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Technology, Productivity, and Organization

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ABSTRACT

The on-coming age of changing technology and knowledge intensification, and its interactions with human values are expected to bring forth fundamental shifts in socioeconomic environment. The paper presents an overview of the dynamics of technological change, a hypothesis on productivity dynamics, and likely shifts in organizational structure. To cope with changes, organizational productivity has to be increasingly governed by human creativity and managerial effectiveness. The structure will be flatter, action-oriented, entrepreneurial, and, above all, flexible. By being organically alive, it will be different from conventional mechanical setups. The future will witness more of flexible manufacturing and flexible management systems and a change of emphasis from "management of technology" to "management of change," governed by a multiperspective vision. The paper also analyzes major problems likely to be faced by developing countries in getting prepared for the future. In addition to their current focus on technological aspects, the Third World countries have to be seriously concerned about people and organizational issues.

Introduction

Great strides in technological developments, knowledge intensification, and globalization are ushering in an era of dynamic complexity. The technological changes bring new opportunities as well as challenges, but the awesome rate of technological change is expected to leave most countries unprepared. Whereas there exists some appreciation of technological trends, perception of the interaction of forthcoming technological breakthroughs and human values is relatively weak. The extent of appreciation and understanding of the dynamics of technological change, organization, and productivity do vary among countries, depending on their current stage of socioeconomic development. In general, what differentiates developing and industrialized countries is the dynamics of change. An overview of the concepts of technology, productivity, and organization and their dynamics is a prerequisite to face a future, that is not going to be an extrapolation of the past. This paper presents an overview of such trends, a hypothesis on productivity dynamics and likely changes in organizational structure, in the hope of inducing all concerned towards catalyzing preparatory actions to face the future.

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Technology and Technological Change

It is said that whenever the characteristics of a technology changes by a factor of ten or more, a revolution in life style results [1]. The impact on family relations of steam locomotives, global linkages through jet age and communication, the visual impact of television and its role as a third parent in the house, and the entry of desktop computers in the home are some typical examples. However, these may represent only the tip of the iceberg, in comparison to the envisaged changes from emerging technologies. A recent survey of senior managers in twenty industrialized countries found that the biggest problem in the future will be "keeping pace with new technologies" [2]. In general, technological innovations extend the limits of resource utilization and enhance the value added. Figure 1 shows the benefits reaped by Japanese firms in their share of the global market, through innovations in consumer electronics, such as radio, tape recorders, black and white and color television sets and video recorders. Assessment of specific contribution by technology to overall productivity or economic growth has largely been an academic exercise, with results therefrom differing widely. A study by the U.S. National Science Foundation concluded that social returns from technical change is nearly twice as great as the private returns on such investments [3]. According to another analysis, over 87% of productivity growth in the United States between 1950 and 1980 stemmed essentially from technological improvements [4], though some others estimate it between 30 and 56% [5]. Irrespective of these differences, it is not difficult to conclude that a high technological potential enabled the United States to reach commanding heights and become an industrial leader. Despite rapid catching up by countries like Japan, the overall productivity level of the U.S. manufacturing industry still continues to be the highest in the world [6]. A Japanese study has estimated that nearly 29% of growth in overall manufacturing industry between 1955 and 1979 could be attributed to technological innovation. In the case of machinery industry, the corresponding figure was 40% [7].

