

High-Tech/Low-Tech: Appropriate Technologies for Developing Nations

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A central (and long-standing) debate in the fields of Information Technology (IT) and Economic Development has centered around what (if any) information and communications technologies are ethically “appropriate” for developing nations. IT has largely been developed in the industrialized West under capital-rich, labor-scarce economic conditions, and inherently, a technology will address the special constraints in its generative environment. Indeed, Schumpeter pointed out long ago that “intermediate” technologies (developed especially for a developing nation’s special circumstances) might be preferable. Now, with the resurgence of interest in industrial technology (a la Schumpeter) as the driving force for economic development, policy makers, business leaders, and citizens in developing nations are asking whether advanced information and communications technologies are appropriate for the capital-scarce, labor-rich developing nations. Indeed, the real question may not be whether they are appropriate, but whether there is an inherent difference between industrial and information technology (which would make “intermediation” unnecessary or even detrimental), whether IT can be (or needs to be) effectively adapted, and whether lack of access to advanced IT bars developing economies from the global marketplace, thus impeding economic advancement. The current paper first presents the context in which “appropriateness” has been argued, including the question of whether being part of the global marketplace really benefits developing nations. The paper then outlines and provides criticism of the bipolar debate and activity to date, and offers a new approach to the question in the context of an “information age” world economy.

The proliferation of computing, networking (especially the ubiquitous Internet), and other forms of information and communications technologies in the industrialized nations in the 1990s has brought about tremendous benefits to the population in those parts of the world. The question of whether the developing economies in Asia, Africa, Eastern Europe and Latin America can take advantage of these technologies (and what those advantages might be) is a matter well worth pondering.

What constitutes the “appropriateness” of a particular technology? Of course, it depends on the purpose to which the technology is applied. In the context of developing economies as well as in the industrialized nations, technology is used, among other equally important purposes, to stimulate economic growth, thereby improving the quality of life of its population as a whole. As a means to this end, what type of communications and information technologies are suitable for developing economies? There are really three perspectives from which we can view the issue of appropriateness. From

the *economic* perspective, a technology is appropriate if it optimizes productivity, provides future opportunities for further economic growth and utilizes the cheapest resources (usually local, if available). When seen from a *social* viewpoint, a technology is appropriate if its employment does not lead to negative social ramifications. For example, a sociologist might consider a technology appropriate if it is environmentally friendly, if it does not have an adverse effect on the community, and if it improves employee satisfaction and quality of life. Last but not least, for a modern technology like communications and information technology to be effective, we also need to consider the *technical* aspect of appropriateness. Certain vital infrastructures have to be present before such a technology is viable (Avgerou and Land, 1992). These may include:

- **Skilled manpower** and the presence of educational and training facilities to equip a critical mass of the population with the required skills. This has a powerful impact on the

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level of the technology that can be employed.

- **Electrical power** for information technology hardware such as personal computers, mini computers, workstations and mainframes.
- **Communication channels** ranging from conventional telephone lines and postal services to fiberoptic networks, cable links and communication satellites.
- At a higher level, a **legal infrastructure** to protect the intellectual property rights of the software writers.

However, it would be myopic to assume that these three perspectives of appropriateness are mutually exclusive. To achieve sustainable benefits for the population, attention must be paid to all three. Some of the criticisms of advanced technology have focused on this very issue — that decisions are often made using one perspective (e.g., economic) without taking into account the others (e.g., social). Wherever possible, this paper will take into account all three.

One of the primary benefits may be that technology can equip a nation with an enhanced ability to participate in worldwide commerce by bringing forth a vast reduction in communications and transaction costs. Worldwide information and communications enables production to be more decentralized, allowing firms to base different parts of their business in different parts of the world, connected by computer networks. If access to global markets is used as justification for appropriateness, then, the “Globalization Question” must be asked: Does it actually benefit developing economies to “hook into” the global marketplace?

