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BRIDGING THE TECHNOLOGY GAP BETWEEN AND WITHIN NATIONS

Report of the Secretary-General*

Executive summary

This report examines the extent of the technology gap between and within nations, and draws on policy lessons from countries that have successfully moved up the technological ladder. It elaborates policy frameworks for developing countries to build up their technological capabilities. It also presents the latest work of UNCTAD and the CSTD on measuring the digital divide.

* This document was submitted on the above-mentioned date as a result of processing delays.

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I. INTRODUCTION

1. At the Millennium Summit in 2000, United Nations Member States adopted a set of time-bound and measurable goals, targets and indicators to combat poverty, hunger, disease, illiteracy, environmental degradation and gender inequality. Five years later, Member States gathered at the World Summit in New York in September 2005 to review the progress made towards fulfilling the commitments contained in the United Nations Millennium Declaration, including internationally agreed development goals. At this gathering United Nations Member States renewed their commitment to achieving these goals, and affirmed the vital role of science and technology, including ICTs, in this endeavour.

2. The Commission on Science and Technology for Development (CSTD) has addressed the role of science and technology (S&T) in meeting the MDGs during the past few years. It has concluded that the progress made towards achieving the MDGs has been slow, and that many developing countries are not likely to meet these goals without concerted efforts to place S&T at the centre of their development agenda. Achieving the MDGs will therefore require a reorientation of national science, technology and innovation policies to ensure that they serve the needs of development effectively. The Commission has also recognized that the current North-South gap in the generation and application of technologies to economic and social development constitutes a technology gap that must be bridged if developing countries are to participate effectively in a globally inclusive knowledge society.

3. Building on its work in the past two years, the Commission decided at its eighth session to select "Bridging the Technology Gap between and within Nations" as the substantive theme for the inter-sessional period 2005-2006, with specific emphasis on multi-stakeholder partnerships to bridge the technology gap, as well as prevent it from growing wider.

4. To contribute to a further understanding of the issues, and to assist the CSTD in its deliberations at its ninth session, the UNCTAD secretariat convened a panel meeting in Rabat, Morocco, from 10 to 12 November 2005. The present report is based on the findings of the panel, on national reports contributed by members of the CSTD, and other relevant literature.

II. THE EXTENT OF THE TECHNOLOGY GAP

5. The technology gap is the divergence between nations and communities in their abilities to access, diffuse and use scientific and technical knowledge. It is one of the main causes of the rapidly expanding socio-economic gap between rich and poor nations and constitutes a major challenge for developing countries in their efforts to achieving the development goals. Recent findings[†] indicate that almost 60 per cent of the differences in income levels between sub-Saharan African (SSA) and the industrialized countries can be attributed to differences in the stock of knowledge.

6. Countries diverge greatly in their access to S&T knowledge; most of this knowledge is generated in developed countries and protected by intellectual property rights regimes and global rules; they also have varying capacities to translate S&T knowledge into goods and services and invest in human resources and entrepreneurial capacity-building. Similarly, they

[†] UNIDO (2005) Industrial Development Report 2005 (Vienna: UNIDO).

diverge in appreciation of the importance of science and technology to development; in capabilities to provide S&T advice to multilateral negotiations at the international level, and to implement the results of such negotiations at the national level.

7. Over the past several decades, a small group of newly industrialized economies (NIEs) has successfully reduced the gap between themselves and industrialized countries and, in some areas, even overtaken them. Their catching-up experiences illustrate the pivotal role of knowledge and the building of national capabilities in using knowledge. During the same period, some developing countries have stagnated or even slipped behind with regard to technological development. Of these countries, sub-Saharan African (SSA) countries deserve special policy attention.

8. Various quantitative measures indicate that there is a large gap between countries in terms of technological activity, human capital, industrial structure and performance. The technology gap is evident not only along the traditional North-South divide, but also between developing and transition economies.

II.1. Gap in technology inflows

9. As the bulk of technological activity in developing countries involves the mastery, adaptation and use of foreign technologies, data on technology inflows are one of the essential conditions for the creation and strengthening of technological capabilities. Technology inflows take place through imports of capital equipment and machinery, licensing and foreign direct investment (FDI). East Asian countries rely on the constant upgrading of their capital stock, with new embodied technology to improve their industrial performance. More than 40 per cent of their import expenditures is spent on capital equipment, while SSA countries spend less than 17 per cent of the total imports on equipment imports.[‡]

10. Several NIEs have adopted policies to promote technology transfer via FDI and effectively inserted themselves into global production networks, and are now part of the world's fastest growing exporters of manufactures. The share of SSAs in world FDI inflows remains very small – about 2 to 3 per cent of global flows.[§] Moreover, with the exception of South Africa, little FDI goes into manufacturing. The bulk of FDI inflows to SSA are concentrated in resource-intensive sectors rather than technology-based ones, with minimal impact on the transfer of technology to SSA.

II.2. Gap in knowledge generation and technological activity[**]

11. More than 84 per cent of the publications in scientific journals monitored by the Institute for Scientific Information are from industrialized countries. With the exception of the Republic of Korea, Taiwan Province of China, Hong Kong (China) and Singapore, most developing countries account for a negligible amount.

