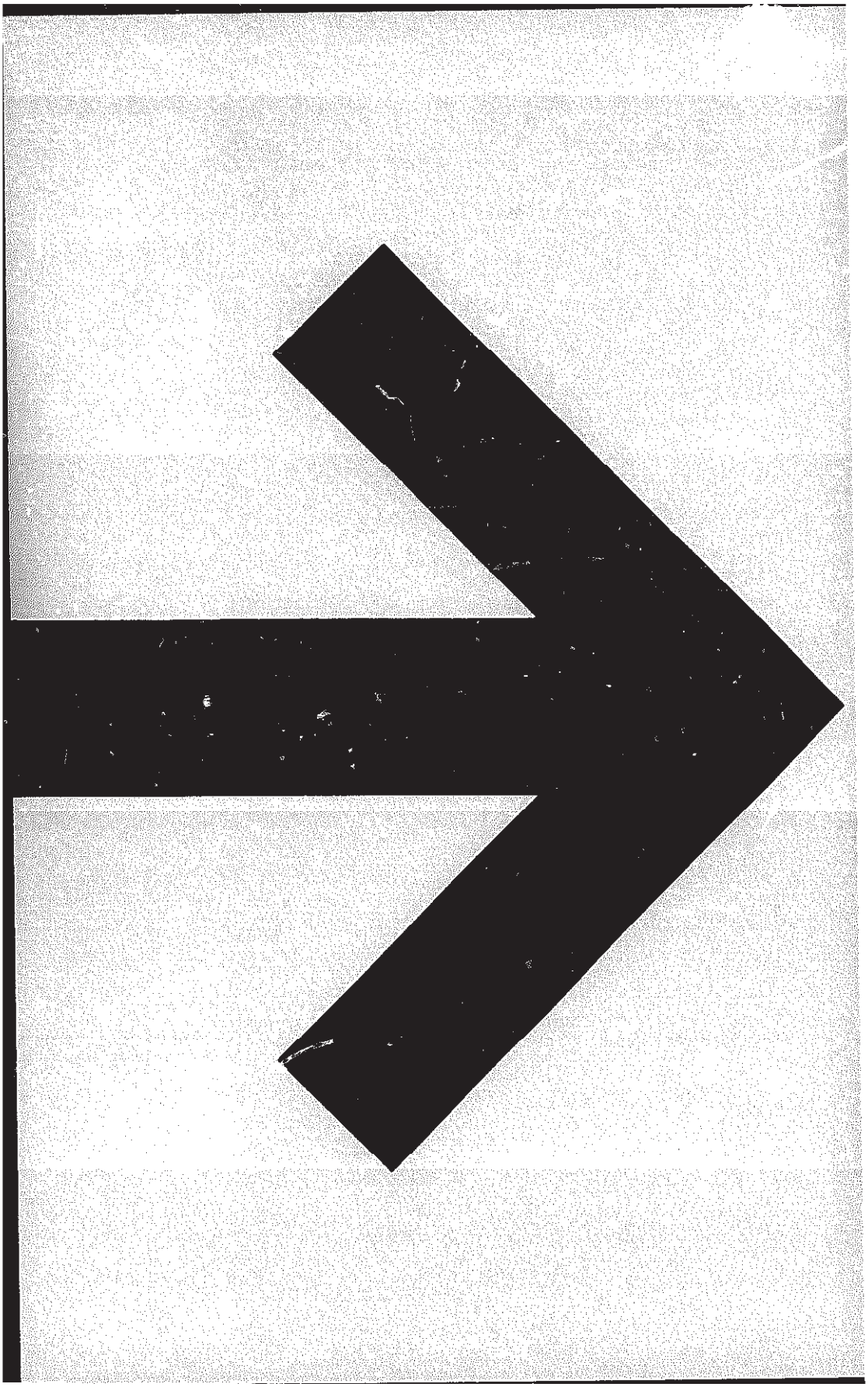

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In the British Parliamentary election campaign of 1964, Labour Party leader Harold Wilson repeatedly promised to lead the nation to prosperity through the "white heat of technological revolution." Across the Atlantic, the Apollo Program was in full swing, with the goal of putting a man on the moon by the end of the decade. In Asia and Latin America, the Green Revolution was about to get under way, and it seemed to promise a technological solution to the world's food problem. As for energy, although it was generally acknowledged that oil and gas reserves would not last forever, nuclear power was waiting in the wings, ready to provide electricity "too cheap to meter."