The following sections provide first a brief review of the “globalization question,” then an overview of the predominant schools of thought (which have polarized into “high-tech” and “low-tech”) on the topic of appropriate technologies for developing economies. The paper then points out some inherent deficiencies in the arguments, and finally concludes by proposing a possible middle ground between these extremes — a new approach to understanding information technologies in the context of the “global information age.”

Review of Literature

The discussion on this topic has, at some level, followed a dichotomous route. There are some who advocate the application of high technologies to aid economic growth in developing economies, but there is an equally vocal group of experts who favor Schumacher’s concept of intermediate technologies (Schumacher, 1973). Part of the discrepancy centers around the question of whether globalization helps or hurts developing economies. This section will first outline the globalization question and will then address the “high-tech” and “low-tech” arguments, in turn.

Globalization & Economic Development

In recent times, there have been serious doubts over the effects of globalization on developing economies. The deluge of Multi-National Corporations (MNCs) into the developing

world has been criticized on several accounts. Environmentalists have attacked these foreign enterprises for taking advantage of lax environmental laws to reduce costs in waste disposal and pollution control, thereby leading to destructive effects on the environment (Goldsmith, 1996). Studies have also linked globalization to a resurgence of diseases (The Harvard Working Group on New and Resurgent Diseases, 1996). Some developing economies have even acted against the over-liberalization of trade by imposing restrictions on manufacturers from industrial nations to protect domestic manufacturers against what they deem to be unfair foreign competition. These countries have charged that the industrialized nations often have the benefit of superior technical know-how and capital and hence, are in an unfair position to compete against the local producers (Bernama News Agency, 1996). Traditional methods of production and livelihood have also declined as the MNCs often employ capital-intensive methods of production, using their own “modern” technology. Even when more labor-intensive or traditional methods are feasible, the MNCs have a strong propensity to purchase capital-intensive equipment from their home countries because of the reduction of search and information costs (Wells, 1973).

However, despite these drawbacks, it is undeniable that globalization does have overwhelming benefits. Technology transfer as a consequence of globalization often has the effect of stimulating advances in education within a developing economy. The mere presence of a multinational firm and its need for staff often acts as a catalyst in a developing economy’s efforts to promote education (Arghiri, 1982). Although certain older forms of employment have been made obsolete, foreign direct investment, which presently accounts

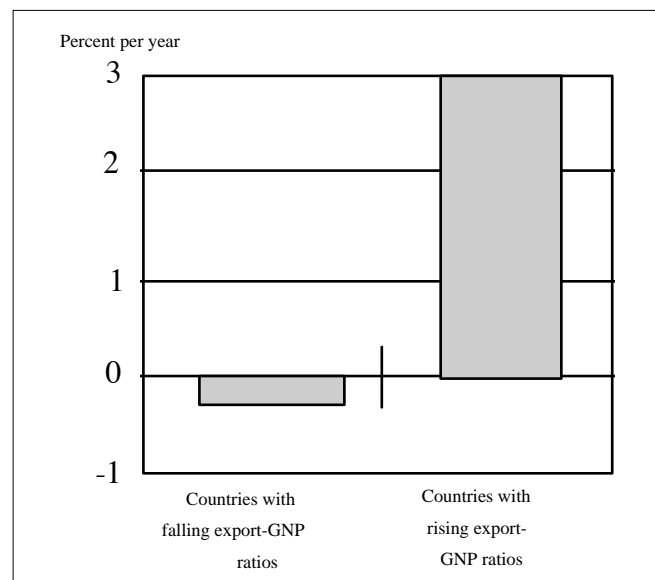


Figure 1: Real Wage Growth in Manufacturing and Export Orientation: Wages Rose in Countries Whose Export Orientation Increased. Data are annual averages for 1970-90 for a sample of 37 countries with falling and 32 countries with rising export-GNP ratios. (Source: World Development Report, 1995.)

for 30 percent of capital flows to low- and middle-income economies, has in fact created many new jobs. It is also undeniable that cross-border flows of goods, services, capital and people present new opportunities for a greater proportion of the active work force. Research has shown that along with the rapid rise in exports in national economies, real wages have also risen by an average of 3 percent per year between 1970 and 1990 (Fig 1). Sixty percent of worldwide growth in the payrolls of MNCs occurred in these countries between 1985 and 1992 (The World Bank, 1995).