[‡] Source: United Nations COMTRADE Database and World Bank (2003b). *World Development Indicators 2003,* (Washington, D.C., World Bank).
[§] UNCTAD (2005). Economic *Development in Africa: Rethinking the Role of Foreign Direct Investment,* (Geneva: UNCTAD).
[**] The data in this section are drawn from the World Bank's *World Development Indicators 2003* and UNDP's *Human Development Report* (2001, 2005).

12. Developing countries seriously lag behind in terms of investments in R&D activities. In 1996 and 2002, ten countries accounted for more than 86 per cent of the world total, with their share marginally increasing over that period. Eight of these countries are developed countries, and one of them, the United States, accounted for the largest amounts in both these years. Only two developing countries are among the top ten, i.e., China and the Republic of Korea.[††] Industrialized economies allocate on average 2.6 per cent of their GDP to R&D activities. In comparison, for developing countries, this share is only around 0.7 per cent in developing countries, and in some of the LDCs, it is as low as 0.01 per cent of the GDP.

II.3. Gap in education and human skills base[‡‡]

13. In education, mean year schooling ranges from 12.1 years in the USA, to 4.2 in Kenya and 0.8 in Guinea Bissau. Tertiary enrolments as a percentage of relevant age group stand at approximately 25 per cent for East Asia, 10 per cent for South Asia and Latin America, 7 per cent for the Middle East and North Africa and 2 per cent for SSA. The tertiary enrolment ratio in 1999 was more than 50 per cent for Korea and Taiwan Province of China, 30 per cent for Malaysia and Thailand, 13 per cent for China and 15 per cent for South Africa, a decline from 18 per cent in 1995.

14. Tertiary science enrolment ratio ranged from 27.3 per cent in Finland, 5.5 per cent in Colombia, 2.4 per cent in Albania, and only 0.1 per cent in some LDCs. The dispersion for technical subject enrolments seems to be wider than the general tertiary enrolment. Tertiary enrolments in technical subjects stands at less than 0.1 per cent of the population in SSA, at slightly more than 0.1 per cent in Malaysia, India and South Africa, more than 0.4 per cent in Argentina and Chile, more than 1 per cent in Taiwan Province of China, and more than 1.5 per cent in the Republic of Korea.

III. NARROWING THE GAP: STRATEGIES FOR CATCHING-UP

III.1. Successful strategies adopted by NIEs

15. The experiences of the more economically dynamic developing countries, particularly East Asia's NIEs, indicate that coherent and carefully crafted technology policies can accelerate competitiveness and promote entry into more complex and higher-level technology activities. A number of key lessons can be drawn from their catching-up experiences:

- Domestic innovation is difficult without access to international markets, technology transfer and learning; in turn, access to international markets will not be possible without domestic technological innovation. Strategic investments in human resource development, education and infrastructure, and openness to foreign technologies, investment, and the flows of human resources are critical and complementary elements in policy design.

[††] UNCTAD (2005). *World Investment Report 2005: Transnational Corporations and the Internationalization of R&D* (Geneva: UNCTAD).
[‡‡] Figures are calculated on the basis of data from World Bank (2003b). *World Development Indicators 2003* (Washington, D.C., World Bank). UNESCO (2001). *Statistical Yearbook* (Paris: UNESCO), Barro, Robert J. and Jong-Hwa Lee. 2000. "International Data on Education Attainment: Updates and Implications." *NBER Working Paper 7911* (Cambridge, Mass.: National Bureau of Economic Research), and UNDP (2001, 2005). *Human Development Report* (New York: UNDP).

- Skills development, industrial specialization, enterprise learning and institutional change create cumulative, self-reinforcing processes that promote or retard further learning. It is very difficult for countries that have set on a pattern with a low technology, low-skill and low-learning specialization to change course without a concerted shift in a large number of interacting markets and institutions. Those countries that leave capability development to the "hands of the market" alone may suffer from long-term marginalization.

- "Learning to learn" is a critical element for a country at all levels. Enterprises, in particular, need to develop absorptive capacity, which requires supportive policies such as fiscal incentives and subsidies; promotion of collaboration through business incubators, science and technology parks, clusters and other forms of organization; and of technology prospecting institutions that identify and select technology from abroad for local diffusion and use. Connecting local universities and research centres with world-class centres of excellence is an effective way to build science and technology capabilities.

- Proactive sectoral policy is of vital importance to bridging the technology gap; particularly important is the development of the productive sector, which provides opportunities for and benefits from technological upgrading and learning.

16. East Asian economies adopted two main strategies in climbing up the technological ladder: (1) autonomous and (2) FDI-dependent. Autonomous strategies, such as those undertaken by the Republic of Korea and Taiwan Province of China, entail extensive industrial policy and interventions in factor markets and institutions. These strategies resulted in a massive development and deepening of indigenous skills and technological capabilities, and enabled these countries to keep abreast of new technologies and allowed domestic enterprises to become significant global players in their own right.