Technology seemed to hold the key to many treasures in the fifties and sixties, as a stream of technological innovations changed virtually every facet of life in the industrial world. The postwar recovery of Europe and Japan heralded a period of rapid economic growth, and foreign aid programs were constructed around large, high-technology projects in the expectation that economic development would quickly follow. But by the early seventies, some of the bright hopes invested in the technological revolution began to dim.

In the industrial countries, rising concern about environmental pollution, the Vietnam war, and the consequences of unlimited growth in material consumption focused attention on the negative side effects of some technological developments. In the Third World, it has become clear that the technological revolution has bypassed most of the world's poor. Although the Green Revolution has increased grain yields, for example, chronic malnutrition is still a fact of life and death for at least half a billion people—a grim reminder that technical fixes cannot solve complex social problems.

The transition from the gung ho technological optimism of the postwar era to the more uncertain mood of the seventies is symbolized by two events of singular technological importance—the 1969 moon landing and the 1973 Arab oil embargo. The moon landing marked the pinnacle of a long, spectacular effort that demonstrated humanity's technological prowess. Just four years later, however, the oil

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embargo underlined the fragility of the industrial world's petroleum-based economies, and provided a forceful demonstration of the close bonds between modern technology and a finite, shrinking resource.[1]

The persistence of deep-rooted social, economic, and environmental problems in rich and poor countries alike has provided fertile ground for questioning the nature and direction of technological development. A few have rejected the values of modern technological society, while others have espoused the "small is beautiful" philosophy put forward by E. F. Schumacher.[2] In general, the prevailing attitude has changed from confidence that technology will pave the way to a better future, to uncertainty, summed up in the query *"If we can put a man on the moon, why can't we. . .?"*

The uncertainty is understandable, for the world faces an uncertain future. Economists are unable to diagnose, let alone cure, the economic ills that have afflicted most countries in the seventies. Unemployment has reached epidemic proportions in much of the developing world, and it shows every sign of rising in the next few decades. In the industrial countries as well, joblessness is at unacceptable levels. Income gaps between rich and poor countries, and between rich and poor within many countries, have been widening in recent years, a trend that is raising justified demands for greater global equity. The longevity of the world's oil and gas reserves is in doubt, and rich and poor countries alike face the necessity of switching to new sources of energy supply in the next few decades. And there are signs that pressures on many of the world's ecosystems are reaching unsustainable levels.

Those four concerns—employment, equity, energy, and ecology—are likely to remain high on the international agenda for the remainder of the twentieth century and beyond. They must be taken into account in the choice of technologies within countries and in the transfer of technologies between countries. These criteria have not played a prominent role in technological development during most of the postwar era, however.

During the fifties and sixties, unemployment was relatively low in the industrial countries, capital was abundant, energy was cheap and seemingly boundless, and raw materials were available in copious quantities. Technological development therefore generally led to the substitution of capital and energy for labor in the production of

goods and services. Technologies have become more complex, energy-intensive, labor-saving, and larger in scale, and industrial society has acquired a voracious appetite for raw materials. Those trends must be examined in the light of the changing global environmental and economic prospects.

Those prospects require that technologies be adapted to the use of constrained rather than abundant resources. But no technology—*however appropriate*—will solve social problems by itself. The development, introduction, and international transfer of technologies involve a constellation of government policies, vested interests, and political and economic trade-offs. Those factors all constrain the choice of technologies. Moreover, an attack on problems of poverty, malnutrition, disease, and land degradation requires political will, as well as material resources, to overhaul credit facilities, mount adequate public health programs, and institute land reforms.[3]

Nevertheless, the choice of inappropriate technologies can only exacerbate social, economic, and environmental problems. It is clearly time to shed the notion that the biggest, fastest, most modern technologies are always the best, and to seek alternatives that are more compatible with the changing global conditions of the final quarter of the twentieth century.

Employment Impacts

Unemployment on an unprecedented scale has emerged as one of the most pressing political and social problems of the seventies. While governments in industrial countries have been grappling with a pernicious combination of inflation and unemployment, rates of joblessness throughout the Third World have reached extraordinary levels. Two ominous features of the global employment picture stand out: the job shortage will probably worsen before it improves, and it is unlikely that conventional economic remedies will offer sufficient relief.

Economic development theories that held sway during the fifties and sixties are beginning to lose their credibility in the light of mounting unemployment and underemployment throughout the Third World. And as this occurs, it is becoming evident that a massive transfer of modern technology from rich to poor countries will not provide the key to prosperity in the developing world. Meanwhile, in the indus-

trial countries the link between technology and jobs—particularly in the area of energy policy—is being re-examined in the face of unemployment levels unmatched since the Great Depression.