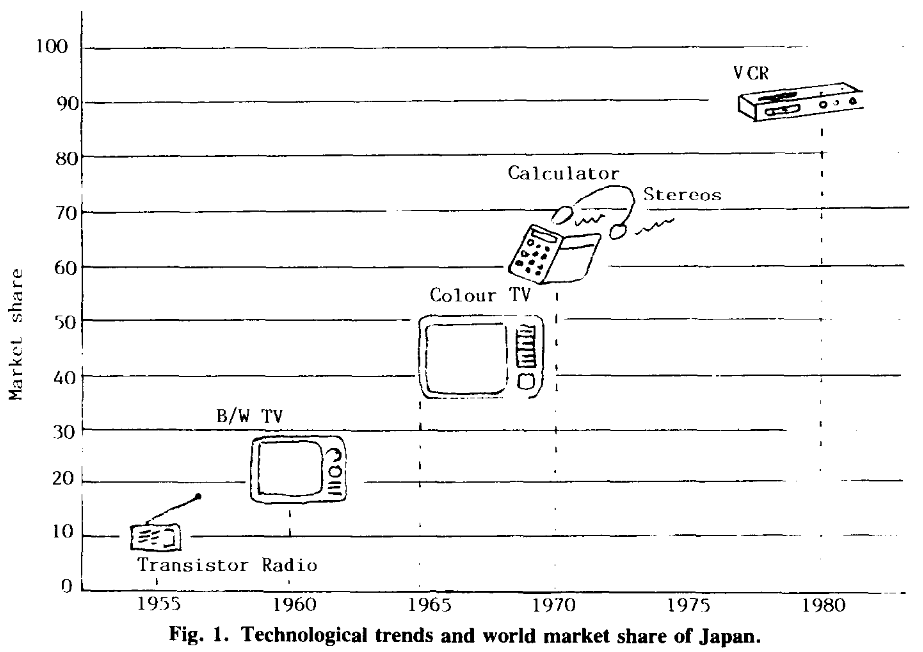

Fig. 1. Technological trends and world market share of Japan.

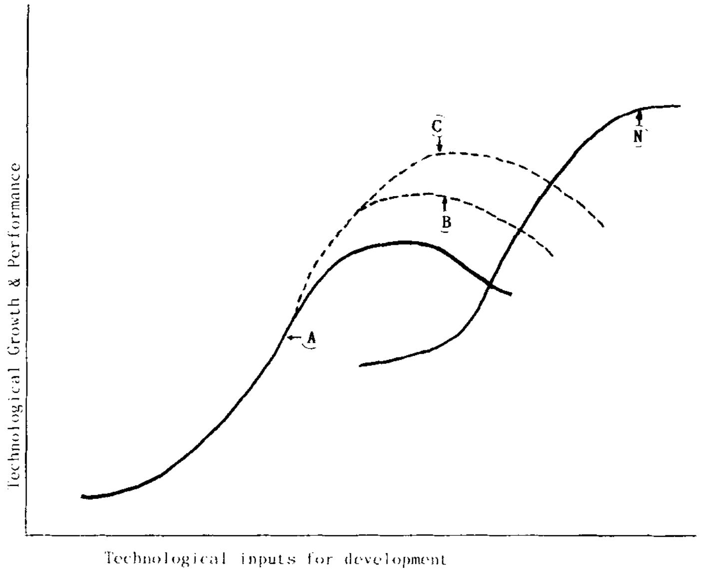

Fig. 2. Life of technology.

With advent of the current technological and information revolution, contribution of technology to growth is expected to rise significantly. Recent trends in reduction of time gap between scientific inventions and technological developments, increasing dependence of technological breakthroughs on scientific discoveries, and emergence of science-based industries bear testimony to this. Unlike technological developments of yesterday, which essentially replaced physical labor, intelligence emanating from microelectronics and computers and their networking could replace some aspects of human thought process. Biotechnology is bringing life into the realm of engineering. There is also an increasing emergence of system technologies, and opportunities for technology mixing would be far greater than before. In the case of Japan, technological progress is expected to contribute as much as 65% of growth [8], arising from its strengths not only in technological stock but also its ability to cope with technological changes.

The Gompertz S-shaped curve A in Figure 2 broadly depicts technological innovation, growth, maturity, and decline. Initial innovation and development are relatively slow and involve considerable efforts as indicated by the lower end of the S curve. The creation phase is followed by rapid growth with its inbuilt advantages and efficiency. This is replaced by a period of maturity reaching the limit of further growth. In other words, returns from efforts to improve the technique further will not be worthwhile. Thereafter, the technology enters a phase of decline. Table 1 presents the trends in the labor time required in selected manufacturing activities in Japan between 1965 and 1983. Though these are national averages influenced by a number of factors, they do indicate the limits to growth by a certain group of technologies. Reductions in labor time per ton of pig iron, steel, or cement, or for a passenger car or truck, were remarkable between 1965 and 1975, and improvements thereafter have been only marginal. Incidentally, the Japanese steel industry, which has been an outstanding example of productivity growth surpassing the U.S. steel industry, is now on the decline. The Japanese steel makers like Nippon Steel and Kawasaki Steel and shipbuilders like Ishikawajima-Harima Heavy Industries (IHI) are diversifying into new areas like electronics and aerospace. Likewise, the giant U.S. Steel Corporation has become USX, with interest in oil and other areas.

