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KNOWLEDGE AND DEVELOPMENT IN A FRACTURED GLOBAL ORDER

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This article explores the nature, dimensions and consequences of the emerging 'fractured global order', focusing both on the globalization processes now under way and on the deep fractures, both between and within nations, that are becoming an entrenched feature of the new world order. It then highlights the overriding importance of the knowledge fracture to explain the predicament of the poorer sectors of society, and examines the role that science and technology can play in promoting sustainable human development.

A new and as yet fluid world order is in the making as we approach the transition to the 21st century. The multiplicity of changes and trends that can be observed at present indicate that there is an accelerated, segmented and uneven process of globalization under way. The worldwide expansion of productive and service activities, the diminishing importance of national frontiers, and the intensive exchange of information and knowledge, all coexist with the concentration of 'global' activities in certain countries, regions, cities and even neighbourhoods, and also with the marginalization of many local productive and service activities and of the peoples engaged in them.

Emerging fractured global order

The transition to the 21st century is witnessing the emergence of a *fractured global order*, an order that is global but not integrated; an order that puts most of the world's people in contact with one another, but simultaneously maintains deep fissures between different groups of countries and between peoples within countries; an

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order that segregates a large portion of the world's population and prevents it from sharing the benefits provided by scientific advances and technological progress.

A brief review of the main changes that are taking place in the mid-1990s provides a background against which to appreciate the extent and depth of the fractures in this emerging global order, as well as the complexity of the challenge of sustainable human development in the transition to a new century, and the role that science and technology can play in addressing this challenge.

Politics and security

The end of the Cold War has undermined the ideological, military and political foundations of the international order that prevailed during the past half century. The world is in transition to a post-bipolar political order, whose nature is in the process of being defined, but which will require a profound re-examination of the means to provide local, national, regional and international security as a precondition for development.¹ Some elements of this new order include the virtual elimination of the threat of an all-out nuclear war, an increase in the number and intensity of regional conflicts, the likelihood of a more cooperative approach to conflict resolution among key political and economic players, and an emerging larger role for international institutions in fostering and maintaining international security.

The range of possible outcomes for these various elements of the emerging political order is rather wide. The demise of East–West rivalry has complex implications for national security and governance in developing countries. Conflict and insurgency based on Cold War ideology, once generously financed by the superpowers, have all but vanished, as has the possibility of playing one camp against the other. But Soviet and US disengagement could encourage other countries, and regional powers in particular, to build and exercise military power with the enthusiastic support of arms merchants.

Ethnic and religious tensions within countries have aggravated these trends, since they can attract support from neighbouring states. So could new regional conflicts over natural resources such as water, oil or tropical forests, and over environmental spillovers. These tensions and conflicts may be kept in check by concerted actions by the major military powers, by regional and international organizations, or a combination of both. However, so far, despite diminished global superpower rivalry, there is no evidence of a decline in regional disputes, or in organized violence by ethnic groups, religious fundamentalists, secessionist movements, terrorists, or drug traffickers.

At the same time, states are becoming less important as political units in the sense of being able to control whatever phenomena—economic, social, environmental or technological—take place in the world at present. The pre-eminence and sovereignty of states are being eroded in many aspects of foreign and economic policy, as highlighted by the renewed importance of the United Nations in conflict prevention and resolution, by the proliferation of regional trade and economic agreements, by the growing economic power of international corporations, and by the conditions established by international financial institutions for obtaining access to resources under their control. The movement towards supranational action is likely to proceed by fits and starts, with temporary reversals and renewed bouts of nationalism, but will probably gain momentum as the world moves into a new century.

Political pluralism, popular participation and democratic movements are

becoming a fact of life everywhere— East, West, North and South. It is now almost unthinkable to accept—at least without outrage, loud protest and international sanctions—any government's imposition of a repressive regime on its citizens. By the mid-1990s Eastern European countries had their first open elections in half a century; almost all the countries of Latin America had democratic regimes; a military coup failed in Russia and the Central Asian states of the former Soviet Union were struggling to become modern nations; pressures for political liberalization were rising all over Asia, including China; white rule disappeared in South Africa, and there were attempts to abolish one-party rule in many countries of Africa. However, as the civil wars in the former Yugoslavia and Somalia, and the self-inflicted coups by elected leaders in countries as varied as Russia and Perú have shown, advances towards democracy, respect for human rights and peaceful coexistence are by no means guaranteed.²

However, the new international political context alters radically the balance in favour of democratic forms of governance.³ Without the justification of East–West conflict, it has become much more difficult for Western industrialized countries to accept friendly authoritarian regimes in the developing world. With the collapse of one-party rule and the spread of democratic practices, Eastern European countries and the Soviet Union are in no mood to support authoritarian regimes in the developing countries—even if they could afford it.