In part a result of population growth during the past few decades, massive unemployment in the Third World has been a long time in the making. It will take even longer to abate. About 200 million people have flooded the labor markets of developing countries during the seventies, and an additional 700 million are expected to require employment by the turn of the century. Already, the number of prospective workers has greatly outstripped the supply of new jobs. By the mid-seventies nearly 300 million people, more than three times the number who have jobs in the United States, were believed to be unemployed or severely underemployed, eking out a precarious existence as casual laborers, street peddlers, shoe-shine boys, and other fringe workers.[4]

More than 30 million jobs must be created each year over the next 20 years merely to keep pace with expansion in the Third World's labor force. Anything less is likely to aggravate inequities and lead to rising levels of poverty. If at the same time productive employment is provided for those who are now grossly underemployed—a critical dimension of any effort to lift the incomes of the poorest people—about one billion new jobs must be created by the year 2000.

These figures provide a central reason why modern technologies cannot be a panacea for development: the capital needed to create enough jobs in modern industries and in Western-style agriculture would be staggering. It now costs an average of $20,000 to establish a single workplace in the United States, and modern industrial jobs in the Third World are no cheaper to create. It requires only a pencil and the back of an envelope to demonstrate the difficulty of establishing a billion jobs at those prices, to say nothing of the energy and materials that such a task would require.[5]

Indiscriminate transfer of modern technology from industrial countries to the Third World can cause more problems than it solves. Technological development since the Industrial Revolution has led to the substitution of capital and energy for human labor in the production of goods and services, substitutions that generally reflected the relative availability and cost of capital, energy, and labor in the industrial world. But these capital-intensive, energy-consuming, labor-saving

"There can be no universal blueprint for an appropriate technology for any particular task."

technologies make lavish use of the very resources that are scarce and expensive in the Third World, while failing to utilize much of the Third World's most abundant asset—people.

In general, technologies are economically efficient if the factors of production—labor, capital, energy, and raw materials—are blended together roughly in proportion to their cost and availability. The guiding economic principle should be to maximize the output of the scarcest factor. Since the availability and cost of these four factors vary between rich and poor countries, it follows that different countries require different technologies—or at least different mixes of technology—to make the best use of their resources. There can therefore be no universal blueprint for an appropriate technology for any particular task.[6]

Nevertheless, for the developing world in general, technologies that use locally-available raw materials, serve local needs, and can be maintained without sophisticated repair and maintenance services will usually be cheaper to develop and operate than imported technologies. Moreover, by stimulating local innovation and reinforcing other development efforts, simple technologies can lead to self-sustaining development. Although increasing attention is being paid to the use of such technologies in some developing countries, a recent World Bank report candidly notes that "this potential remains largely unexploited."[7]

Governments do not deliberately plan to have a large portion of their labor force unemployed or underemployed, but often that is precisely the outcome when a poor country invests most of its national savings in imported capital-intensive technology. Such investments do raise the productivity of a few workers, and the gross national product consequently increases. But this approach leaves little capital to aid small farmers, landless laborers, and small-scale manufacturers—producers who now constitute the majority of the labor force in most developing countries.

Many developing countries have sought to implant U.S.-style agriculture in their fields by subsidizing imports of heavy machinery and labor-saving techniques, often with assistance from international lending institutions. Pakistan, for example, received a loan from the World Bank in the late sixties to buy some 18,000 large tractors. A subsequent Bank study, which has generated considerable contro-

versy, provides a sobering warning of the danger in assuming that technologies appropriate in one country will confer the same benefits in another setting. Farmers who bought tractors found it easier to work larger farms so they increased their holdings by displacing tenants and by buying extra land. On the average, farm sizes doubled after the introduction of tractors, while labor use per acre dropped by about 40 percent. Yet yields per acre showed little change. The Bank's report concluded that "the widespread introduction of tractors in Pakistan agriculture in the future, if it followed the course that was manifested in the past, would be little short of a disaster to the economic and social fabric of the rural sector."[8]

Such an experience should not lead to the blanket conclusion that *all* capital-intensive modern technologies are inappropriate in the developing world. Far from it. Often, there may be no feasible alternative to sophisticated technologies developed in the industrial world. Imported modern technologies may offer significant advantages in the production of certain goods, such as chemical fertilizers, that are essential for development. And a country that seeks to earn foreign exchange by exporting manufactured goods to the industrial world may be forced to use capital-intensive technologies to bulk-produce high quality merchandise that can compete on the international market. Nevertheless, faced with chronic shortages of capital and rapidly swelling labor forces, most poor countries need to find productive employment for large numbers of people with small expenditures per worker.