Despite its many criticisms, international migration has in actuality resulted in income gains to the migrants, higher remittances to those who stay, and increased production of goods and services in the host countries. Without making optimal usage of their active labor force, low- and middle-income countries cannot sustain the growth they need. However, as these countries gain access to international markets through globalization, developmental policies which allow these markets (domestic and international) to steer the path of development and progress, will enable the developing economies to achieve sustained growth with rising labor demand (The World Bank, 1995). Such economic growth also improves the employment status of its work force. With growing affluence, increasing numbers of workers move into higher productivity, higher wage employment (Table 1). This paves the way for further growth and increases in living standards, and ultimately, the general well being of the population improves.

As shown above, participation of a developing economy in the global marketplace in conjunction with sound government policies, does present it with immense opportunities in trade and development. These would ostensibly outweigh the negative effects outlined above (via stricter legislation to protect the environment) and encourage innovation in the local industries. To assist workers who are vulnerable to new changes (i.e., those who are stuck in declining activities and lack the means to adapt to new circumstances), policies can be implemented to improve their skills and expand retraining opportunities. Although such a measure is not an instant panacea, it is a wise first step in the right direction to prepare

a developing economy's labor force to embrace a more dynamic economy. It is imperative that developing economies make efforts to improve their position in the global marketplace. Countries which have remained oblivious of this need, especially those in Sub-Saharan Africa, have become increasingly marginalized.

“Low-Tech”

Facing the pernicious effects of industrialization, as evidenced by the rapid depletion of non-renewable resources, rising unemployment and social discontent, people have wondered if large scale industrialization employing a disproportionate portion of machines as compared to human labor is really sustainable. Schumacher (like the scholars who carried on his work in the “Low-Tech” school of thought) felt that the conventional approach to development adopted by the industrialized nations when providing foreign aid to the developing economies might not really be suited to their needs (Schumacher, 1973). He questioned the practice of adopting capital-intensive, high-technology methods of mass production in a labor-rich, capital-scarce economy and was a strong advocate of the critical need for rural development. If such a need was neglected, he felt that it would lead to the creation of ‘dual economies.’ This would be a situation where there would be a mass flooding of the rural population into the cities, accompanied by a reduction in the ability of the rural hinterland to provide for the needs of the urban population. Such overcrowding of the cities would lead to mass unemployment and its resulting undesirable consequences of crime, homelessness and other predicaments that have plagued the present-day overfilled cities and conurbations in epidemic proportions. The countryside, on the other extreme, would be devoid of its productive population, and end up as ghost towns. ‘Mutual poisoning’ of this form between the urban and rural sectors, would portend grim prospects for the entire population.

Schumacher disagreed with the employment of high technologies in developing economies on several accounts. He felt that the level of technology may far exceed the ability of the population in these developing economies to operate

Occupation	Earnings in 1989 (manufacturing=100)	Annual average growth rate of earnings, 1973-89 (percent)
Wage workers:		
General plantation workers	50	3.0
Manufacturing workers	100	3.5
Self-employed workers:		
Street vendors	111	4.4
Hairdressers	95	4.6
Launderers	42	-1.6
Tea preparers	64	2.5
Truck drivers	120	4.7
Shop owners	138	5.6

Table 1. Earnings in Selected Occupations in Malaysia: Growth Benefited Workers in Nearly All Sectors. (Source: World Development Report 1995.)