TABLE 1
Productivity Trends in Selected Japanese Industries

Industry	1965	1970	1975	1980	1983
Steel industry					
Direct labor time					
Required/ton of product					
Blast furnace pig-iron	100	46	37	32	32
Conversion furnace steel	100	71	79	71	71
Electric furnace steel	100	64	49	27	22
Automobiles					
Direct labor time					
Required/vehicle					
Compact passenger car	100	61	43	31	30
Small truck	100	60	43	30	30
Standard size gasoline engine truck	100	92	44	38	29
Standard size diesel truck	100	89	49	33	28
Cement					
Total (direct + indirect)	100	50	37	22	23
Labor time/ton					

Source: Computed using Data from Statistical Survey of Labor Productivity, Ministry of Labor, Government of Japan.

The life of a given technology can be prolonged by incremental innovations in process and of product. Technology mixing could also offer some lease of life. For example, the camera market became mature in Japan in the early 70s, and this led companies like Cannon to enter the field of calculators. However, the impact of microelectronics and opening of the U.S. market came as a windfall for the expansion of camera sales [9]. The dotted curves B and C in Figure 2 indicate such possibilities. However, these approaches too would meet with limitations, unless fresh impetus is given by new innovations and breakthroughs, as shown by the curve N in Figure 2. Typical examples are the replacement of mechanical calculators by electronic ones, or traditional watches by digital devices. In short, it is a replacement of an older technology or a take over by a newer technology.

The dynamics of change resulting from the emerging technological revolution is fundamentally affecting the above scenario. On the one hand, the growth phase of the S curve is getting shortened. Before one could reap the full benefits of the growth phase or even grasp the technological potentials, newer developments like the N curve emerge. On the other hand, new opportunities for technology mixing open up venues for reaping greater benefits from a given technology. In either case, one has to be very alert, particularly in the light of ever-increasing international competition and price decline. Mere survival would not be good enough for growth. The turbulent environment is bringing forth new relationships between competitors and a new role for the government in promoting cooperative technological developments with private sector. For example, Hitachi and Fujitsu in Japan would be cooperating in the development of a new 32-bit microprocessor to compete against the chips of Intel, Motorola, National semiconductor, and others. Fujitsu attempted to acquire a controlling interest in Fairchild Semiconductor. The "Moonlight Project" on energy conservation in Japan, for the development of fuel cells, cogeneration technology and Stirling engine for multiuse, has involved private sector firms like Mitsubishi Electric Co., Fuji Electric Co., Toshiba Corporation, Hitachi Ltd., Aishin Seiki Corporation (Toyota Group), Tokyo Gas Co., and other gas and electric power companies and academic institutions. This project has been sponsored by the New

Energy Development Corporation of the Japanese Ministry of International Trade and Industry [10].

Such developments are not confined to Japan. In other words, the industrialized countries are already on the way to explore newer approaches to grasp and to tackle the dynamics of technological change. Conventional static criteria to judge business like sales, quality, return on investment or stock prices are being replaced by dynamic criteria, such as innovative management, unique ways of doing business, flexibility to deal with changing environment, and whether the company has a dream. Innovative Japanese companies like Cannon Incorporation and Kao Corporation are finding that their business management and R & D strategies are becoming more and more identical [11]. In the United States, innovative corporations like the IBM question the management not on profit or budgetary control, but on what has been changed [12]. These are in keeping with the increasing significance of managing the change and of technology, which will be a major force for future development.

Productivity and Its Dynamics

Productivity analysis has to consider two factors, namely the productivity level and the rate of productivity growth. Though the productivity level of the overall manufacturing sector in the United States has been and continues to be in the lead, the rate of catching up by Japan and some other countries over the last two decades has been remarkable. A paper published in the U.S. in 1980 reads, ". . . the manufacturing sector of our economy . . . has always been in the forefront in using technological innovation to raise productivity . . . We have fallen behind our international competitors. In recent years, the rate of productivity improvement in Japan has been almost three times ours; that in France and West Germany, two times ours . . ." [13]. Although a latecomer in the technological arena, Japan is maximizing the benefits of transferred technology to strengthen its international competitiveness to become one of the world leaders in advanced technology and innovation. During the past four decades, Japan's progress in technology and trade shifted through several stages. Thus Japan is now moving from a stage of importing technology and exporting products to one of exporting technology and importing products [14].