As most of the population in developing countries now lives in the countryside, most of the increase in the labor force will also come from the rural areas. If the crushing urban migration that has taken place during the past few decades is to be halted, productive employment must be created in the fields, villages, and small towns. All the above considerations point to the need for technologies that will create employment for landless laborers, lead to more productive use of labor in public works programs, and establish labor-intensive industries.

Demand for rural labor in developing countries fluctuates according to the season. During planting, weeding, and harvesting, every available person is usually busy in the fields from dawn to dusk, but at other times of the year jobs are scarce. A shift to more intensive cultivation can greatly increase agricultural employment, but in regions

"If crushing urban migration is to be halted, productive employment must be created in the fields, villages, and small towns."

where the growing season is short, new technologies may be required to allow more than one crop to be grown each year. Selective mechanization, for example, may be needed to speed up planting and harvesting to squeeze additional crops into the growing season. A variety of inexpensive pedal-operated machines, designed to ease and shorten some operations, have been developed in recent years. The International Rice Research Institute (IRRI) in the Philippines has developed a range of relatively inexpensive power tillers, threshers, and weeders for rice cultivation. And a project financed by the World Bank has introduced draft oxen into cotton-growing areas of the Ivory Coast, a technology transfer that has provided significant improvement over hand cultivation at a fraction of the cost of tractors.[9]

Irrigation alone can increase labor demand per acre by up to 80 percent by extending the growing season to permit multiple cropping. But the construction and operation of irrigation systems is often a costly business and wealthy farmers with large holdings are usually the first to benefit from irrigation. There are, however, cheaper alternatives. The use of locally-available bamboo or baked clay as filters, instead of metal screens, can cut the cost of a single well to about $15, and a reliable and easily maintained hand pump has been developed for about $100. Windmills constructed with local materials are providing low-cost irrigation in the Omo Valley in Ethiopia. The World Bank is also experimenting with a scheme in India that involves renting portable diesel pumps to farmers for short periods, a strategy that spreads the capital cost and brings them within the reach of small farmers.[10]

High-yielding varieties of rice can also greatly increase labor requirements, largely because they need additional applications of fertilizers and pesticides. A study in Bangladesh found that labor requirements on unmechanized farms (farms that used oxen rather than tractors for draft power) were increased by between 30 and 50 percent when high-yielding varieties were used. When mechanization was introduced along with the new seeds, however, labor requirements dropped. There was little difference in yields between the mechanized and unmechanized farms, which implies that capital invested in mechanization does not necessarily generate more output per acre.[11]

Public works programs, such as the construction of dams, irrigation canals, roads, and buildings, consume a large portion of the budgets

of developing countries. Such projects are of two types. Some employ the same technologies that are used in the industrial countries—bulldozers, mechanical diggers, tar spreaders, and so on—and they are consequently highly capital-intensive. Others employ armies of people to move earth with head baskets and shovels. These projects create jobs, but they involve heavy toil and take a long time.

Studies by the World Bank and the International Labour Office have indicated, however, that there is considerable scope for using more efficient labor-intensive methods. Improved wheelbarrows, ox-carts, and hand-operated rail carts to haul materials, ox-drawn plows to break up the ground, and block-and-tackle systems to help move heavy loads can all reduce back-breaking toil and raise productivity to the point where labor-intensive construction is cheaper than capital-intensive methods. Moreover, if the improved tools are fashioned locally with widely available materials, employment is also created indirectly. This may require that local industries be upgraded.[12]

The Chinese have made extensive use of such public works programs. The most famous example is Tachai, where small rocky fields that were frequently washed out by heavy rains have been transformed by hand into productive units through the construction of drainage tunnels, terracing, and the replacement of lost topsoil with earth carried down the mountainside. Similarly, in Lin County, a 1500-kilometer canal network was dug with manual labor during the sixties to irrigate arid and relatively unproductive fields. Such projects have not only absorbed slack agricultural labor, but also greatly increased the productivity of the land, raising demand for agricultural workers. In a sense, the Chinese have harnessed reserves of idle labor and used them for capital formation—a manifestation of Marx's description of capital as congealed labor time.[13]

The use of labor-intensive construction technologies can be limited, however, by shortages of organizational skills. Since a few machines are easier to organize than a large number of workers, there is often a strong incentive to use capital-intensive technologies in place of people.