and maintain them. In addition to adding to the foreign debt, the purchase of such "high" technologies might further increase the dependence of the developing economies on their industrialized debtors for assistance in their operation and maintenance. In many cases, such equipment often ends up as broken, useless "white elephants." He also felt that there were other "softer" functions of work which are just as important as production (Schumacher, 1979). These other functions include *"enabling workers to use and perfect their gifts like good stewards, and in the process of work and cooperation with others, empower humans to liberate themselves from their inborn egocentricity."* He believed that subjecting humans to brainless mechanical labor would rob them of these other functions. Last, but definitely not least, he questioned the sustainability of "high-tech" methods of production which have an increasing tendency to consume ever-expanding quantities of Mother Earth's non-renewable resources. Such an approach might be able to placate the ever growing range of human wants in the short run, but in the long run, it would result in dire consequences for our future generations.

In the light of all of these drawbacks of high technologies, Schumacher proposed that developing economies should proceed cautiously in their choice of technologies to spur economic growth. He felt that a prudent choice would be for the development of intermediate technologies that would lie "between the sickle and the combine harvester," to assist in the production by the masses. In fact, research has shown that in terms of production quality, labor-intensive methods are sometimes comparable to their capital intensive counterparts (Wells, 1973). In such cases, the argument for using more "advanced" high-capital/low-labor technologies is severely weakened. The crux of the argument for intermediate technology is that science and technology should not be pursued as ends in themselves; rather, they should be viewed as important tools to enhance the well-being of the population in question. The development of science and technology towards this end should be the objectives of human effort. Important consideration has to be given to often-overlooked factors like the environment if these goals are to be realized in the long-term.

Another sociological concern is the gradual erosion of local culture. This is apparent with the homogenization of global culture aided by broadcast technologies and the mass media. There is also the danger of segregating the population into a class of elites who command the resources for the use of such "high" technology and a disadvantaged underclass who have to resign themselves to be mere cogs in the economic machinery, performing little-valued mechanical chores to keep these machines running.

"High-Tech"

Since the end of the Second World War, most efforts aimed at improving the state of developing economies have followed the strategy adopted by the industrialized nations. The logic of this approach is that these industrialized countries seemed to be at the peak of their evolutionary development and hence, if the third world was to have any hope of breaking

out of their cycle of poverty, following this model of success must be the sure way to go. The main message of this model was to move millions of people out of agriculture into mass production (Toffler, 1980). Proponents of this school of thought have argued that to optimize chances of success, the most modern and capital-intensive technologies should be applied, as this would maximize the quantity of products made available to a country's population and hence improve its social welfare. Another crucial point in their argument is that the transfer of this "high" technology would shorten the development path to be taken by the third world, as it was already shown that this modern technology had accelerated the development of the industrialized countries. Consequently, the MNCs (as repositories of this advanced technology) became the favored economic development partners (Arghiri, 1982). Amidst the wave of MNC-style industrialization, it was expected that there would be a corresponding improvement in various other critical amenities like medical facilities, more hygienic methods of sanitation and increased opportunities for education, thereby leading to a general enhancement in the quality of lives of the population in the developing economies.

There is indeed empirical evidence to show that the employment of modern technology does bring with it certain tangible benefits. After the installation of an automatic digital exchange for 100 lines in a town with almost no previous telephone service in the state of Karnataka in India, there was a significant rise in commercial activity due to an enhanced means of communication. In the six months after the introduction of service, total bank deposits in the town rose by an impressive 80% (Pitroda, 1993). In addition to such proven advantages, there is also a potential for even newer information and communications technologies to play a pivotal role in economic development. The advent of the Internet offers a window of opportunity to developing economies for facilitating inter-governmental negotiations, monitoring efforts in sustainable development and transferring technical data (Madon, 1996). With a gradual improvement in information technology and networking infrastructure, distance education implemented with the aid of such technologies could even present a possible solution to the previously insurmountable problem of taking education to those parts of the population that are isolated geographically (Hall, Davies and Sharp, 1994).