Governance

In parallel with these changes in the political and security arenas, governance issues became important in developed and developing countries for a variety of reasons, such as the erosion of the power of nation-states, the spread of democratic practices, and the threats posed by internal disruptions related to terrorism, drug traffic, corruption and crime. The salience of governance issues has also been reinforced by the impact of technological advances in telecommunications, mass media and information processing, which are changing the nature and functioning of representative democracies, which were instrumental in hastening the demise of communism in Eastern Europe and the Soviet Union, and which are also creating a more open and transparent setting for politics in developing countries.⁴

In the industrialized nations a variety of political events has led to what is perceived as a widespread 'crisis of governance'. Corruption scandals undermined the confidence in the political system in Japan, Italy, France, Spain and Germany; right-wing xenophobic political groups emerged in Germany and France; constitutional crisis and conflicts surfaced in Canada and Japan; citizens expressed their dissatisfaction with the functioning of political systems, as evidenced by the setbacks experienced by traditional and ruling political parties in several countries of Europe and in the USA; prolonged economic decline in the UK, Australia, Canada, Spain and Sweden, among other countries, led to disillusion with the political establishment; and the spread of organized crime, drug traffic and terrorism throughout Europe, North America and Japan—not to speak of the former Soviet Union and Eastern Europe—have generated a new sense of insecurity and instability that is breaking the social compact between the state and civil society, and between governments and the people.⁵

Governance problems have intensified in developing countries because of the sharp contrast between the growth in social demands and the capacity of the institutional frameworks—including the institutions of the state, the private sector

and of civil society—to satisfy them. The need to marshal political support for economic reforms, the precarious nature of new democracies, and the need to have legitimate and effective mechanisms of citizens' participation and political intermediation have also made governance issues more prominent.⁶

The emergence of governance as a critical development issue coincided with attempts at redefining the roles of the public and private sectors, and of markets and state intervention, in fostering economic growth and social justice. Government failures in economic policy management, in productive activities and in the provision of services—added to renewed confidence in the positive role that market forces can play—prompted the international development community to pay greater attention to the ways in which power and authority are exercised through state institutions in the pursuit of development objectives.

Governance and good government have also emerged as an area of concern for international development organizations. Throughout most of the post-World-War-II period, development assistance focused primarily on investment projects in infrastructure, agriculture, industry and the social sectors. However, by the early 1980s it had become clear that many projects supported with external technical and financial resources failed to yield the anticipated rates of return. One reason was that investments were made in highly distorted policy environments, which prevented benefits from materializing. By the end of the 1980s most developing countries had accepted the need for policy reforms and sought a better balance between market forces and state intervention. These developments underscored the importance of the government's capacity to formulate and manage policy reforms, and of private sector capabilities to assess the impact of the policy environment on enterprise performance.⁷

Policy reforms had important social consequences, many of which were not anticipated in the early 1980s. Without interventions to ameliorate the impact of macroeconomic stabilization, trade liberalization, deregulation and privatization, social conditions worsened in many developing countries, prompting a renewed concern with the political sustainability of economic reforms.

International economy

The major transformations taking place in the patterns of world economic interdependence include, among others, the rapid growth and globalization of financial markets, fundamental changes in trade patterns, and a deepening of inequalities between rich and poor countries. The range and diversity of possible outcomes in practically all aspects of the international economy appears much larger during the 1990s than at any time during the past four decades. Growing interdependence and globalization, primarily a consequence of advances in communications and information technologies, has created an international economic environment which transmits disturbances, magnifies disruptions and creates uncertainty. This situation has been exacerbated by the absence of effective international rules and institutions to regulate financial and trade flows and by the limitations of economic policy coordination among the world's leading economies.⁸

International financial markets now comprise a tight web of transactions involving global securities trading, arbitrage in multiple markets and currencies, portfolio investments through a bewildering array of international funds, and massive transborder capital movements (witness the recent debate on how to regulate the international market on financial 'derivatives'). Financial transactions have acquired

a life of their own and are becoming uncoupled from the production and distributions of goods and services.⁹ The globalization of financial markets has taken the form of an explosive growth of transactions between the financial centres of a few cities, which are located primarily in the industrialized countries (New York, London, Tokyo, Frankfurt, Paris, Chicago, Zurich, Hong Kong). Even though the recent growth of the emerging capital markets of Asia and Latin America is beginning to register in the screen of international financial transactions (primarily because of the high profits they yield to speculative investors), these markets are a long way from challenging or even joining the established centres of global finance.

There have also been changes in the direction and content of international trade, such as the emergence of the North Pacific as the world's largest trading area; the movement towards worldwide trade liberalization, best exemplified by the GATT agreement and the creation of the World Trade Organization; the rise of regional trading blocs, such as the European Union and the North American Free Trade Agreement; and the shift in the content of international trade against primary commodities, exported primarily by developing countries, and in favour of high-technology services and manufactured products, typically industrialized nations' exports.