A comparison of value-added labor productivity in Japan and the United States in selected manufacturing groups, presented in Table 2, reflects this trend [6]. For example, in iron and steel the U.S value-added labor productivity in 1970 was 1.43 times that of Japan, but by 1981, Japanese productivity climbed to 1.58 times that of the United States. The increasing concern for productivity growth in the United States as well as in all other

TABLE 2
Ratio of U.S. to Japan Value Added Labor Productivity by Manufacturing Group[a]

Industry	1970	1973	1978	1981
All manufacturing	204	187	148	131
Chemicals and allied products	156	147	121	108
Iron and steel	143	107	86	63
Nonferrous metals and products	152	137	102	82
Electric machinery, equipment and supplies	246	183	115	93
Automobiles	223	203	120	87
Transport equipment (excl automobiles)	268	181	119	104
Precision instruments	316	296	197	139

[a]Manhour base: U.S. Level for each year of Japan = 100.

developed and developing countries arises from the necessity to ensure continued economic growth, to face increasing international competition, and to contain inflation. Rise in wages in excess of productivity growth leads to inflation. Comparison of productivity and wage levels also indicate the competitive strengths of an economy. For example, the income of a Japanese worker is nearly 2.4 times that of a Taiwanese worker, whereas the output of a Japanese NC machine tool worker is 4.4 times of that in Taiwan [15].

Despite its significant contribution, technological change is not the key factor for productivity growth. If it were so, development would have been a much easier game. As is well known, even with identical technologies, there are substantial differences in productivity among countries, largely arising from differences in human attitudes and adaptation. Technology could be borrowed from abroad, but not work ethic, which has to be developed indigenously. Productivity improvement has to be achieved through people, and the fundamental criteria influencing it are the enthusiasm and creative skills of people.

The working ability of individuals could be enhanced through education, exposure, training, and experience. But this alone cannot assure work performance, as this is linked to motivation for work. As compared to skill upgradation, promotion of motivation and enthusiasm and removal of work alienation are very challenging tasks for management. Being governed by sociocultural values and work ethics of each society, it is difficult to evolve an uniform formula. And yet, the basic human nature being the same, there are several commonalities. To tap the hidden human dynamism and to make the best possible use of human and technological potentials, organizations at the macro and micro level

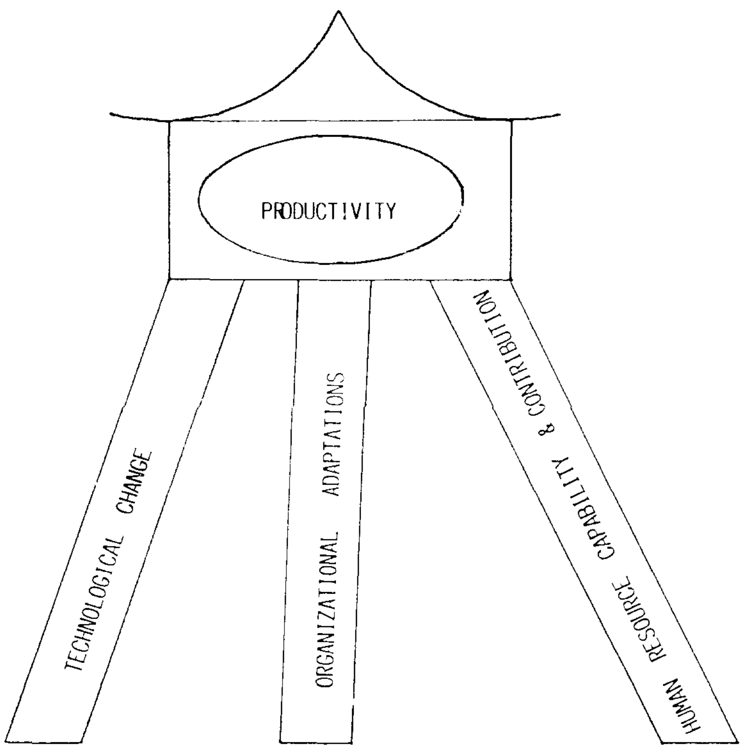

Fig. 3. Productivity.

have to generate the requisite climate and render support. Basically, productivity, as shown in Figure 3, rests on three pillars. These are:

- Technological change;
- Human resource capability and contribution;
- Organizational adaptations.