Despite qualms that such advanced forms of networking might have limited utility for a population grappling with the daily issue of poverty and hunger, it is conceivable that if the developing economies do not take steps to get onto the global commerce and information web, they will be increasingly marginalized and lose competitiveness in international markets, making even more arduous the task of freeing themselves from poverty. To the adherents of this school of thought, it would seem that the opportunities of "high-tech" far outweigh the threats.

In fact, contrary to popular assumption, a low-tech option might actually prove to be more cumbersome to operate than its high-tech counterpart. For example, in the electrifica-

tion of saw mills in Nepal, more refined electronics technology has proved to be more useful and easier to maintain than simpler mechanical governing devices (Hislop, 1988). While the mechanical devices are simpler in terms of the state of technology, their design is actually more complicated to operate and maintain, requiring the services of trained engineers who are in scarce supply in the villages. Electronic load controllers on the other hand, can be easily operated by the mill owners themselves and require no maintenance. Repairs require only a “go/no-go” decision on replacing circuit boards. Although this is more an exception than the rule, the very existence of such an example shows the hazards of totally eradicating the high-tech options when considering what is an appropriate technology for a developing economy.

Besides this, the main grouse against the low-tech argument is that it does not leave any scope for future development. Except for the capital-labor tradeoff, it ignores the role of more advanced forms of technologies (such as IT) as a contributor to sustainable development. Such technologies have an important effect on several interactive dimensions of sustainable development (Labelle, 1995). As a tool to achieve *economic sustainability*, new communications and information products have changed the way business operates. They have the capability of putting the developing economies into the global marketplace, enabling these nations to take advantage of the increased trade and commerce that globalization allows. Environmental information systems relying heavily upon satellite and international telecommunications linkages play an integral part in achieving *environmental sustainability* by providing early warning of the degradation of the land environment, pollution of the oceans and climatic catastrophes. In its capacity as a contributor towards *social sustainability*, information and communications technologies have expanded educational opportunities and improved basic health for populations in many parts of the world. In one Canadian-supported rural water and sanitation project in northern Ghana, 80,000 villagers learned about the importance of clean water and hygiene through radio learning courses which took advantage of a new FM radio network. Although computers can never fully replace teachers, telecommunications can improve access to better teachers and more sources of educational information in the form of electronic libraries and databases. Advancements in information and communications technologies have also provided work and study opportunities for disabled individuals. Recent progress in voice recognition technology has created a means for paralyzed individuals to access a computer which would otherwise have been impossible. Rapid and reliable international telecommunications has also played an important function in assisting the achievement of *political sustainability*. In varying degrees, they have broken the isolation which protected repressive regimes from outside scrutiny. The growth of pluralistic political systems and greater respect for human rights has been heartening, in spite of some setbacks and many existing obstacles. Such pertinent roles of modern information and communications technologies in sustainable development have been overlooked by the proponents of the low-tech

argument.

Another problem with the low-tech argument is that while it does aim to ameliorate the worst conditions of poverty in some third world nations, in practice, it often does little to address the root of the problem. It is more like a Band-Aid than a good dose of antibiotics. There is no real transformation of the developing economy whose level of progress would remain very much stagnant as long as prevailing conditions remain stable. While a “low-tech” tool might enable a farmer to produce enough for subsistence, it may not do very much to relieve his back-breaking toil in the fields or rice paddies. It may not sufficiently empower the less-advantaged in those countries with the means to break out from the cycle of poverty. By sticking to old technologies and impeding innovation, generations would have to be condemned to the same impoverished conditions and squalor that plagued their forefathers.

A Possible Compromise

There are several problems with the direction of inquiry and activity in the “High-Tech/Low-Tech” debate: over-generalized notions of technological advancement and economic development, idea evolution, the problem of practice vs. theory, and application of industrial-technology arguments to information technology.