New webs of commercial linkages between transnational corporations—covering manufacturing, finance, trade and services—have now emerged, and are characterized by complex patterns of cooperative and competitive arrangements that shift continuously over time. Strategic alliances between corporations in pre-competitive R & D, coupled with fierce competition in final product markets, are a prime example of these new trends. There is a significant shift in the organization of productive and service activities in the globalized segments of the world economy: the economic unit is no longer the enterprise, either local, international or transnational, but rather a specific network that is created for a particular purpose at a particular time, and which operates largely independently from the various enterprises that established it.¹⁰

A core of strategic economic activities—capital markets, business services, travel and tourism, technology, and a few production lines such as automobiles, computers and electronic goods—now sets the pace for the evolution of the globalized economy, operating in real time and simultaneously throughout the globe. At the same time, many parts of the world—both in the developing and the industrialized nations—are being marginalized and run the risk of becoming irrelevant to the functioning of an increasingly globalized economy in which, as the Indian social scientist Rajni Khotari put it, 'for the first time in history, the rich do not need the poor'.

Social conditions

Despite dramatic improvements in life expectancy and standards of living in many parts of the world during the past several decades—for example, average per capita consumption has increased by 70% in real terms, average life expectancy has increased from 51 to 63 years, and primary school enrolment has reached 89% during the past 25 years—there are still enormous and persistent economic differences between regions and countries, and particularly between the industrialized and the developing countries.

According to the World Bank, in 1992, the average per capita gross national product (GNP) for the 43 low-income economies was US\$390, while the average for

the 23 high-income economies was \$22 160, about 57 times higher. The total population of the low-income countries was approximately 3.2 billion, nearly four times as much as the 828 million of the OECD countries, even though both groups of countries cover roughly the same area.¹¹ The absolute number of poor people in the world has continued to increase and disparities between the rich and the poor have widened even further. In the 1980s the rate of improvement in economic and social indicators began to slow down.¹² Among developing countries, a few outstanding successes, notably in South-east Asia, coexist with a large number of stagnant or even regressing situations, particularly in sub-Saharan Africa, but also in Asia, Latin America and the Middle East.

Moreover, between 1960 and 1991, the share of world income for the richest 20% of the global population rose from 70% to nearly 85%, while the share of the poorest 20% declined from 2.3% to 1.4%. In 1991 the ratio of income shares of the richest to the poorest 20% was about 61 to 1.¹³ The fracture between poverty and affluence has proved to be one of the most enduring and alarming features of the emerging global order.

The explosive growth in social demands in the developing regions has been largely triggered by population increases during the past 30 years. Coupled with a significant slowdown in population growth in the industrialized nations, this has led to a highly skewed worldwide distribution of social needs and of the capabilities to satisfy them.

The dynamics of population growth strongly condition the demand for food, education, employment, housing and other social goods to satisfy basic needs. Food and nutrition demands have multiplied many times over, particularly in the poorest countries, and although world aggregate food production is sufficient to provide each and every human being with adequate nourishment, existing political, social and institutional arrangements—both at the national and international levels—have proved incapable of doing so. As a result, more than 800 million people in the world go hungry every night. Armed conflicts, droughts and natural disasters have conspired to make even more difficult ensuring access to food in many developing countries.

Demand for basic healthcare and elementary education expanded at a rapid pace during the past four decades, as developing countries made efforts to improve the provision of these services to growing populations. Nevertheless, disparities between rich and poor countries in access to these social services remain abysmal; for example, there is one doctor for every 400 people in the industrialized countries, the corresponding figures are one doctor for every 7000 people in the developing countries and every 36 000 people in sub-Saharan Africa. Migration and accelerated urbanization created huge demands for housing, sanitation, transportation and energy supply, a situation that adds unmet urban needs and widespread urban poverty to the deprivation which characterizes rural populations throughout the developing world.

Unemployment has emerged as perhaps the most troublesome and persistent problem in developing countries. The inability of the modern sectors of their economies to absorb new entrants into the labour force has led to a variety of informal arrangements for workers to earn their means of subsistence. Developing countries face the difficult challenge of raising labour productivity, so as to increase standards of living and improve competitiveness, while at the same time absorbing the growing number of entrants into the labour force.

A significant drop in the population growth rate of industrialized countries is to

be expected during the 1990s, from an average 0.5% per year in the 1980s to only 0.3% in the 1990s. This implies a rapid rise in the number of aged people (particularly in Japan, France and Germany, where people aged 65 or more will reach one-fifth of the population by 2020), a significant increase in the ratio of dependents (children and old people) to workers, and a further shift in the balance of world population. Ageing in industrialized nations will have a major impact on the demand for social services, as well as important consequences for the patterns of consumption, employment and savings. Considering that investments in scientific research and technological innovation are highly concentrated in industrialized countries, these population trends have important consequences for the direction of technical progress, which is likely to move further in the direction of labour-saving innovations.

In developing countries rapid population growth is expected to continue through the 1990s, although at a moderately slower pace, dropping from an average rate of 2.0% per year in the 1980s to 1.8% per year during the 1990s. As a consequence, youth will remain by far the largest segment of the population in most of these countries, whose economies must expand at rates significantly above those of population in order to satisfy the growing demand for work.¹⁴

Population imbalances could pose the problem of uncontrolled mass migration from developing to industrialized countries, threatening social cohesion and international solidarity. In some Western European countries there is already a backlash against 'foreigners', although the fear of massive inflows of workers from the East has failed—as yet—to materialize. In Asia, migration pressures are likely to build up as a result of the growing demographic imbalance between Japan and the poorer overpopulated countries of the region. Despite increased participation of women in the labour market, the Japanese will experience a decline in the labour force after 2000, and labour shortages will be compounded by moves to reduce the number of working hours.¹⁵

The role of human capital and technological capabilities will become even more important as a major determinant of long-term growth in the developing countries in the next decade. The level and quality of investments in human resources will have to rise significantly during the 1990s in order to deal with the rapid rise in the number of young people, and also to enable their labour force to utilize new technologies that increase productivity.