Mistakenly, productivity still continues to be viewed by some as a mere rationalization or efficiency concept. If it were so, the concept would have been very short-lived [16]. Basically, productivity denotes the willingness to accept change and generate change. It is essentially an attitude of the mind based on a belief of continuing progress [17]. It is this concept of productivity which has been in vogue in Japan and in several other countries. Such human-oriented productivity concepts focus on a holistic approach of development as against suboptimization and stresses more on effectiveness than on mere efficiency. While "efficiency" denotes doing things right, the goal-oriented "effectiveness" is doing the right things better. In other words, productivity must not be like finding right answers to wrong questions, and this becomes more critical as we get into the dynamic side of manufacturing. The integrated approach brings into its fold, internal efficiency, outside relationships and their impacts, and environmental challenges. Being a dynamic concept, productivity has to continually adapt to changing economic and social conditions and make incessant efforts to apply new techniques and methods.

While it could be easier to understand the dynamics of technological change, it takes more efforts to appreciate the dynamics of productivity concept and its promotion. For example, work, which used to appear under the input in a productivity ratio, is trying to

TABLE 3
Productivity Dynamics and Related Aspects

Past	Current Trends	Future
Rationalization: efficiency improvement and suboptimization	Concern for effectiveness and integrated approach at firm level	Increasing societal considerations and a holistic approach at the organizational, national and global levels
Labor productivity	Total productivity	Qualitative emphasis and managerial productivity
Hierarchical systems of management and top–down decision making	Joint consultation	Transparent organization of networks and decisions based on multiple perspectives; combination of top–down and bottom–up approaches with greater role for middle management
Human utilization and material oriented	Human-orientated productivity improvement, sharing of gains, education and training in requisite skills	Flatter organizations, higher educated workforce, lessening of union power, continuing education, human development and retraining, emphasis on creativity and mental productivity
Immediate interest	Long term view and national interest	Longer term view with global perspective
Mass production	Flexible manufacturing systems	Flexible management systems and growth of service sector

make its entry into the output, in the guise of work satisfaction or work itself satisfying existence. As progresses in information technology increasingly take over or assist man's mental tasks of information processing and some decision making, there will be an increasing focus on human creativity. Table 3 presents a hypothesis indicating the past, current, and emerging trends in productivity dynamics and related issues. The past, present, and future are relative terms. Instances, wherein people are entangled in old concepts and not grappling with realities, are not uncommon even today. In productivity trend too, if a nation or firm does not change fast enough, it will be left behind. Productivity cannot be improved by writing notes, enunciating precepts and policies, or by professionals confined in their rooms. Instead of the top sending down the decisions, it should come down itself to understand the realities and share the joys and sufferings of the shop floor.

Organization and Its Dynamics

Organization brings together technology and people to produce goods, services, and value added. Streams of technological innovations, their hybrids, knowledge intensification, shifts in social values, and impact on markets are bound to influence organizations. To survive and prosper in a constantly changing environment, enterprises would have to evolve continuously. The changes will not be limited to mere substitution or diversification of operations, but involve new corporate culture and human resource development, to take advantage of the initiative, capabilities, and talents of employees at all levels [18]. Organizational shift from an efficiency phase to a creative phase will be a veritable challenge due to the basic differences between the two orientations, as indicated in Table 4. An efficiency-oriented organization is routinely demanding, and it punishes failure. On the other hand, a creative organization is flat and entrepreneurial, flexible and appreciative in attitude. It tolerates mistakes, rewards success, and promotes people commensurate with contribution. Incremental improvements during the efficiency phase can be very beneficial, but they seldom produce new waves of business. Provision of internal venture capital funds and growth of intrapreneurism reflect attempts to develop coexistence of these phases [19]. An example is the development of IBM personal computer within a span of one year, through the creation of a small company spirit within the big company [20].