First, regarding over-generalization, conventional practice and thought seems to regard the “appropriateness” of a particular technology in terms of its level of “advancement,” i.e. that an appropriate technology is either “high-tech” or “low-tech.” The folly of such generalization is that it does not take into account the unique capabilities of a given technology or the circumstances of a particular nation. A developing economy may have attained a certain level of advancement in a particular arena that necessitates the use of a more advanced technology (e.g., the software export industry of India), while it may be still lagging far behind in other sectors. The World Bank and United Nations spend enormous efforts classifying nations as LDCs, NICs, etc., and no one seems to have yet been able to (or perhaps attempted to) classify the technologies. For example, is wireless telephone high-tech or low-tech? How about a 486 PC? The old standard — case-by-case analysis — seems to be the best practice available, as long as the decisions are informed by the arguments on both sides, an attempt is made to judge impact, and an understanding is built that some impacts (perhaps the most important impacts of a technology) cannot be foreseen (McKenney, 1995).

Second, on the problem of idea evolution, ideas do tend to grow beyond the author’s original intent, and critical portions of arguments are sometimes left by the wayside. It was never Schumacher’s intent that technologies for developing economies should be deliberately low-tech for the sake of being low-tech. With a little innovation, local resources may be utilized for the development of suitable tools and implements. There is no real conflict between Schumacher’s stand and Schumpeter’s findings that technological advancement is essential for economic growth (Schumpeter, 1934). The

stance of the former was simply that there was a crucial role for smaller scale, environmentally friendlier forms of technologies that were not beyond the grasp of the citizens of the developing economies. Such technologies being smaller scale and less complex, could be easily modified to suit the requirements of the local population. This was also consistent with later research which showed that incremental rather than radical advances in technology had a greater chance of being diffused across and adopted by a population (Henderson and Clark, 1990). Financial resources expended in the development of such technologies could be recouped by the export of such innovations to other developing economies, or indeed, to the over-polluted industrialized world with its own pockets of underdevelopment. His contention was that given the circumstances of developing economies, it would be foolhardy to adopt wholesale, large-scale modern technologies from the industrialized nations. He also felt that such a more sustainable form of technology has important implications for its applicability to the industrialized West to curb the problems of pollution and overuse of natural resources.

Third, on the problem of practice vs. theory, more advanced forms of technologies like communications and information technologies can have an important role in spearheading the growth and betterment of the developing economies. The view that they are inappropriate in an environment confronted with the more pertinent issues of poverty, hunger and unsanitary living conditions fails to take into account the fact that such technologies have an important capacity to alleviate these very conditions. The viewpoint that developing economies face many resource constraints in the implementation of these high technologies is valid, but it does not mean that attempts to improve the requisite infrastructure should not be made. Older technologies might already reap very tangible benefits for the population. With the installation of an automatic digital exchange with 100 lines in a rural Indian town, communication amongst the townspeople became much easier, relative to what they had to go through previously (Pitroda, 1993). It was noted that one particular villager had to undertake great efforts (no less than sending 20 messengers on trains and buses) to inform relatives in nearby villages of his father's passing. However, after the installation of the telephone lines, all he had to do was to go to the local tea shop and phone all 20 villages when his mother followed. Such morbid examples notwithstanding, it illustrates the convenience and other positive effects that such a form of technology can bring.

Hence, when financial resources do not permit, the population may have to "make do" with older (and, yes, perhaps even obsolete) models of a particular technology. In fact, in many cases, taking into account local considerations of literacy and skills, the newest models of such technologies might have limited applications. For example, the outdated Windows 3.1 operating system running on an equally outmoded IBM 386 PC might work just as well as the latest release of Windows 95 running on the most powerful Pentium Pro PC with the latest MMX technology from the vantage of a local Indian entrepreneur. The extra-fancy multi-tasking

and plug-and-play features may really be of little relevance to him. In fact, some enterprising businesspeople have long recognized the less sophisticated-needs of some businesses in the developing economies and have tailored their strategies to satisfy these needs. For example, a successful Malay businessman based the bulk of his trade on the import of used photocopier and facsimile machines from Europe and Japan to be reconditioned for re-export to developing economies like India, the Philippines and Vietnam (Sapawi, 1996). Such reconditioning and reuse is also prudent from an environmental point of view.