17. FDI-dependent strategies consist of two sub-strategies, i.e. targeted and passive. Sustaining growth entails increasing policy intervention to deepen the local skill and supplier base and to target FDI itself. This is the challenge facing a number of developing countries that have done well out of the relocation of the clothing industry in building simple manufactured exports, but that have not been able to upgrade their activities to more complex or technology-intensive activities.

18. Simply opening up to free trade and investment flows may not be an adequate strategy for countries at the low end of the technology ladder. Liberalization can remove constraints on growth caused by poor macro-management, inefficient public enterprises, high entry costs for private enterprises and restrictions on FDI. However, liberalization by itself cannot allow the economy to build more advanced capabilities, to escape the "low technology trap". As import competition in the final product market increase, enterprises have increasingly found it difficult to cope and close down or withdraw into non-traded activities. Without any strategic support from their respective governments, they find it difficult to bridge the gap between their skills, technologies and capabilities and those needed for international competitiveness.[§§]

[§§] UNCTAD (2003) Investment and technology policies for competitiveness: review of successful country experiences (Geneva: UNCTAD).

19. New enterprises find it more difficult to enter into complex activities with increasingly stringent skills and technology requirements. There is a danger, therefore, that low-income countries with passive sectoral policy will regress into simple activities that do not provide a basis for sustained growth and productivity increase.

III.2. Strengthening national systems of innovation

20. National innovation systems (NIS) play a crucial role in countries' efforts to catch up with technological advances. Different educational institutions and systems, legislation, frameworks for technological activities and policies are believed to impact deeply on a country's technological performances and in turn influence their economic performance.

21. The NIS system defines domestic capabilities in absorbing international technology and adapting and improving upon it on a local level. As the majority of technological activities in developing countries entail accessing, mastering, adapting and using foreign technologies, policy measures should place greater emphasis on facilitating access to foreign technologies, and supporting domestic efforts, especially at the level of the firm in order to master, learn, use and adapt these technologies. As the global marketplace becomes increasingly liberalized and competitive, countries need to constantly upgrade their technological capabilities. Governments ought to assess existing conditions governing the transfer of technology and the requirements for upgrading technological capacity, and identify weaknesses in their technology policy and institutions.

22. All components of the NIS, which includes, *inter alia*, knowledge institutions such as universities, research centres, business and manufacturing enterprises, standard setting and government institutions, are interrelated and their interaction changes over time. Although governments facilitate and catalyse technological learning, enterprises remain the locus of learning. They import, master, use and improve technology and also stimulate the demand for innovative technologies. Enterprises, especially those in manufacturing, are important for upgrading technology and organizational practices. Their ability to create, acquire and adapt new technologies is a critical requirement for competing successfully in the global marketplace. They are important engines of innovation, not only for making products, but also for the diffusion of processes, organizational practices and learning opportunities. For the process to thrive, they need active, supportive and dynamic government policies and institutions.

23. Efficient technology use entails: building capabilities, technical understanding and an information base; acquiring new technical skills and managerial practices; and forging linkages with other firms and institutions. It also requires the ability to understand and master new technology; to adapt it to local factors and conditions; and to upgrade it as technologies improve and new products appear. Different firms use the same technology at vastly different levels of efficiency.

III.3. Stimulating international technology transfer and learning

24. Most developing countries do not innovate at the technological frontier. Instead, they acquire, adapt, diffuse and use technologies that are developed in industrialized countries. In addition to capital equipment imports and licensing, FDI and inter-firm partnerships are important channels for international technology transfer and learning.

25. Transnational corporations (TNCs) dominate global FDI flows and have been the main source of innovation for many years. They play a crucial role in international

technology transfer, especially in high-tech industries where extensive use of knowledge-based assets is required. When accompanied by appropriate government policies, FDI could increase the level of technology in the host economy in three ways. First, foreign affiliates are in general capable of applying more advanced technology and are therefore often more productive; second, through "deep integration" between foreign affiliates and local firms, spillovers to domestic competitors can occur; and third, FDI can stimulate more competition in the domestic market, thus improving allocation of resources. Evidence from East Asian countries suggests that technologies have been transferred not only from parent companies to their subsidiaries, but also from their subsidiaries to local firms.

26. The policy challenge is how governments should build local capabilities to target and facilitate the acquisition of technology through FDI. To this end, policies on technology transfer through FDI should focus not only on the “physical” aspect of investment, such as imports of machinery and equipment, but also on the acquisition of information and knowledge. For example, Singapore has relied heavily on industrial policy to target and attract hi-tech TNCs, build local skills and institutions and develop specialized infrastructure. As a result, it has moved to the top of the technological ladder and is now targeting R&D and high-value service activities by TNCs.

27. Another channel for international technology transfer and learning is cross-border inter-firm partnerships where the flow of knowledge and technology tends to be “two-way”. Evidence, however, shows partnerships are still overwhelmingly concentrated in developed countries with the exception of a small group of developing countries. To increase partnering, governments could adopt a number of policy options, including specialized skill development, provision of business development services to firms to make them partnership-ready, and FDI strategies which target TNCs interested in partnering, and identification of firms with high potential for such arrangements.