Manufacturing technologies developed in industrial countries, like agricultural and construction technologies, are often ill-suited to the

needs of the Third World. Not only do they require large amounts of capital and provide few jobs, but they often use materials that are not available locally, produce large volumes of goods for remote markets, and need sophisticated repair and maintenance services. It has been assumed that large-scale modern industries would be efficient in developing countries because they take advantage of economies of scale. But such hopes have often proven false. Factories are frequently operated at less than full capacity, which means that capital invested in the plants is used inefficiently and employment is kept well below its potential. Large-scale, centralized production also requires dependable, cheap transportation for the supply of raw materials and the distribution of finished products, but in many developing countries, transportation facilities are inefficient and expensive.

Mounting evidence of such problems has begun to focus attention on the role of labor-intensive, small-scale industries in providing employment and promoting development. In many developing countries, small-scale enterprises, ranging from village artisans to textile producers, constitute the bulk of manufacturing employment. Such enterprises are often shoestring operations, however, lacking access to capital and established markets.

Deliberate attempts to foster small-scale industries, instead of replacing them with large-scale production technologies, have produced encouraging results in a few countries. China's rural industries are perhaps the best known. According to one estimate, there may be as many as 500,000 rural industrial units in China, producing items such as cement, fertilizer, iron and steel, agricultural machinery, textiles, and processed food. They rely for the most part on local materials and supply local needs. Like China's rural public works programs, the rural industries are geared toward improving agricultural productivity, a process that creates employment directly in the factories and indirectly in the fields.[14]

Although there has been considerable debate about the efficiency of China's small-scale industries, a team of American experts who visited China in 1975 under the auspices of the National Academy of Sciences generally found them to be effective in stimulating rural development. The failure of many "backyard" iron and steel plants established during China's "Great Leap Forward" in the late fifties

and early sixties, however, shows there are limits to the extent that some plants can be scaled down and remain economically viable.[15]

Labor-intensive, small-scale industries play a key role in the development policies of South Korea and Taiwan as well. They form links between agriculture and manufacturing and provide some inputs into the modern, large-scale industries that have been established in those countries. By decentralizing its industries and ensuring early integration between the farming and industrial sectors, Taiwan, like mainland China, has managed to curb migration from the countryside.[16]

India has also experimented extensively with small-scale, labor-intensive manufacturing. When Gandhi led the Indian people to independence from Britain, his vision—summed up by the choice of the spinning wheel as the symbol of the independence movement—was of decentralized "production by the masses." During the fifties and sixties, however, the Indian government invested heavily in large urban-based industries, and Gandhi's concept of village and cottage industries took a back seat.[17] But rising unemployment and underemployment in India, coupled with widespread flight from the land, has refocused attention on the potential for decentralized industries to provide productive, low-cost jobs in the countryside. The ruling Janata (People's) Party pledged in November 1977 to dismantle urban-based textile, shoemaking, and soapmaking industries and to move their production to the villages.[18]

Domestic research and development can sometimes produce a more appropriate alternative to imported manufacturing technologies. A good example is the development of small-scale sugar plants in India. In the fifties and sixties, several modern factories were established in India to produce white sugar from locally-grown cane, but farmers in remote areas were not able to sell their sugar to the plants and the processing capacity proved insufficient to use all the cane that was available. The Planning Research and Action Institute in Uttar Pradesh developed an alternative technology suitable for small plants serving local markets. The comparison between the two technologies is striking: an investment of 28 million Rupees can establish one large plant capable of producing about 12,000 tons of sugar a year with 900 employees; the same investment can build 47 small plants with an output of about 30,000 tons and a total employment of nearly 10,000.[1]

"Small producers who lack financial resources are in no position to experiment with unproven technologies."

As these examples indicate, low-cost technologies designed to increase employment are finding growing use in some countries. But the difficulties in taking an alternative to the high-technology route to development should not be underestimated.

All technologies require extensive development and testing before they can be widely used. Low-cost technologies are no exception. Indeed, considerable ingenuity is often required to scale down production processes and to develop equipment that can be easily maintained by local people. Small producers who lack financial resources are in no position to experiment with unproven technologies.

Notions of prestige can influence governments to choose the latest modern technology when more appropriate ones are available. Many developing countries lack domestic research and development programs and have little capacity to innovate. Moreover, when capital is underpriced by such factors as government-subsidized credit arrangements, tax breaks, and overvalued exchange rates—while labor costs are elevated by powerful unions operating in the modern industrial sector—there is a strong incentive to choose capital-intensive, labor-saving technologies.[20]

Most important, without social and political changes that redistribute income, overhaul inequitable land ownership patterns, reform credit systems, and provide support for small farmers and manufacturers, appropriate technologies will be difficult to introduce. Powerful vested interests support large-scale manufacturing, mechanized farming, and other symbols of modernity.