A prominent and most disturbing feature of the global social situation is the difference in social and economic indicators between men and women throughout the world. Despite two decades of efforts dedicated to women in development, women and children remain the 'poorest of the poor' and the gender gap in development is widening. In industrialized countries, gender discrimination appears in employment and wages, with women often getting less than two-thirds of the employment opportunities and about one-half of the earnings of men. In developing countries the greatest disparities, besides the job market, are in healthcare and nutritional support. For example, women comprise two-thirds of the world's illiterate population, and the 1989 World Survey on the Role of Women stated that women do two-thirds of the world's work, own one-tenth of the land, and have only one-hundredth of the world's income.¹⁶ This is another fracture in the global order that demands urgent attention.

Environmental sustainability

During the past two decades environmental concerns have risen to the top of the international public policy agenda. There is now greater awareness of the limits that the regenerative capacity of natural ecosystems impose on human activities, as well as of the dangers of the uncontrolled exploitation of natural resources (fisheries, forests, land, rivers), and from overloading the capacity of the earth to absorb waste (air and water pollution, acid rain, toxic and nuclear wastes). The 1980s and early 1990s witnessed the emergence of truly global environmental problems such as depletion of the ozone layer and global warming, which underscored the possibility that unforeseen ecological instabilities could cause irreversible environmental damage.

The problems of environmental sustainability and resource use are closely related to population growth and poverty in the developing countries, and to the often wasteful consumption habits of rich nations. Major changes in lifestyles will be essential in both groups of countries to address seriously the problem of environmental sustainability in the transition to the 21st century. According to the World Bank, 'The most immediate environmental problems facing developing countries—unsafe water, inadequate sanitation, soil depletion, indoor smoke from cooking fires, and outdoor smoke from coal burning—are different from and more immediately life-threatening than those associated with the affluence of rich countries, such as carbon dioxide emissions, depletion of stratospheric ozone, photochemical smog, acid rain and hazardous wastes'.¹⁷

The Earth Summit in Rio de Janeiro endorsed 'Agenda 21', a wide-ranging world programme of action to promote sustainable development, but the negotiations exposed the divergence of perspectives between industrialized and developing nations on approaches to sustainable development.¹⁸ Questions of lifestyles, national sovereignty, barriers to trade and financial assistance, in addition to access to less polluting technologies, are now at the centre of the debate on sustainable development.

As a result of the greater salience of environmental problems, international governance issues have acquired greater importance. There have been proposals to redefine 'national security' in environmental terms, and moves to strengthen international institutions have led to the creation of a Sustainable Development Commission at the United Nations.¹⁹

One consequence of the greater importance of environmental concerns is that access to development assistance during the 1990s will be increasingly linked to the attainment of environmental objectives. Another result is that some industrialized countries—notably Japan and Germany—are positioning themselves to compete in what will be one of the most dynamic markets of the future—that of environmentally sound technologies. Being able to deliver 'green' technologies could soon become a source of competitive advantage in the global search for new markets.²⁰

Cultural factors

Three powerful cultural forces are shaping the international scene in the transition to the 21st century: the growing importance of religious values and the rise of fundamentalism as a main driving force of economic and political actions in many parts of the world; the tensions between cultural homogenization pressures brought about by the pervasive influence of mass media, and the desire to preserve cultural

identity; and the emergence of moral, spiritual and ethical issues at the forefront of choices about inter- and intra-generational equity, particularly in relation to human rights, the environment, income distribution and poverty reduction.²¹

The revival of religious and spiritual concerns has been a characteristic of the past two decades of the 20th century, which have witnessed the renaissance of Islamic values in Northern Africa, the Middle East and Central Asia; a revival of the Orthodox Christian Church in Eastern Europe and the former Soviet Union; the spread of evangelical churches in Latin America and other developing regions; a surge in the popularity of the Catholic Pope; the growing influence of Christian fundamentalism in US political life; and the renewed interest in mysticism and Oriental religions, often associated with 'New Age' movements. All this points to the fact that, because of the overriding concern with improving material well-being and standards of living, the spiritual dimensions of human development have been neglected during the post-World-War-II period.²²

As a consequence of the globalization and pervasive influence of mass media—a direct result of technological advances in communications during the past two decades—two contradictory cultural forces can now be seen at play: pressures towards the standardization of aspirations and cultural values throughout the world, and the desire to reassert individuality and preserve cultural identity. These two contradictory forces create cultural tensions and emotional stresses, particularly in developing countries where the images of affluence brought by television programmes from industrialized nations contrast sharply with the harsh reality of mass poverty—and with the fact that those worlds of plenty are simply unattainable for the vast majority of the population.