III.4. Strengthening technology infrastructure

28. Infrastructure includes services such as business incubators, S&T parks, access to finance, business development agencies and investment promotion agencies, etc. Not only does infrastructure serve as a foundation for technology creation and diffusion, but developing it also provides opportunities for technological learning and upgrading. Infrastructure services such as business incubators and S&T parks are considered as central elements in well-functioning national innovation systems. Access to venture capital and the collaboration between venture capital investors and incubators are also crucial elements in this respect.

III.4.1. Providing extension services to SMEs

29. Firms in developing countries, especially those not geared to export activity, find it difficult and costly to obtain the information they need on sources of technology. East Asian NIEs have made great strides in informing their enterprises on sources of technology import, through the use of online databases in all major industrial centres. Information provision was backed by extensive support in terms of advice, financing, consultancy and marketing support. The main focus of technology transfer policy, therefore, should be on information provision to enterprises, particularly export-oriented SMEs, on the sources, costs and appropriateness of foreign technologies, backed by the provision of technical extension services to help them absorb new technologies.

30. Productivity centres, such as those that have been successfully set up in Taiwan Province of China and Hong Kong (China) have proven to be effective measures in helping SMEs to acquire and use technologies. They not only undertake productivity analysis, but also help finance productivity-enhancing and marketing measures. They set up teams of experts who visit enterprises, provide free diagnoses and put together packages of technology and training. These services could be initially provided at low cost to enterprises and at full cost after a period of time. In China, there are currently more than 850 productivity promotion centres, which provide services to more than 60,000 enterprises. The total number of consulting organizations providing services to enterprises exceeds 13,000.

III.4.2. Technology intermediaries

31. In the initial period of "catching up", governments may play a greater role in creating technology intermediaries, which can "spot" and assess technology, forecast technology needs, and bring together the potential technology receivers and sellers (Box 1).

Box 1. Fundación Chile: technology intermediary

One of the best examples of technology intermediaries is the Fundación Chile, created in 1976 as a joint public-private institution. It develops, adapts and sells technologies to clients in the productive and public sectors, both in Chile and abroad, fosters institutional innovations and develops new transfer mechanisms. It disseminates technologies to multiple users, through seminars, specialized magazines and project assistance. It has promoted the development of new enterprises in agribusiness, marine resources, forestry, the environment and chemistry. It has created two salmon farming companies that pioneered the industry's boom in the country; developed the technological concept of vacuum-packed beef; established quality control and certification of export fruit; and introduced berry crops into Chile.

Fundación Chile creates pilot firms to demonstrate the technical and commercial feasibility of some new technologies. Once feasibility is proven and economic profitability is established, the institution transfers the firm to the private sector. It has sold about 30 of the 40 firms it created to recover the foundation's initial investment and fund new projects.

Source: United Nations Millennium Project Task Force on Science, Technology and Innovation (2005).

III.4.3. Improving the research and development climate

32. A critical driver of technological development and innovation is R&D. Research activities can be carried out through universities, public and private research institutes, as well as private company research centers. R&D activities are necessary for innovation, technology creation as well as for local adaptation and incremental improvement of imported technologies. They are thus key in bridging the technology gap not only between nations, but also within nations (Box 2).

33. In most developing countries, R&D spending is low, mostly carried out by universities and of little relevance to industry; however, in developed countries, private sector funds more than half of R&D activities and are used in more than two thirds of the projects.

According to UNCTAD,[***] private sector finances roughly 70 per cent of total R&D activities in the ten leading countries with highest R&D spending. By contrast, in many developing countries, the public sectors' share in research activities is more that 70 per cent.

34. In many least developing countries, imported technology is used passively, and often without making much effort to master it owing to the absence of R&D activities. By contrast, most Asian NIEs allocate a large share of their GDP for R&D activities, and subsidize and tax-exempt such activities.

35. For enterprises lacking the scale or capability to internally conduct necessary R&D for the development of a particular product or process, they can leverage the R&D resources of local universities or research institutes. These relationships simultaneously benefit universities and research institutes, which frequently lack the full capability to commercialize R&D. Working with industry provides them with the necessary capital to develop their infrastructure and support their R&D efforts. Moreover, it also affords the opportunity for students, faculty and researchers to conduct marketable research. Appropriate support mechanisms and institutions are necessary, including implementing tax incentives for research and industry/university collaboration; making capital available through venture financing or affordable loans. Governments can encourage public-private R&D linkages by establishing formal institutional relationships.

Box 2. Bridging the technology gap within nations: the experience with the new Länder in Germany

With German unification in 1990, the former GDR has become a region in transition within the largest economy of the EU. In 2001 the share of R&D employees in total employment in Germany's new Länder was 3.8 per cent (including Berlin), and 2.5 per cent (excluding Berlin), compared to 4.3 per cent in the rest of Germany. Firms in the former GDR achieved only 40 per cent of the productivity level of firms in the rest of Germany.

Since the late 1990s the Federal Government formulated a strategy aimed at building up a strong economy in the new Länder. Its research, technology and innovation policies have since undergone a number of reviews and changes. The current policy places special emphasis on stimulating regional development focuses, networks between enterprises and research institutions, as well as competencies and management capabilities. It also adopts a "bottom-up approach" which builds on and mobilizes regional initiatives and their "endogenous potentials".