While developing countries are facing the certainty of rising unemployment in the coming decades unless present trends are reversed, the outlook for the industrial world is more difficult to gauge. Whatever the future holds, present unemployment levels in the industrial world allow no basis for complacency. Seventeen million workers were idle in Northern Europe, North America, and Japan in 1975. Unemployment reached 8.5 percent in Canada in December 1977; in November, the number of unemployed in the nine countries of the European Economic Community reached six million for the first time in history.[21] In the United States, though total unemployment dropped slightly in early 1978, it still stood at a level that would have been considered intolerable just a few years prior, with inner-city joblessness among black youths at a numbing 40 percent.[22]

Energy problems loom large in the unemployment picture in these countries, and they will continue to be a dominant factor. Shortages of natural gas during the 1976/77 winter were directly responsible for idling some 1.8 million U.S. workers, and the economic malaise that has led to current high unemployment rates throughout the Western world can be traced in part to rising energy prices. The choice of energy technologies has both direct and indirect impacts on employment.[23]

An energy strategy featuring large-scale coal and nuclear generating plants will require vast amounts of capital expenditure, but will provide few jobs directly. The energy policy along these lines outlined by the Ford Administration in the United States in 1975, for example, was expected to require about $1 trillion in capital expenditure by 1985, an amount that would soak up about 75 percent of all net private domestic investment, compared with about 25 percent in recent years.[24] Such a program would divert spending from other, more labor-intensive sectors of the economy. Conservation programs, on the other hand, generally provide large numbers of jobs for relatively small monetary outlays, and several studies have shown that solar energy technologies are particularly labor-intensive.

A projection of the employment impact of an aggressive solar energy program in California indicated that some 377,000 jobs a year could be created in the eighties. That level of job creation would be sufficient to halve California's present unemployment total. Another study found that while construction and operation of California's controversial Sundesert nuclear plant would provide about 36,300 jobs directly and indirectly, a solar program producing an equivalent amount of energy could create about 241,000 jobs. Solar technologies, moreover, create jobs in the areas where people live, while construction of giant power plants requires work crews to be gathered in one location, disrupting the life of local communities.[25]

With unemployment rates at their present levels and prospects for a return to the surging economic growth rates of the fifties and sixties remote, governments in industrial countries—like their counterparts in the developing world—must pay increased attention to the link between employment and the choice of technologies.

Technology and Equity

In the quarter-century following World War II, production of goods and services tripled in value, and the global economy seemed set on an upward path. In those heady days, government leaders everywhere were able to promise their poorest citizens that economic growth would produce benefits for all. If the economic pie continued to expand, the argument went, everybody's slice would eventually grow larger.

Those promises have been fulfilled for very few. The gap between rich and poor countries has widened into a gulf, and in many nations the wealthy have prospered while the impoverished majority have become relatively worse off. More than a billion people are now thought to be living in conditions of extreme poverty, at least half of them unable to meet their basic food, health care, shelter, and education needs. The coexistence of rising wealth with widespread poverty is not found in every country, nor is it limited to the Third World. But it is clear that rapid economic growth, measured in terms of gross national product, is not sufficient to guarantee a better life for all.

For too long, planners have been preoccupied with growth itself rather than with the nature of growth and the distribution of benefits. Pressure for the redistribution of global wealth, both within and among countries, has been rising during the last ten years. Moreover, since the global economy ran out of steam in the mid-seventies and economic growth is unlikely to resume its earlier pace, the world faces the difficult task of dividing a pie that is expanding more slowly.

The reasons for the concentration of wealth in a few hands are manifold and complex. But one contribution to the forces that preserve and aggravate inequities is the nature of the technologies adopted in many countries. Investments in technology for agriculture, industry, health care, transportation, and energy often benefit only a fraction of the population, raising the living standards of a few and stretching the gap between rich and poor.