Moral and ethical questions, once the province of academics and religious activists, are finding their way to public debates on the rights of future generations in relation to sustainable development, and on a variety of issues such as racism, abortion, corruption, crime prevention and drug traffic.²³ A renewed concern with human rights throughout the world has led to a questioning of the principle of non-intervention in the internal affairs of states where governments do not respect basic human rights.²⁴ Finally, reversing the trend that prevailed during the 1980s, equity considerations are finding their way to the political agenda of many industrialized and developing countries, at the same time that the moral and ethical aspects of economic behaviour have begun to receive greater attention.²⁵

Humanity in transition

The emergence of a fractured global order is embedded in an even larger framework of changes in the realm of concepts and ideas that are leading to a fundamental reappraisal of the human condition. New findings, discoveries and speculations are challenging centuries-old ideas about the nature of human beings, and about the place of humanity in the order of things. They are also challenging the prevailing conceptions of the human potential.²⁶ These findings suggest that humanity is in the midst of a bewildering and paradoxical transition towards something that cannot as yet be clearly visualized, although some intellectuals have referred to it as the post-modern condition.²⁷

For example, there is an increasing awareness of the tight coupling that exists between the activities of human beings and the physical and biological worlds, and an acceptance of the fact that it is no longer possible to act with impunity on the environment, trusting blindly in the regenerative capacities of ecosystems. This

implies a radical shift away from the ideas that prevailed during the 18th, 19th and much of the 20th centuries, which conceived human beings as lords and masters of creation, with the right to do as they saw fit on the planet. Human beings are now considered as stewards of a precious heritage that must be passed on to future generations.

At the same time, advances in information technology are creating a new level of reality—'virtual reality' or 'cyberspace'—that lies in between the tangible and real world which has been with humanity since time immemorial, and the world of abstract concepts which was created about 2500 years ago with the invention of theory by the Greeks. Communications technologies are also generating new modes of human interaction, and in the process are altering what is meant by experience, privacy, selfhood, cultural identity and governance.²⁸

In addition, humanity is becoming aware of its newfound capacity for consciously altering the direction of human evolution, and of the possibility to overcome the limitations of an individual's biological and genetic hardware.²⁹ However, although the realization that it may be possible to manage our biological evolution is dawning on men and women, there is still the need to develop the ethical and moral foundations for a conception of the governance of evolution. Such a conception should correspond to the newly acquired responsibility that humanity has acquired for its own biological, in addition to cultural, future.³⁰

Advances in expert systems, artificial intelligence and robotics are also forcing us to reconsider what were held as unique attributes of human beings. As the awareness grows of the impact that artefacts and mechanical constructions can have on living systems, the idea of 'co-evolution' between humanity, nature and machines is beginning to emerge. Processes such as natural selection, once thought to be restricted to the realm of living organisms, are now being applied to computer programs and technological systems as well.³¹

Finally, new speculations about the origins and the ultimate destiny of the universe, and new discoveries about the origin of life and of human beings, are putting the earth and humanity in a cosmic context whose history spans billions of years. Against this backdrop, the ephemeral character of the few thousand years of human civilization contrasts sharply with the human capacity to transcend its limitations and comprehend the vastness of the world it inhabits.

Knowledge in the emerging fractured global order

Scientific advances and technological innovations are at the root of the complex process of transformation that has led to the emergence of the fractured global order. At the same time, changes in the political, economic, social, environmental and cultural fields have stimulated and supported the growth of science and technology activities, and have shaped the particular direction of their evolution.

Since World War II the products of scientific research and technological innovation have become more and more deeply enmeshed in all aspects of human activity, and there have been profound modifications in the way in which knowledge is generated and utilized. A problem, which could also be seen as an opportunity, is that too little of the great power of modern science and technology has been directed at development. Mobilization of developed country scientists to deal with problems found mainly in developing countries has not been very successful, and the science and technology capabilities of developing countries are far too limited to deal adequately with the enormous problems of development in a fractured global order.

Only about 4% of the world expenditure on R&D and about 14% of the world's supply of scientists and engineers are in developing countries, which contain more than 80% of the world population.³² These differences, which have persisted over a long period, constitute a distinguishing feature of the emerging fractured global order. The role that knowledge now plays in the process of development is so critical that development itself could be redefined in terms of the capacity to generate, acquire, disseminate and utilize knowledge, both modern and traditional. The presence or absence of this capacity constitutes a crucial divide between the developed and developing nations; between those parts of the world in which individuals have the potential to decide and act with autonomy, and those in which people are not yet empowered to realize their potential.³³

Two aspects of science and technology merit particular attention in the transition to the 21st century: the changes taking place in the conduct of scientific research, and the increasing systemic character of technological innovation.³⁴

Scientific research

In the five decades since World War II, knowledge has grown at an astonishing pace: the stock of knowledge doubled during the first half of the 20th century, and now it doubles every four or five years.³⁵ The growth of scientific research, supported by advances in information and computer sciences, has been primarily responsible for this explosion of knowledge. There has also been an increased interpenetration and cross-fertilization between scientific research, technological innovation and the commercial exploitation of research results.