Of particular importance is a new initiative "Enterprise Region" (Unternehmen Region) with its four sub-programmes. One of these, the InnoRegio Programme, provided 65 million Euros in 2003 to subsidize cooperative networks with a regional focus. The total funding for the period 1999-2006 is estimated to be 255 million Euros. The programme targets large companies, SMEs, research institutes, universities, public authorities and individuals, provided that the projects include a region-specific focus. Two-fifths of these firms have submitted requests for patents in the last two years and almost all have introduced new products. The InnoRegio Programme has also helped create 50 new firms since 2000.

[***] UNCTAD (2005b) *World Investment Report 2005: Transnational Corporations and the Internationalization of R&D* (Geneva: UNCTAD).

As a result of these policy measures, R&D expenditures in the new Länder have almost doubled from 1996 to 2003, and have contributed to boosting GDP growth to 8 per cent in 2003 (and 14 per cent in manufacturing). Firms with higher expenditures on R&D grew faster and achieved better export performance. Altogether, productivity grew by 9 per cent and innovation is faster in the new Länder than the rest of Germany.

Despite these improvements, economic indicators such as GDP per capita or unemployment still show a marked gap between the new Länder and the rest of Germany. Even 15 years after reunification, the transformation process is still ongoing. Two important policy lessons drawn from this experience are: (1) Regions have different paths of development and growth; designing innovation policy needs to take into account the regional characteristics. (2) Bridging the technology gap is a learning process over an extended period of time.

Source: Lo, Vivien (2005). *"Bridging the technology gap within nations: The experience with the new Länder in Germany"*.

III.5. Improving human capital and skills

36. The large difference in opportunities in education between countries is one of the basic causes of global inequality.[†††] A quality workforce contributes to a country's ability to respond flexibly to rapid economic and technological change; to produce higher-quality products; to adopt and improve upon new production processes and technologies; and to develop new skills as the structure of jobs evolves. Over the past decade, concerns regarding the supply of skilled workers have become acute in both developing and developed countries.

37. Four Asian Tigers, the Republic of Korea, Taiwan Province of China, Singapore and Hong Kong (China), have heavily invested in all levels of formal education and even outpaced OECD countries in human capital formation as measured by S&T enrolments in the tertiary education as a percentage of population. Studies also show that S&T education should be strengthened at the earliest level in educational systems, as well as at the tertiary level. Special efforts should be made to encourage young people, especially women and girls, to study science and technical subjects.

III.6. Raising awareness and appreciation of science, technology and innovation

38. Many countries in the developing world lack a solid base for technology and innovation. Often, there is little understanding and appreciation of why innovation is important for industry. Government could launch information campaigns including awards and official recognition programmes to ensure that technology consciousness diffuses from the leading technology performers to others. Lead performers could be selected as models to showcase how technology can be improved or developed locally. Industry associations can play a key role in this regard.

39. In China, all levels of government are invested heavily in raising public awareness on the importance of S&T. As of the end of 2002, 425 S&T exhibition halls were built around the country and 7,000-8,000 kinds of science education publications are produced each year.

[†††] ILO (2004) *A Fair Globalization: Creating Opportunities for All* (Geneva: ILO).

40. In recent years, Jamaica saw a decline in science and engineering enrolments at its three universities, this was particularly apparent among male students. To address this problem, the National Commission on Science and Technology facilitated the launch of the Jamaica Young Scientists Forum. The group comprises over 30 young research scientists representing at least 15 R&D institutions. The aim of this Forum is to promote the entry and retention of more young people in the S&T professions, especially in technologically-led entrepreneurial activities. The young scientists participate in policy discussions on the development of S&T capability of Jamaica, undertake joint research with the private sector, and set up an electronic debate forum to raise awareness about the importance of S&T.

III.7. Undertaking reviews of national science, technology and innovation policies

41. The CSTD (1999)[‡‡] identified some of the problems of the national innovation systems in many developing countries as: (1) lack of a clearly defined set of objectives for the development of science and technology (S&T) and for innovation; (2) absence of the integration of S&T in the country's development policy objectives; (3) lack of networks of S&T institutions (such as universities, research institutes, standards institutions); (4) isolation of the preceding from the productive sectors of the economy; (5) insufficient horizontal coordination between the main areas of public policy – fiscal and monetary, foreign investment, intellectual property, competition, trade, agricultural and industrial development, environment, health, etc. – that may be interrelated with investment in S&T development; (6) insufficient vertical coordination between S&T policies at the national, regional and community levels; and (7) failure of government decision makers to consult with or secure the participation of all main actors – such as government agencies, business, academia, science and technology institutions, consumers, labour and civic groups – in the formulation and implementation of S&T and innovation policies.

42. A number of African countries formulated their S&T policies in the 1970s and 1980s, but these not been reviewed since. Many of these policies focused on organizational aspects rather than programmatic issues. In these countries, public expenditure on research and development (R&D) has been low and declining; links between industry, science and technology institutions are weak; results of public R&D are not applied by local industries, especially small- and medium-sized enterprises. Further, R&D activities are often not related to national development goals and strategies.[§§§] Responsibility for relevant policies is spread over a large number of ministries and institutions which are not necessarily coordinating their activities. Governments should review, as a matter of urgency, these policies to ensure they are aligned with the development priorities.