Past experiences indicate that successful companies tend to miss emerging opportunities. Several large corporations in the United States and Japan resting on their past laurels had assumed that the future will be an extrapolation of the present and that technological changes would not be fast. With their focus on improving the efficiency of on-going operations, they failed to recognize limitations of their technological poten-

TABLE 4
Basic Differences between Efficiency and Creative Phases

	"Efficiency" Orientation	"Creation" Orientation
Organizational structure	Hierarchical	Flat
Leadership style	Administrative	Entrepreneurial
Daily operation	Highly programmed	Substantial freedom
Promotion	Systematic (seniority-based)	Contribution-based
Personnel assessment	Failure-based	Success based
Communication style	Formal	Informal
Organization constituents	Homogeneous	Heterogeneous
Goals	Cost minimization	Innovation

Source: Shimizu Norihiko, Boston Consulting Group, Tokyo [19].

tials. The Japanese lead over the Swiss watch companies, the lag of U.S. automobile corporations, failure of Suntory in Japan to recognize the market for white liquor (*Shochu*), and Texas Instruments missing the opportunity in desk calculators and personal computers are some typical examples [19, 21]. As it may be recalled, the transistor was an innovation by Western Electric in the United States, but it took Sony of Japan to exploit it in radios. The Japanese are also taking a lead in audio disc players using laser technology, the greatest invention since the days of Edison [22].

A recent book entitled *Longevity of Corporations* (*Kaisha no Jumyo*) concludes that longevity of a corporation is, on an average, less than 30 years [23]. Reflecting on the poor performance of big U.S. companies, Dr. Thomas J. Peters quoted an American Executive: "Probably the best thing in the world that could happen is that we require every corporation to dissolve after 15 years. Just break it apart, because they stop doing things and spend most of their time protecting themselves. Not creating things, but protecting things" [24]. It appears that size has lost its significance and big corporations lack focus on quality, service, innovation, and people [12]. According to Toray Industries, Japan, over a period, corporations tend to be afflicted by the so-called "large company vice or disease," which makes organizational structure as well as employees rigid [20]. An example of the on-coming trend is the Mayekawa Manufacturing Company of Japan, which operates nearly 50 minifirms or blocks within Japan and 17 overseas units as a loosely interlinked whole, as opposed to a tightly knit administrative setup [20].

These trends are not confined to the manufacturing sector, and their impact, particularly that of information technology, is likely to be even greater in the service sector. A typical example is the liberalization and internationalization of banking business. Main sources of income of banks have changed from deposit taking and lending to securities, international transactions, and handling fee of various transactions. Emerging new financial engineering practices have begun to influence organizational changes. The Mitsui Bank of Japan has recently restructured its pyramid-shaped organization with a long intricate route for decision, into a "Bunchin" (a wing-shaped flat paper weight used in Chinese and Japanese calligraphy) organization. Like the long and narrow base and the small top handle of the Bunchin, channels connecting markets with decision-makers have been significantly shortened and delegation of authority to local units have been augmented [20]. Similar developments are also on the anvil in departmental stores like Seibu Saison group in Japan [20].

A common denominator of above developments is the increasing need for organizational flexibility which can make an organization alive. The future will call for not only flexible manufacturing systems, but also flexible management systems. The predicted characteristics of the corporation of the future are: flatter (less hierarchical) organization; entrepreneurial approach promoting risk and creativity; action orientation; quality focus; customer orientation; leaner organization or smaller setups within large units; integration of individual productivity and organizational productivity; replacement of sequential approaches by an holistic approach [12, 18]; and need for certain ambiguity [11]. Figure 4 shows characteristic features of organizational change.

The Third World and the Dynamics of Change

For the countries of the Third World, the so-called Third Wave has been generating some optimism to leap-frog and to catch-up in the development race. As of today, new developments like satellite communication and remote-learning techniques through television and video are providing new opportunities to communicate with and educate the people. Technological breakthroughs and technology mixing are opening up ways to