However, before the local manpower resource can keep pace with even the most rudimentary forms of these technologies, the application of intermediate technologies would seem to be a discreet option. The rationale is that some form of assistance for the toiling farmer in the paddies would be better than none at all. In many cases, these smaller scale, lower tech innovations seem to be just what is needed. Indian scientist Amulya Kumar N. Reddy has shown that in India, the most urgent need is for decentralized energy in the countryside rather than vast, centralized supplies for the cities (Toffler, 1980). The family of an average, landless Indian peasant now spends about six hours a day merely finding the firewood it needs for cooking and heating. Research by Reddy on rural energy needs has shown that the requirements of a village can easily be met by a tiny, cheap bio-gas plant that uses human and animal waste from the village itself. He concluded that many thousands of such units would be far more useful, ecologically sound and economical than a few giant, centralized high-tech generating plants.

However, as over emphasis on labor-intensive technologies can retard the progress of a developing economy, such developing economies should not ignore the possibilities of investment in high-growth areas like microelectronics and information and communications technologies, especially since there have been strong attempts to cut tariffs and liberalize trade in these fields. This was evidenced by the signing of an accord (the Information Technology Agreement) to eliminate tariffs on a range of high-technology products before the year 2,000 by a number of key players at the WTO Ministerial Conference in Singapore during 1996. Where financial resources are scarce, it is certainly advantageous for developing economies to get greater output per unit of capital invested. The great product diversity in these fields would allow these countries to take a basic technology and adapt it accordingly to suit their local requirements and available raw materials. These industries have significant potential for decentralization of production. Besides minimizing population pressures in the cities, the trend towards miniaturization also cuts transportation costs. This form of production also has low energy requirements and might be suited for the smaller energy production capabilities of the rural areas.

Recognizing the strategic importance of these technologies, governments should devote extensive efforts towards the development of infrastructures. This must not only include physical amenities like telephone lines and electrical power, but also encompass the education and training of its population

in the relevant skills. To optimize the benefits from such a form of technology, the population has to be sufficiently equipped to exploit them and perhaps even innovate and develop applications that are more relevant to the local market. This is an interactive and synergistic process with information and telecommunications technologies contributing to the development of skills and education in a developing economy, and with local talent and technical manpower stimulating the growth and progress of the industry within the economy. Perhaps an envisionable transformation strategy for a developing economy might be one based on the development of both low-stream, village-oriented, capital-cheap, rural industries and certain carefully-selected high-stream technologies with an economy zoned to promote both.

Finally, on the problem of applying industrial technology arguments to information technology, replacing labor with capital, which is one of the keystones of industrial technology, is really only a small part of information technology. Applying information technology towards this purpose alone would be tremendously under-utilizing its potential. *The real strength of information technology (indeed, the defining characteristic that separates it from industrial technology) is that it augments human labor, enabling humans to do things never before possible* (such as fast and accurate calculations and analysis, high-volume information retrieval, multi-party round-the-world communication, etc.). Indeed, information technology directed at solving information-processing crises have in the past provided significant competitive advantage for corporations by radically altering the basis of competition in their industries *by doing what the human workers could not do*. When Bank of America experienced booming business in the years after the Second World War, it found that its growth would not be limited by new business, but by its inability to service new accounts adequately (McKenney, 1995). It was a crisis which confronted the entire American banking industry, and it could not be solved by hiring more clerks. Check use in the United States had doubled between 1943 and 1952 from 4 billion to 8 billion checks per year, and bankers were projecting continuing increases of 1 billion checks per year by 1955. Banks were at a standstill, unable to expand, or in some cases, even to keep pace with the increasing flow of paper. As Bank of America moved to automate its check handling process by its innovative use of magnetic ink character recognition (MICR) technology, it inadvertently became the industry leader, and other banks proceeded to emulate its innovation. If information technology can enable a firm to be the leader in its industry, what about a nation? What about firms within a nation and their potential to earn foreign exchange?