III.8. Undertaking technology foresighting

43. Most industrialized countries set priorities in science and technology through foresight programmes. These programmes involve stakeholders from industry, academia, research institutes, services, financial institutions and the government to determine the technological course countries will take and establish their priority needs. A number of developing countries, including India, the Republic of Korea, Thailand and several Latin American countries, are conducting forecasting exercises. These exercises create strong awareness among all stakeholders of the country's technological needs, emerging global

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[‡‡] E/CN.16/1999/Misc.4. Framework for a Common Vision for the Future Contribution of Science and Technology for Development: Elements of Change and Possible Responses.

[§§§] African Union /NEPAD (2005). "Africa's Science and Technology Consolidated Plan of Action", Mimeo.

trends and the implications for national competitiveness and priorities. They are critical in the formulation of relevant policies that promote technological innovation and application, strategies for funding and implementation as well as the planning and decision-making in different sectors of the economy.

44. Technology foresight also allows countries to anticipate where the technological frontiers might be and develop policies to take advantage of emerging technologies. Information and communication technologies (ICTs), biotechnology, nanotechnology and new materials are platform technologies of vital importance in technological innovation and their combined impacts are likely to have significant implications for long-term economic transformation in years to come. They therefore deserve special policy attention.

III.9. Stimulating international research cooperation

45. At its seventh and eighth sessions in 2004 and 2005, respectively, the CSTD emphasized the crucial importance of North-South and South-South research networks as hubs for training and exchange of experiences. These research networks provide an important opportunity for developing countries to pool limited resources to address problems that are unique to these countries. International organizations have a role to play in facilitating South-South cooperation to generate research relevant to industrial and technological development, and the exchange of knowledge and best practice. A welcome recent development to facilitate the South-South exchange of scientists and researchers is an UNCTAD project which seeks to establish a network of centres of excellence.

46. Access to scientific knowledge is crucial. The Internet has made it possible to share scientific knowledge that is relevant to local development needs more widely than ever before. Through access to digital libraries and databases, university curricula worldwide and other electronic resources, scientists and engineers in developing countries could take advantage of such knowledge to develop local programmes and projects. However, many of the databases and e-journals are proprietary and the most recent research findings in academic journals are often only available to subscribers.

47. A movement towards global science has emerged in recent years. The number of internationally co-authored articles in scientific journals doubled between 1990 and 2000. There has also been a rise in the numbers of open and collaborative projects to create public goods. These projects, often referred to as open access regimes, include free and open source software, the human genome project, the World Wide Web, the single nucleotide polymorphisms (SNPs) consortium and open academic and scientific journals. These projects are extremely important as they enhance the capacity of countries to achieve the MDGs. The CSTD, in collaboration with other partners, could explore the possibility of reviewing experiences in open access regimes, especially with regard to open journals.

IV. THE DIGITAL DIVIDE[****]

48. Within the technology gap, special attention should be devoted to the digital divide. The digital divide can be defined as a growing asymmetry in the capacity of firms, institutions and individuals in different countries to use ICTs effectively in accessing and applying knowledge, and thus, spurring competitiveness and innovation. The digital divide

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[****] This section draws on UNCTAD (2003, 2005). *Digital Divide: ICT Development Indices*. (Geneva: UNCTAD).

between the information-rich and the information-poor remains significant – at twice the average levels of income inequality and thus, is of increasing concern.

49. ICTs offer unique opportunities for developing countries to narrow the development gap with industrialized countries. They have the potential to assist developing countries leapfrog entire stages of development. Despite the potential benefits, developing countries face significant obstacles to ICT connectivity and access. The underlying causes of low levels of ICT penetration in developing countries include lack of awareness of what these technologies can offer; insufficient telecommunications infrastructure and Internet connectivity; expensive ICT access; absence of adequate legal and regulatory frameworks; shortage of requisite human capacity; failure to develop local language content; and the absence of a entrepreneurship and business culture open to change, transparency and social equality.

50. These problems are reflected in highly uneven growth in the use of ICTs across countries.[††††] The size and scale of the potential benefits that are missed as a result of not participating in the new digital society are likely to be much greater than ever before. A major challenge for policymakers at the national and international level therefore lies in addressing the digital divide between rich and poor countries, rural and urban areas, men and women, skilled and unskilled citizens, and large and small enterprises.

51. The digital divide between countries has typically been analysed using hardware counts and various measures of connectivity, such as Internet hosts, personal computers, telephones and mobile phones. However, it is important to note that it may not be the amount of hardware that is most significant to the digital divide, but ultimately the use that is made of this hardware and overall changes in the economy.

IV.1. Extent of the Digital Divide

52. A person living in a high-income country is over 22 times more likely to be an Internet user than someone in a low-income country. Secure Internet servers, a rough indicator of electronic commerce, are over 100 times more common in high-income countries than in low-income countries. In spite of their rapid growth in developing nations, mobile phones are 29 times more prevalent in high-income countries, and mainline penetration is over 21 times that of low-income countries. It is somewhat encouraging that the divide between high and lower-middle income countries is notably smaller; however, it is still very large and 2.3 billion people live in low-income countries.