The multiple and complex interactions between research, innovation and commercialization have shown the inadequacy of the 'linear' model of scientific and technical progress, in which scientific findings lead directly to new technologies that can be incorporated into productive and service activities. Instead, it is now clear that the accumulation of technological innovations provides a base of observations for science to delve into, technological progress plays an important role in defining the agenda for scientific research, high-tech industries continuously identify new problems to be addressed by science, and techniques of observation, testing, measurement and instrumentation are a major determinant of scientific progress. All this has dramatically reduced the time between scientific discovery and commercial exploitation.³⁶

The institutional settings for the conduct of basic research, applied research, and the development of new products and processes are experimenting significant changes, particularly because of shifts in the sources of funding and a more prominent role for the private sector. Links between universities and industries are being strengthened, collaborative industrial research and technological alliances have become an imperative in certain fields, and venture capital firms and some specialized government agencies are playing an increasingly important role in providing capital for new-technology businesses.

These changes have been largely in response to major increases in the cost of basic and applied research, which are also bringing about greater concentration in fields where large facilities are needed and results may take a long time. Certain fields of research have become increasingly dependent on advanced and expensive instruments which, as in the case of chemical synthesis, combine advances in electronics, optics, analytical techniques and data processing.³⁷

The high cost of advanced instruments and financial constraints have been

creating a difficult situation for university laboratories in industrial nations, and have effectively put many fields of research out of the reach of the vast majority of scientific institutions in developing countries. However, there is still ample scope for developing countries to become actively involved in many aspects of scientific research, even in areas that would appear at first sight closed to them.³⁸

The accelerated pace of scientific progress requires a continuous effort to keep up with advances in the state of the art, for the stock of knowledge and the capabilities acquired through training and research become obsolete rather quickly. These needs and trends have important implications for human resources development and for training researchers in advanced scientific fields, particularly in the developing countries where high-level professionals are in short supply.

The closer links between scientific capabilities, developments in technology and economic growth, the increasing costs of scientific research, the accelerating obsolescence of research capabilities, the emergence of new transdisciplinary fields, and the growing complexity of the institutional setting for the conduct of research are making it more difficult for most developing countries to push quickly towards the frontiers of knowledge and take advantage of scientific and technological advances. At the same time, the slow-down in the rate of economic growth, the severe resource constraints and the growing social demands are undermining the long-term efforts required to build scientific and technological capabilities in developing countries.

Technological innovation

The nature of the innovation process has also changed significantly, particularly in science-intensive industries, and acquired a more complex and systemic character, becoming more expensive, involving greater sophistication in management techniques, giving rise to new forms of appropriation of technological knowledge, intensifying both international collaboration and competition, and enlarging the role of governments in the support of innovation. All this is closely associated with the emergence of a new technoeconomic paradigm, associated with the transition from energy (mainly oil) towards microelectronics (primarily the microprocessor) as the key factor that influences the organization of productive and service activities.³⁹

The systemic nature of the innovation process is manifested in at least two ways: the complementary character of specific technical advances required to materialize a particular innovation, and the larger network of institutions and support services necessary for innovation to take place. New technologies are differentiated from old ones by their greater combinative and contagious character, which means that individual advances in information technology, automation, new materials, chemical synthesis and biotechnology, among many others, cannot be applied on their own without complementary inputs from other technologies. This has become clearly noticeable in automation, where microelectronics, computers, telecommunications, optoelectronics and artificial intelligence are fusing together into an integrated technology system, which is clearly associated with the new technoeconomic paradigm based on microelectronics as the key factor of production.⁴⁰

The technological convergence implied by the systemic character of innovation has made it necessary for firms to develop expertise quickly in a broader array of technologies and scientific disciplines, as evidenced by the need for the food processing and pharmaceutical industries to develop competence in biotechnology, molecular biology, and advanced electronic instrumentation.⁴¹ The increasingly

systemic character of innovation is also reflected in the larger number of actors that take part in the process of bringing major innovations to the market. In addition to the firms directly involved in this process, there may also be subcontractors, suppliers of inputs and equipment, laboratories and other organizations that provide technological services, management consultants, educational and research institutions, marketing research units, distributors and trading companies, financial institutions and venture capital firms, and government agencies and departments.

As a result, the costs of incorporating research results into productive and service activities, and of bringing new products to the market, have been steadily increasing during the past few decades. The higher costs of innovation and the larger risks faced by firms in a more competitive environment have in effect increased barriers to entry in many fields of industry.⁴² Paradoxically, the increase in competitive pressures has generated a host of cooperative arrangements between industrial firms, primarily in pre-competitive research and marketing, giving rise to new specific enterprise networks in which the interests of other enterprises converge at a specific time for a specific purpose. However, only firms with substantive financial or technological assets (including small firms focusing on specific technology niches) can be expected to become players in the complex competition–collaboration game of international technological alliances.