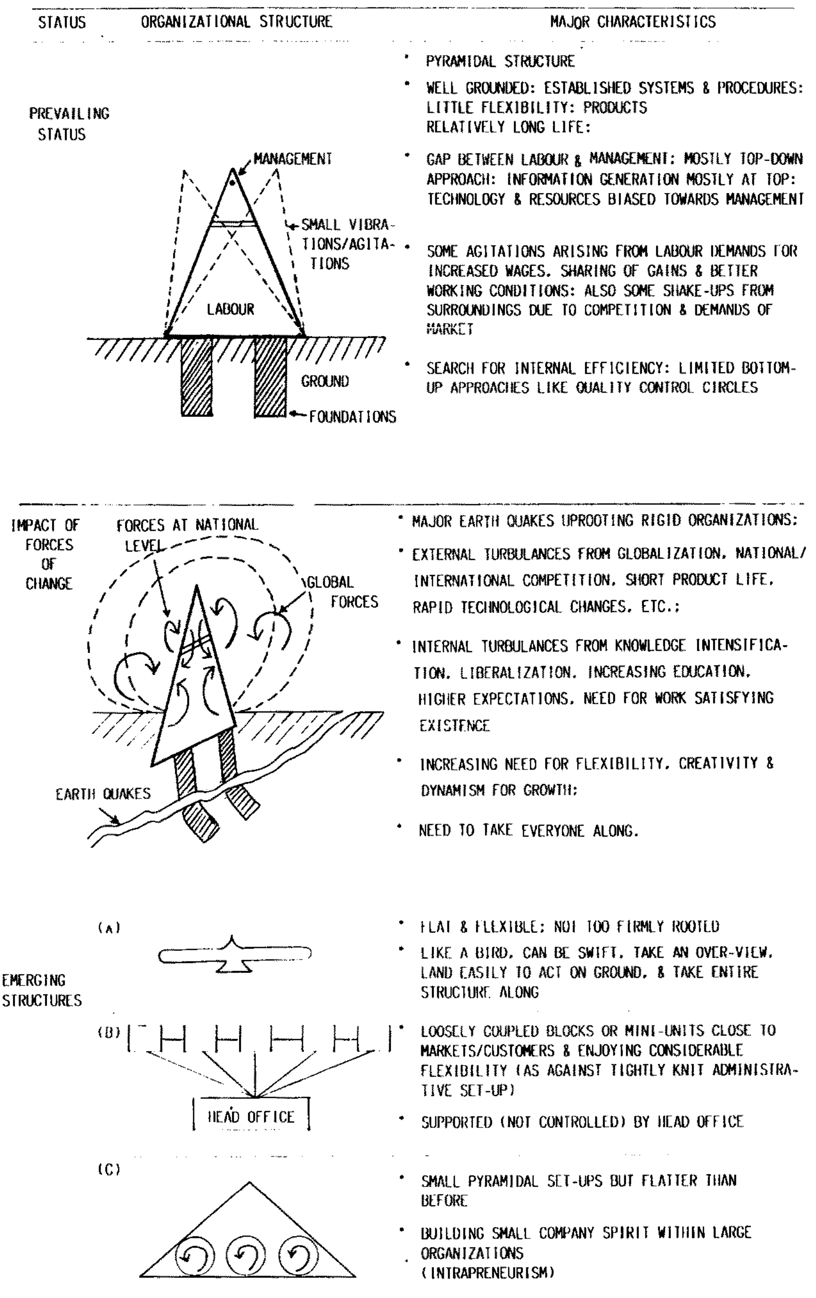

Fig. 4. Organizational change.

apply low-cost high-tech solutions to low-tech problems. Declining or vanishing advantages of bigness in industrial operations and flexible manufacturing systems could be favorable factors. Barring a few large-size state-owned operations, industries in developing countries are of small and medium size, and they are not tied down by huge investments in technologies of yesterday. Dominance of software in new developments and cost advantage of highly qualified specialists are also positive features. But are these strengths sufficient to enable the Third World countries to attain their goals?

A number of developing countries have established impressive infrastructure for science and technology (S & T) to provide an S & T base, to assimilate, digest, and improve imported technologies and to generate new technologies. Except some isolated successes, the general scenario is one of in-built resistances in indigenous technology transfer flow and wide differences in perceptions among all actors. While the industry and society have high expectations from S & T institutions to work out miracles almost single handedly, the R & D institutions flood themselves with too many projects and tend to justify their existence by tall claims. Transorganizational cooperation in developing technology is relatively new. The prevailing belief is that technological innovations would come essentially from new developments, and there is relatively less attention on making incremental improvements in existing products and operations. Instances of improving imported technologies are not many, not to mention reexport of imported technologies.