53. The cost of a 20-hour Internet service is roughly twice that of a high-income country – over 2.5 times the average monthly income. In a high-income country, Internet affordability relative to income is over 150 times better than in a low-income country. Even in lower-middle-income countries, the cost of 20 hours of inferior Internet service is nearly one third of the average monthly income. It is only in the high-income countries that the cost of Internet service is low enough to be affordable for most households and small businesses, and, even in these countries, internal digital divides exist between urban and rural areas, genders, age and racial groups.

54. Additionally, Internet service in a low-income country is far inferior to that in a high-income country. Broadband connectivity is rare and poor infrastructure often results in

[††††] UNCTAD (2005a). *Information Economy Report 2005: E-Commerce and Development* (Geneva: UNCTAD).

sub-standard dial-up speeds and low reliability. Backbone networks are congested, as are international links. As a result, the applications that are available on these networks are limited and more difficult to use. An Internet user on a slow, unreliable dial-up connection in a low-income country may be limited to character-oriented applications. Even simple Web browsing may not be possible. The Internet experience is therefore qualitatively different than in a developed nation.

55. The numbers of telephone mainlines, mobile telephony, personal computers and Internet usage suggest that there may be a reduction in the digital divide measured by inequality in these distributions. However, marked disparities in ICT access and usage between countries continue to exist and remain sizeable. For example, in a low-income country, Internet use is more likely to take place in a shared facility and be less reliable and slower. The personal computer being used is likely to be an older model, less powerful and more likely to be shared at work or school. Similarly, telephone mainlines in high-income countries are generally more reliable and typically installed without delay. Although mobile phones are diffusing rapidly, fast, data-capable third generation mobile networks are less common in low-income nations.

IV.2. Bridging the Digital Divide

56. Coordinated policy initiatives are needed across different areas to build local capabilities to master and adapt and apply ICTs efficiently. This would require efforts to develop a range of local capabilities in infrastructure, skills, research and the diffusion and development of business services. At the national level, a central body is needed to coordinate and oversee all policy issues, to ensure policy coherence across different policy domains and that efforts in some fields are not held up by bottlenecks in other areas. Several countries have established high-level task forces charged with monitoring and overseeing the implementation of policies for ICTs, such as the ICT taskforce in Australia, and the National Information Technology Council in Malaysia. These Task Forces are often formed on the basis of public-private partnerships to ensure that policymaking can respond more rapidly to the needs and concerns of firms. These central bodies focus attention on ICTs, analyse trends in ICT development, identify gaps and/or priorities for action and make recommendations for urgent action to boost and maintain countries' performance in ICTs and their international competitiveness.

57. There is an indication that demand-oriented policies which can raise awareness of ICTs are especially relevant in developing countries. All too often, the importance of ICT policies and the market supply-side is considered to the neglect of underlying demand. Public access and 'computer for every home' initiatives are vital in raising awareness and encouraging the take-up of ICTs. The experience of Mali in adapting and using ICTs in a range of fields including education, telemedicine and the promotion of tourism and arts and crafts shows the importance of local content in ICT development through a multi-stakeholder approach (Box 3).

Box 3. The importance of relevant content: the case of Mali

Mali is a landlocked country in West Africa with 11.6 million inhabitants and an average per capita income of US$300 in 2003. The country has 8 regions and 11,234 villages, many of which are located in rural areas. From relatively low penetration rates in telecommunications, ICTs are now being used for several different and innovative purposes. For example, they help meet the strong demand for higher education. ICTs and an Intranet were introduced at the University of Mali in 2003, although difficulties remain because of the lack of equipment and connections, inadequate documentary resources and insufficient teaching staff.

ICTs are also used in telemedicine to overcome some of the challenges in a country where around 35 per cent of the population does not have access to basic healthcare. The Keneya Blown medical network was set up in 2001 by a group of researchers at the University of Mali to cover five hospitals. A pilot centre for research and training has been established in conjunction with partner universities and other institutions linked for real-time access to the electronic resources of libraries, laboratories and online journals. Monthly tele-teaching lessons were broadcast from Geneva and Bamako in August 2002, and followed in Sekou, Timbuktu, Nouakchott and N'Djamena and organized by different organizations in France and Geneva.

Mali has a strong tradition in artisan crafts, which employ 5.4 per cent of the workforce, the majority of whom live below the poverty line. These crafts are still oriented towards local markets. The Ministry of Tourism and Artisan Crafts and the National Centre for the Promotion of Artisan Crafts have been working on the promotion of tourism and publicity and sale of artisan arts and crafts over the Internet.

Mali has embarked on a telecentre programme that includes community telecentres (Télécentres Communautaires Polyvalents) in rural regions, as well as Community Multimedia Centres (CMCs) at the community level. These are used as a tool for development in relaying weather and hydrological information, financial news (local market and foreign market news) and other information over the Internet, and other audio and visual media, to reach overwhelmingly illiterate rural populations. The Government is now focusing its efforts on awareness and training efforts to build human capital and reach wider audiences through its community centres.