The unequal impact of technological change stems from a simple relationship. Goods and services are developed largely in response to demand, and demand comes from those who have power in the marketplace and in the halls of government. Skewed income distribu-

tion leads to the development and adoption of technologies that meet the demands of the privileged, and those technologies in turn exacerbate inequities because they lie beyond the reach of the poor. A multinational corporation in the United States claims in its advertising that "technology is a continuing response to the needs of life"; unfortunately, the needs of the poor and the demands of the elite are often not synonymous.[26]

The same skewed distribution of technological supply and demand takes place within and among countries. More than 95 percent of the global research and development budget and most of the world's technological capacity is concentrated in the industrial countries, and consequently the bulk of the world's technological effort is devoted to solving problems of the affluent world. For example, the United States alone spends more than $1 billion every year on research into cancer and heart disease—the major killers in the industrial world—while only a tiny fraction of that amount is spent worldwide on research to control schistosomiasis, a debilitating parasitic disease that afflicts some 200 million rural poor in the Third World. There is a vast collection of published research on sewage disposal, but more than 98 percent of it is irrelevant to the needs of poor countries, according to a survey conducted for the World Bank.[27] Most agricultural research is geared toward raising the productivity of large farmers working temperate zone soils; comparatively little attempts to develop technologies for small farmers in the tropics.

Any reduction of inequities in most poor countries requires not only the creation of large numbers of jobs, but also an attempt to raise the productivity of people who have so far been left out of the development process—small farmers, small-scale manufacturers, landless peasants, and others now barely making ends meet. This should include the development of low-cost production technologies that do not depend upon large-scale enterprises, and the overhaul of credit and land tenure systems to allow small producers to take advantage of new technologies. Technologies alone, whatever their scale, cannot eliminate inequities; social and institutional changes are also required.

The Green Revolution provides a closely studied example of how seemingly beneficial technologies can worsen the lot of small producers when the system is biased against them. Although high-yielding seeds work as well on small farms as on large holdings, they re-

"The health budgets of most poor countries are heavily weighted toward modern hospitals that cater to the urban elite."

quire irrigation and increased use of fertilizers and pesticides—all of which raises the costs of production. In countries such as Taiwan and Japan, where egalitarian credit systems allow small farmers to purchase the necessary inputs, high-yielding dwarf rice has not exacerbated inequities. But in parts of such countries as India and Pakistan, small farmers often have difficulty raising credit, and they are less able to take risks with new agricultural techniques. Benefits from the Green Revolution have therefore accrued mostly to the wealthier farmers, and income gaps have widened.[28]

In industry, as in agriculture, investments in capital-intensive technologies benefit a narrow section of the population while other parts of the economy are starved of capital. And concentrating investment in urban-based industries can also aggravate disparities between urban wage earners and rural peasants. A study of employment and income distribution in Colombia in 1970, for example, found that the living standards of about one-third of the total population had probably declined in absolute terms since the thirties, although incomes of workers in modern industries had advanced considerably. Similarly, the soaring economic growth rates achieved by Brazil in the sixties and early seventies benefited primarily the top 20 percent of the population; the remainder, mostly rural peasants, were left relatively worse off by Brazil's "economic miracle."[29]

Although raising the productivity and incomes of those who are now grossly underemployed will be a major key to securing greater distribution of wealth, the link between technology and social equity is not limited to production technologies. Striking examples of how the choice of technology can determine whether the benefits are available to all sections of the population can be found in health policies.

The most severe health problems of the Third World are malnutrition, and infectious and parasitic diseases—illnesses associated with poverty and poor sanitation. Yet the health budgets of most poor countries are heavily weighted toward modern hospitals that cater to the urban elite. Typically, 80 percent of the expenditure on health in developing countries is devoted to hospital care, and less than 20 percent is spent on preventive medicine accessible to the rural and urban poor. According to a World Bank estimate, some 800 million people have no access to even minimal health care.[30]

There are many explanations for inequitable health care priorities, including colonial policies that provided curative medicine for expatriate Europeans, medical education systems that are carbon copies of Western medical schools, and hospital services that respond to the demands of the powerful and affluent in developing countries. As British economist Charles Elliott notes:

> The results are bizarre. In the Philippines, a country in which much of the population has no health care beyond that of the helot, is to be found one of the most sophisticated cardiology units in the world. In the Ivory Coast, the Centre Hospital Universitaire has facilities that few hospitals in France can rival. . . . Such facilities are used at half capacity, but preempt the lion's share of the recurrent budget of the ministry of health (over 50 percent in both cases).[31]

To those examples might be added the three open-heart surgery units in Bogota, the running costs of which are sufficient to provide a pint of milk a day to one-quarter of the city's children.[32]