New technologies make it cost-effective to produce more differentiated products and to accelerate innovation by adopting shorter product cycles; flexible automation is lowering the minimum efficient plant size in several industries; and advances in communications and information technology permit adopting a 'just-in-time' approach to production management, reducing inventory costs and requiring close interactions with suppliers and markets. Low labour costs are no longer the dominant criterion to locate production sites, and corporations are finding it increasingly difficult to establish production facilities at long distances from their markets, suppliers and R&D centres.

The more systemic the character of innovation and the changes associated with the new technoeconomic paradigm have placed greater emphasis on management skills and capabilities. To realize the full potential of new technologies it has become necessary to introduce innovations in organization and management, a task for which advances in information technology have provided the tools.⁴³ A well developed physical infrastructure is also required to support innovation, including a good network of roads and transport facilities, telecommunications and data transmission networks, reliable electricity supply, access to waste disposal facilities, and clear water supply. In addition, it may be necessary to count on advanced repair and maintenance services for a variety of laboratory and industrial equipment. Some of the infrastructure requirements are well beyond the existing capabilities of most developing countries.

These changes in the nature of the innovation process have mixed effects on the prospects for developing countries. On the one hand, there is the possibility of incorporating advanced technology components into traditional and conventional technologies in developing countries, known as technology blending, which can lead to more appropriate and higher productivity technologies.⁴⁴ On the other hand, the comparative advantage of developing countries is shifting away from low labour costs and natural resources, forcing a major adaptation in their industrialization and development strategies.

Science and technology for sustainable human development in a fractured global order

Two civilizations amidst a multiplicity of fractures

The preceding sections have dwelt on the changes and trends that are creating the multiple fractures that characterize the emerging global order. These fractures are structured along many fault lines of a political, economic, social, environmental, cultural, scientific and technological nature; they overlap partially and often shift direction; they sometimes reinforce each other and at other times work at cross-purposes. The overall picture they paint is one of a multiplicity of paradoxical and contradictory processes in motion, all of which create enormous turbulence and uncertainty, and which give rise to an extremely wide range of possibilities and threats whose comprehension defies established habits of thought.

But one salient feature of the contemporary scene provides a clear and visible point of reference for all the changes associated with the emergence of the fractured global order. The enormous impact that advances in science and technology have on all aspects of human life—including on the very conception of humanity—are making it abundantly clear that the world is witnessing the rise of what has been called the 'Knowledge Society'.⁴⁵ Among the bewildering multiplicity of fractures that are evident in the emerging global order, the knowledge fracture—this is, the great divide between those people who have the capacity to generate and utilize knowledge and those who do not—could rapidly become an impassable abyss, to the extent that it may now be appropriate to speak of the emergence of 'two civilizations'.⁴⁶

The first civilization is based on the growth of science as the main knowledge-generating activity, the rapid evolution of science-related technologies, the incorporation of these technologies into productive and social processes, and on the emergence of new forms of working and living deeply influenced by the worldview of modern science and science-related technologies. The second civilization is characterized by the lack of a capacity to generate scientific knowledge on a large scale and by a passive acceptance of scientific results generated in the first; by a technological base that comprises a substantive component of traditional technologies and a veneer of imported ones; by a productive system whose modern segment is dependent on the expansion of production in Western industrialized nations and on the absorption of imported technology, and whose traditional segment is based on an often stagnant traditional technological base; and by the coexistence of disjointed and even contradictory cultural forms.

These two civilizations interact strongly, although the interaction is one-sided: the second civilization is dependent and deeply affected by the first and lacks the capacity of influencing it to the same degree. The first civilization, corresponding to the developed or highly industrialized countries—the USA, Europe and Japan—has an endogenous scientific and technological base in which science, technology and production interact strongly with each other. The second civilization has an exogenous scientific and technological base, in which scientific research, technological development and the evolution of productive activities remain apart.⁴⁷ This holds true for the vast majority of developing countries, even though during the past three decades a handful of developing countries have begun to reduce the distance that separates them from the nations of the first civilization, and to establish

the foundations for the development of an endogenous scientific and technological base.

Modern science and technology have always had an ambiguous character, but the cultural context in which it developed from the 17th to the 19th century never really treated its promises as threats to the survival of humanity. Moreover, science and technology do not always bring about improvements to those areas that they affect. Despite what was promised by the rationalism of the Enlightenment and even more by the positivism of the 19th century, scientific and technical progress does not necessarily coincide with social or moral progress. The complex and rapidly shifting context of the emerging fractured global order is making this point in a painfully obvious way as the world moves into the 21st century.

The nations of the second civilization face difficult choices regarding the importance attached to tradition, with its hierarchies, codes and rites, in relation to the weight placed on rationality—which is the hallmark of modern science—with its capacity to create order and disorder, and to transform and destroy. From one perspective, taken to extremes, scientific and technical thinking threatens to reduce human beings to purely instrumental rationality; while from another attacks on rationality, levelled from particular faiths or traditions, threaten to retard or prevent change and may lead to stagnation. The challenge faced by the nations of the second civilization—with their legitimate diversity of cultures, perspectives and viewpoints—is how to integrate harmoniously the pursuit of modern science and technology, as well as its material intellectual manifestations, with the social and cultural heritage that provide them with a sense of identity.