The fact is that information technology is vastly different from industrial technologies which more often than not, have specific, limited applications. Information and communications underlie all facets of human activities, and a technology which addresses these will have wide applicability for both developing economies and the industrialized nations. A fact that we often fail to realize is that information technology is not only labor-replacing but it is also labor-transforming.

For example, a well-trained team of nurses with the aid of a medical expert system, might suffice to cater for the common medical needs of a small village, an important innovation for a village that has *plenty of unskilled labor but no doctors*. This failure to recognize such fundamental differences between industrial and information technologies (and the different categories of "labor") has resulted in their being lumped together and having industrial technology criticisms directed at information and communications technologies.

Conclusions

Unfortunately (for confused decision-makers), the question of what constitutes an appropriate technology for a developing economy is best answered with a "case-by-case" analysis. Both the low-tech and high-tech arguments voice valid concerns but are similarly mistaken on several accounts. Assumptions that low-tech, labor-intensive operations are always the most appropriate may be correct for some developing economies and some production sectors, but wrong for others. Similarly, a more sophisticated technology may also be inappropriate, not simply because of its level of technical advancement but because it has been developed in response to differently perceived socio-economic needs and a marketplace with different requirements and resource constraints. Generally speaking, it would be foolish to employ a particular level of technology across the board in all sectors of the economy.

Lessons gleaned from the social blight confronting the industrialized countries and their wasteful resource use should, however, be heeded by the developing economies. Building on these experiences and their local endowments, developing economies might "leapfrog" the industrialized nations by skipping directly from obsolete ("intermediate") technologies to the development of new ("intermediate") technologies that combine local traditional methods with modern science and technology, and which are more responsive to their local requirements and environmental concerns. These methods would be more sustainable in the long term, and the developing economies are in a better position to start this revolution as they are less entrenched in the existing industrial practices. There have already been heartening examples of such innovation. In India, many amputees reside in remote villages with poor access to modern medical equipment and services. A simple artificial leg called the "Jaipur leg" was developed to meet the needs of these amputees. Besides being much cheaper (about three times cheaper than a conventional polypropylene leg and about five times cheaper than a modular titanium/carbon fiber leg), it does not require any physiotherapy for a patient to learn how to use the orthosis (Menon, 1997). In addition, the banking industry in South Africa has made innovative use of information technology to improve the banking services offered to its customers, and in the process, has even managed to make a profit from every customer, both corporate as well as individual clients (Meiring, 1997). This is no mean feat as most of the American

and British banks only manage to profit from their corporate clients. The progress of South Africa's banking industry has proceeded in spite of its underdevelopment in other areas. In fact, because of their greater need, the developing economies might very well become the hotbeds of innovation.

Our discussion has shown that where developing economies have lagged in the development of their information infrastructures, they are also more likely to fall behind in spurring economic growth and meeting the demands of the global marketplace. With this in mind, "advanced" information and communications technologies are indeed appropriate for the developing economies to spearhead the transformation of their economic and social structures. To address concerns of inadequate resources, earlier and less expensive versions of these technologies could be procured. However, recognizing that these technologies play a vital role in boosting further growth and development, national governments should make concerted efforts to improve manpower and infrastructure resources at a pace that does not alienate the nation from the global marketplace or marginalize the less skilled within a nation. Intermediate technologies could still be relevant in bridging this gap between the less competent and the technically savvy segments of the population which are (at least to some degree) bound by common legal, economic, educational, and other infrastructures. But it may be a disastrous strategy to promote intermediate technologies as a bridge between entire nations, which do not rise and fall together. Information and communications technologies could even contribute to the development of innovative solutions which are more suited to local (and international) circumstances. The resulting synergy will surely herald new beginnings for individual developing economies and for a new age of global economic synergy.

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