Countries like Brazil, China, India, and Mexico have built up impressive industrial structures during the past few decades. But these are basically static building blocks and lack dynamic development in terms of constant change [25]. There is a great pride of possession, of having a spectrum of industries and a variety of industrial production. What is lacking is the pride of performance. The same is true for the status of the service sector. Whereas Japanese management treats employees as a family to produce goods with zero defect, production of poor quality goods in most developing countries has led to the maintenance men being taken into the fold of every family purchasing the product or service. Perhaps, a few exceptions are some newly industrializing countries in East Asia such as Korea, which have had close linkage with Japan [26]. But even there, my personal discussions with several experts have revealed some differences. Pride of performance has been a cultural element in Japan, whether it be in making a pin or packing an article. The Japanese successes in the U.S. market were not through cheaper products but through better quality goods. When even the larger industries in developing countries are not active in dynamic development, it is hardly surprising to see small and medium enterprises as recipients rather than organizers of innovation. Organizations, irrespective of size considerations, are able to survive for a long time without any major innovations in production methods, products, services, materials, and organization procedures and management practices. Again the exceptions are the few countries which had opted an export-oriented development strategy and have been subject to international competitive forces.

On productivity, the focus of the Third World is largely on material-oriented productivity improvement, with less concern for people and organizational factors. Understandably, the early thrust has been on strengthening the technological potentials, relegating work ethic considerations to the background [27]. In the absence of adequate motivation and participation, upgrading of technological skills would not produce the desired results. Further, technology running way out in front of industrial development would only result in underutilization of technological resources. Technological development has to be linked to economic structure, which in turn has to be linked to potential markets. Industrialization in Japan moved from downstream to upstream. Manufacture of plastic goods was followed production of machinery and raw materials and ultimately the petrochemicals [25].

With rapid technological advancements, market orientation will become all the more critical in the high-tech era. Skills to gather knowledge on domestic and international environment and capability to analyze characteristics of changes would be vital. Though the entry fee into high-tech fields may be high, there would still be a number of openings at the application end [25]. Feasibility to leap-frog is a debatable question. A quantum jump does not occur in a vaccum but from a consistent and continuous accumulation of experiences. Growth from basic to high technology is like building a pyramid—the higher one desires to build, the broader should be the base. Perhaps, the various developmental phases could be compressed through very judicious approaches. Basically, the high tech era will be an innovative culture, whereas the developing countries are still in the process of building their industrial base. The deciding factor for quantum jump or accelerated move to innovative phase will not be technology but the human factor.

Despite the above weaknesses, the future is certainly not bleak for the Third World. Environmental adaptation is an age-old phenomenon of nature. Every society has its sparks, but it takes effort to identify them and to fan them into flame. A recent study of 60 case firms in 13 Asian countries on management of technological change revealed the positive attitude of labor in accepting technological change, subject to the conditions that it does not lead to redundancy and it protects the income. There was not a single exception among the case firms [4]. Perhaps, the resistance to change in developing countries rests with the leadership, managers, and the so-called "educated" class and their vested interests. As development proceeds, all wisdom cannot be confined only within the government. As revealed by instances in industrialized countries, vitality of the private sector too is unable to meet the emerging challenges. The question is not whether one wants the change, but how to make it worthwhile, pleasant, and least painful. One of the primary requisites for this, is the change in belief, since one's perception is largely dependent on one's own knowledge and experiences. With a strategic vision and commitment, the very weaknesses can be led to kindle forces of change and vitality in people and organizations.

Conclusion

The on-coming technological age is bringing forth unforeseen opportunities and challenges and the future is expected to be a period of turbulant change. Interaction of technology and human values would result in some fundamental shifts in the socioeconmic environment, including working styles and social attitudes. Organizational productivity in technological age would be increasingly governed by human creativity. Several of the industrialized countries have initiated actions to get prepared for the coming age of uncertainty. Developing countries have the double task of developing an industrial culture and to get prepared for an innovative culture. In addition to their concern for technological issues, they have to be seriously concerned about the people and organizational issues. Only by shifting their emphasis from politics and procedures to people and ideas can the Third World Countries reap the benefit of productivity through people in an age of changing technology.

The views and interpretations expressed are of the author and should not be attributed to the Asian Productivity Organization.

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