Expenditures on expensive medical technologies that soak up the bulk of health budgets in poor countries reflect a choice of providing high-quality medical care for a few rather than meeting the basic health needs of many. During the past decade, however, several developing countries have begun to refocus their health policies, training cadres of paramedical workers and establishing medical facilities in the villages and poor neighborhoods. China's 1.3 million barefoot doctors, Sri Lanka's paramedics, Tanzania's Ujamaa village health centers, and Cuba's neighborhood health clinics all provide routine medical services at low cost per beneficiary. They also provide preventive services. The results can be dramatic. In Sri Lanka, a country with an annual income of only $130 per person, life expectancy at birth is now approaching that in the United States.[33]

The choice of transportation technologies can also result in skewed distribution of benefits. During the past few decades, many Third World governments have tried to entice foreign automobile companies into building factories in their countries in an effort to establish modern transportation systems. Yet only a small portion of their citizens can afford to buy cars. And the huge investments on roads, repair and servicing facilities, and fuel stations that would be needed

"If energy systems are founded entirely on large-scale, centralized power plants, social inequities will inevitably increase."

to support such a system often involve heavy foreign exchange costs. As World Bank economist Mahbub ul Haq notes of his native country, "During the decade 1958-1968, Pakistan imported or domestically assembled private cars worth $300 million while it could spend only $20 million for public buses."[34]

If governments in developing countries were instead to invest transportation funds in bus and rail services, augmented by private bicycles and mopeds, foreign exchange costs would be reduced, domestic manufacture and servicing would be possible, and some air pollution would be avoided. As Lester Brown points out, "If an index of mobility were constructed for a national population, it would undoubtedly show that a system designed along [these] lines . . . would give far more people greater mobility than an automobile-dominated system can provide."[35]

The industrial countries are not immune to distorted investments in transportation. The $4.2 billion spent to build the Concorde represents a subsidy by British and French taxpayers for international travel by a tiny, affluent minority. And since the aircraft are being operated at a loss by state-run airlines, the subsidy is continuing.[36]

Investments in energy systems can have a profound impact on social equity. The construction of large urban-based electrical generating plants has brought much-needed power to the major cities and industrial centers in developing countries, but it has also aggravated differences between urban elites and the bulk of the population in the hinterlands. Professor A. K. N. Reddy has calculated that about 70 percent of the electrical energy consumed in India goes to urban industries, 15 percent goes to other urban consumers, and only about 12 percent is consumed in the villages. Yet about 80 percent of India's population lives in rural areas. Moreover, according to Reddy, electricity is inequitably distributed within the villages themselves: on average, only 15 percent of the households are electrified.[37]

Such unequal distribution of electrical supply is not surprising in view of the immense cost of constructing centralized facilities and building transmission lines to deliver the power. Thus, if energy systems are founded entirely on large-scale, centralized power plants, social inequities will inevitably increase because few developing

countries can afford to extend services to the rural areas. Several recent studies have indicated, however, that decentralized energy sources—based on solar collectors, small-scale hydroelectric generators, firewood plantations, and biogas plants—can provide energy for remote villages more cheaply than centralized power stations and national grids can.[38]

Few countries, however, have yet attempted to build such an energy system. One country that has is China. Although China's major cities are powered mostly by coal-fired generating plants, the villages derive much of their energy from renewable sources, chiefly biogas, firewood, and small-scale hydroelectric power. According to official Chinese reports, some 4.3 million biogas units have been constructed in China during the past three years; and in 1975, there were reportedly 60,000 rural, small-scale hydroelectric plants in operation, an eightfold increase over the 1965 total.[39]

But even seemingly "appropriate" technologies can worsen social inequities in some settings. In the energy field, biogas plants are a case in point. The plants produce methane through the fermentation of a mixture of livestock dung and water (sometimes with the addition of human excrement and crop residues), providing gas for cooking and lighting, and solid residues that constitute an excellent fertilizer. The production of these badly-needed commodities from waste products seems like a good bargain, but there are two major drawbacks. First, the plants require manure from at least three cows to produce sufficient gas for a single family, a requirement that restricts their use to relatively wealthy families. And second, in some countries cattle dung is now collected, dried, and used as fuel by all villagers; it is essentially a free good. The introduction of biogas plants places a premium on dung, however, which can eliminate the poorest villagers' chief source of fuel. Larger plants serving an entire community could get around such problems, but their introduction would require the establishment of new cooperative arrangements.[40] The point is not that biogas plants are inherently bad—indeed, they are one of the most promising solutions to Third World energy problems—but that they cannot be introduced thoughtlessly, without new forms of social organization.

Technologies for housing, water supply, education, and a host of other areas can similarly result in skewed distribution of benefits.

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