Mali has been able to take advantage of membership of the larger online Francophone community with initiatives such as "Le Campus Numérique Francophone", which has provided ICT training to over 2,400 graduates). The African Virtual University (Université Virtuelle Africaine) gives short-term training in partnership with American and Canadian universities. Special efforts are being made to reach poorer and rural communities. 'Internet à l'école' projects are offered in some of the countries' regions, e.g. Timbuktu, through a joint initiative between Swisscom, ITU and the Malian Government.

Source: UNCTAD (2005). *Digital Divide: ICT Development Indices*. (Geneva: UNCTAD).

V. FINDINGS AND RECOMMENDATIONS

A. Main findings

- The technology gap between and within nations is wide and substantial. It exists in all dimensions – from accessing knowledge, to its effective creation and use. Thus, the technology gap severely limits the efforts of developing countries in meeting the MDGs.
- The current North-South gap in the generation and application of new and emerging technologies and their contribution to economic and social development constitutes a "technological divide" that must be bridged if developing countries are to participate effectively in a globally inclusive knowledge society.
- Most developing countries are unlikely to narrow the technology gap without making S&T top priorities in their development agenda.
- In many least developed countries, there is still a severe lack of appreciation of the critical role of S&T in development.
- For developing countries to narrow the technology gap, they need access to new and emerging technologies, which requires technology transfer, technical cooperation and building a scientific and technological capacity to participate in the development and adaptation of these technologies to local conditions.
- Academia/government/industry partnerships, as well as private sector participation, are essential in building scientific and technological capabilities and fostering market-oriented policies and developments. Technology and business incubators are effective mechanisms for promoting academia/government/industry partnerships and entrepreneurship.
- The process of technology creation, diffusion and use is not automatic. It requires carefully designed strategies and policies.
- Many developing countries do not innovate at the technological frontier. For them, accessing, acquiring, locally adapting, effectively using and improving upon existing technologies are the main challenges.
- Local adaptation, effective use and improvement upon existing technologies require more than technology transfer. It requires building a solid scientific base, domestic capacity-building and raising human capital.
- Raising human capital and skills through education and training is essential to building domestic capabilities. Special attention should be paid to young students, especially women, to enter the fields of science and technology. Efforts should also be made to reverse the impact of brain drain.
- Upgrading both physical and services infrastructure are important strategies for domestic capacity-building.

B. Recommendations

58. The CSTD panel has put forward the recommendations below for consideration by the Commission at its ninth session:

The CSTD may wish consider the following:

- *Promoting* networking and facilitating information flows and sharing of national experiences in building technological capabilities and narrowing the technology gap. To this end, the Commission encourages UNCTAD to continue compiling and disseminating good practice case studies from developing countries that have been successful in promoting linkages between governments, research institutes and the private sector, as well as technology foresight and prospecting through multi-stakeholder partnership;

- *Promoting* the establishment of national science and technology parks as a means of fostering technological innovation and development;

- *Providing* a forum for developing countries within the Science and Technology for Development Network (STDev)[‡‡‡] to share success stories and lessons learned in their respective national efforts to apply science and technology for development;

- *Encouraging* UNCTAD to continue providing its expertise and analytical skills for science, technology and innovation policy reviews (STIPs), with a view to assisting developing countries in identifying the appropriate measures that are needed to integrate science, technology and innovation policies in national development strategies in order to ensure that they serve as effective tools for achieving the MDGs; and

- *Encouraging* the relevant bodies of the United Nations System engaged in biotechnology to work cooperatively in the context of the UN-Biotech,[§§§§] and within an integrated framework on biotechnology, to help developing countries in building national productive capacity in biotechnology in such areas as industry, health and agriculture, as well as in risk assessment and management of biosafety. Such a framework should take advantage of existing programmes, such as the newly established UNCTAD network of centres of excellence, International Centre for Genetic Engineering and Biotechnology affiliate centres and UNIDO, UNEP, FAO and WHO programmes.

Governments may wish to consider the following:

- Undertaking needs assessment exercises to determine whether or not existing science, technology and innovation policies effectively serve the needs of national development goals, especially in the context of meeting the MDGs;

[‡‡‡] http://www.unctad.org/stdev.

[§§§§] UN-Biotech is a United Nations inter-agency cooperation network on biotechnology set up in March 2004 in response to General Assembly resolution A/RES/58/200. It has met twice at UNCTAD in conjunction with annual regular sessions of the Commission on Science and Technology for Development.

- *Involving* representatives from industry, academia and public sectors in carrying out comprehensive technology foresight exercises with a view to identifying technologies that are likely to help address pressing socio-economic needs and establish priorities in S&T policy and governmental programmes on research and education;

- *Strengthening* linkages between public research and private industry and tap into regional and international R&D networks;

- *Improving* national mechanisms for the promotion of knowledge-based and innovative enterprises through various interventions and incentives;

- *Setting up* centres of excellence, technology incubators and science parks to apply knowledge and to facilitate commercialization and diffusion of technology;

- *Adopting* special measures to retain and attract young and talented scientists and technologists, and establishing close ties with expatriate scientists and engineers; and

- *Encouraging* venture capital from both public and private sources to assist product development and commercialization of new and emerging technologies.

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