Beyond the two civilizations: towards sustainable human development

Perhaps the most important challenge faced by humanity in the transition to the 21st century is to prevent the multiplicity of fractures of the emerging global order from creating self-contained, partially isolated pockets of mutually distrustful peoples, ignorant and suspicious of the viewpoints, aspirations, potentials and capabilities of each other; and to prevent these fractures from creating inward-looking groups of peoples who relate to one another only through tenuous links forged by mass media or economic transactions, or who interact in ways that are fraught with conflicts that may threaten human and environmental security. Efforts to meet this challenge imply a commitment to building bridges across the multiple fractures of the emerging global order, so as to give all human beings—both individually and collectively—the opportunity to realize their full potential. Above all, this implies a determination to prevent the knowledge fracture from leading inexorably to a globalized world with two distinct civilizations, and to embrace and put into practice a new conception of sustainable human development.

Sustainable human development could provide all individuals, both now and in the future, with equal opportunities to enlarge their human capabilities to the fullest possible extent and to put those capabilities to the best use in political, economic, social, environmental and cultural fields. Development patterns that perpetuate today's inequities and deepen the fractures of the emerging global order—and particularly the knowledge fracture—are neither sustainable nor worth sustaining. The essence of sustainable human development is that all human beings—both in present and in future generations—should have equal access to development opportunities.⁴⁹

Moreover, sustainable human development is concerned with models of

material production and consumption that are replicable and desirable, and which guarantee that future generations will have opportunities similar to the ones enjoyed by previous generations. In addition, because the accumulation of human capital can replace some forms of exhaustible resources, human development should be seen as a major contribution to sustainability. As Gustav Speth, the Administrator of the United Nations Development Programme, has stated:

Sustainable human development should join sustainable development and human development everyday, in practice, on the ground, around the world. It is development that does not merely generate growth, but distributes its benefits equitably; it regenerates the environment rather than destroying it; it empowers people rather than marginalizing them; it enlarges their choices and opportunities and provides for peoples' participation in decisions affecting their lives. Sustainable human development is development pro-poor, pro-nature, pro-jobs, and pro-women. It stresses growth with employment, growth with environment, growth with empowerment, growth with equity.⁵⁰

Sustainable human development is not just for the developing countries. Its lessons are lessons for the industrialized nations as well. It is a new paradigm or a new synthesis of development needs. Moreover, along with this new concept of development it is necessary to evolve new approaches to development cooperation.⁵¹

However, it is important to emphasize that sustainable human development cannot take place without dialogue between cultural heritage and instrumental rationality, even if the two may not be entirely reconciled in all places and at all times. Science and technology can contribute a great deal to sustainable human development, but they do not offer a ready-made solution to the problem of values raised by the clash between tradition and modernity. Therefore, from the perspective of science and technology, sustainable human development has to be considered as an uncertain quest in which the seekers rely heavily on the knowledge and on the innovations that are the product of modern science and technology.⁵²

Knowledge for sustainable human development

In the transition to the 21st century, science and technology will continue to be essential for achieving sustainable human development. While it is necessary to be aware of the problems, threats and limitations of the instrumental rationality characteristic of modern science and technology, through the creation and utilization of knowledge, scientific research and technological innovation expand the range of goods and services available, lead to improvements in productivity, help build the education systems that open up new opportunities for human betterment, and provide the technical options and means for achieving the sustainable use of the earth's resources. In short, they provide the means for bridging the multiple fractures that characterize the emerging global order.

Moreover, without an appropriate level of scientific and technological capability, no country can take the major decisions which affect its policies and strategies for achieving sustainable human development; cannot absorb, adapt, and improve on imported technology; cannot expect to develop its productive potential, even in those areas where it has competitive advantages; and will not be able to follow advances at the international level, particularly in fields of potential impact on the country's strategies to achieve sustainable human development.

It is clear that developing countries at different levels of socioeconomic development, with different social and economic objectives, and with varying

degrees of scientific and technological capabilities, have to approach the problem of mobilizing science and technology for development in different ways. Policies, strategies and priorities for action will change according to the specific conditions prevailing in a particular developing country, and the options it can identify or construct for itself in the emerging fractured global order.

But it is essential to be aware that the mobilization of science and technology for sustainable human development in the transition to the 21st century is likely to take place in the context of severe resource constraints that will tend to reinforce the multiple fractures of the emerging global order. This will test the political will of developing country leaders to embark on the uncertain and long-term enterprise of building science and technology capabilities, particularly when facing a multiplicity of urgent short-term needs. Many successful examples in fields such as health and agriculture suggest that much more could be profitably invested in the development of science and technology capabilities.

In the last analysis, without science and technology there can be no belief in and commitment to the future, no means for dealing with the multiple fractures of the emerging global order. Future generations in developing countries must rely on their access to accumulated scientific and technological knowledge to understand and interact with the environment, not only for satisfying their most basic needs and for establishing their own position in an increasingly interdependent world, but also for realizing their potential contribution to sustainable human development and for reaffirming their sense of identity.

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