Technical Paper

ICT and Human Development: Towards Building a Composite Index for Asia

Realising the Millennium Development Goals

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Prologue

This quantitative study was undertaken as an exercise for the preparation of UNDP's Regional Human Development Report *" Promoting ICT for Human Development in Asia 2004: Realising the Millennium Development Goals*." It is a first attempt for Asian countries that empirically assesses linkages between ICT and human development using the Millennium Development Goals as benchmark. Data from nine countries — China, India, Indonesia, Malaysia, Mongolia, Pakistan, Sri Lanka and Vietnam—have been used in the exercise.

ICT indicators relevant for human development in the Asian context were first identified. The availability of comparable data of acceptable quality determined the final choice of indicators. The indicators were classified into five categories: two categories of availability-linked indicators — skill independent and skill-dependent, indicators of efficiency and speed, indicators of targeting social sectors and indicators of targeting vulnerable groups. Indicators from each of these categories were combined to formulate five component indices which were finally aggregated into a composite aggregate ICTforHD index. Two methods were used in the indexing process. The Range Equalisation method used in the calculation of HDI in the Human Development Reports was first employed in the index calculations. An alternate method based on Division by Mean was then used providing interesting comparisons. The value of the aggregate ICTforHD index for each country revealed the inter-country rankings. While the top and bottom countries remain unchanged across the two methods, some changes in the relative positions were observed for countries in between.

The study concludes that while availability or supply-side indicators of ICT are undoubtedly important from the human development perspective, more information needs to be gathered on access, types of applications, characteristics of users, content, etc. Thus the demand side needs to be brought in much more strongly to capture the spread of technology across social and economic classes, regions, sexes, etc. Data on ICT availability and use across rural-urban, male-female and other categories could help in quantifying digital divides.

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Abbreviations

ALA- Arab and Latin America

DM- Division by Mean

EDC- Educational Development Centre

FDI- Foreign Direct Investments

GCR- Global Competitiveness Report

GDP- Gross Domestic Product

HDI- Human Development Index

HDR- Human Development Report

ICT- Information Communication Technology

IDRC- International Development Research Centre

MDG- Millennium Development Goal

ODA- Overseas Development Assistance

OECD- Organisation for Economic Cooperation and Development

PPP- Purchasing Power Parity

RE- Range Equalisation

SIBIS- Statistical Indicators Benchmarking the Information Society

UN- United Nations

UNDP- United Nations Development Programme

UNIFEM- United Nations Development Fund for Women

WDR- World Development Report

WHO- World Health Organisation

WSIS- World Summit on Information Society

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ICT and Human Development: Towards Building a Composite Index for Asia

1 Introduction

Planners, policy makers and researchers hold highly polarised and equivocal views on the diffusion of Information and Communication Technology (ICT), its role in promoting objectives such as poverty alleviation, universal education, reduction in mortality and health hazards, and sustainable development, and in bridging the digital as well as socio-economic divides in the world. Many consider ICT to be the only possible means of achieving the above-mentioned goals within a reasonable time frame, through technological leapfrogging. An equally vociferous view, on the other hand, is that ICT is of no great value and could even be detrimental to the less-developed world, particularly for populations that are economically and socially underprivileged.

Notwithstanding the controversy, most policy statements, research reports and overview documents at both international and national levels, have regarded positive impact of ICT on socio-economic development to be self-evident.[1] These have applied standard measures like the share of ICT in income or investment and the number of consumer units relative to population, for cross-country comparisons. Such measures would hardly reveal whether or how the growth of ICTs or their diffusion in different countries lead to reduction in poverty or to other socio-economic goals.

Understandably, opinions of planners and researchers on choice of indicators vary widely, often depending on their own experience. Indeed, the impact of ICT in a country or a region depends on its nature, the purpose of its deployment and its spatial spread, besides the economic, administrative and social environment backing up the strategy of its diffusion. In this context, assembling empirical evidence on the impact of ICT on human development is of key importance. It would, therefore, be useful to begin by analysing the nature of interdependencies between the indicators of ICT development and those reflecting human development concerns for the achievement of the Millennium Development Goals (MDGs), that were adopted by 191 countries at the historic UN Millennium Summit in September 2000.[2] This should be done separately for the developed and less-developed countries. In the present report, an attempt is made to map the pace and pattern of development of ICT in less-developed countries, based on in-depth empirical studies conducted in recent years, focusing on the Asian region. A critical review of the UNDP-sponsored country studies on the promotion of ICT towards achieving the MDGs is extremely useful in this regard, as these studies specifically look into the growth of ICT in the context of attainment of the MDGs. This will help in the identification of indicators that reflect the levels of development of ICT in terms of the capacity of the countries to promote economic and social well-being of the people. This, however, is a far more complicated and challenging task than measurement of the level of ICT development.

The present study aims at examining the development of ICT-linked services in harnessing critical concerns of human development and contributing towards the achievement of the

[1] The World Bank in its World Development Report for the year 1998, entitled 'Knowledge for Development', stresses the increasing role of ICT in social and economic development.

[2] Emanating from the Millennium Declaration Summit held in September 2000, the Millennium Development Goals constitute a global set of human development objectives ranging from eradication of poverty and hunger to developing global partnership, to be achieved by 2015. Eight specific goals have been set, clearly structured into 18 specific targets which are to be monitored through 48 specific indicators. The base year for these goals is 1990.

MDGs. The study focuses on nine countries in Asia: China, India, Indonesia, Malaysia, Mongolia, Pakistan, Sri Lanka, Thailand and Viet Nam. The broad objectives of the study are as follows:

i. Examining the interdependency between ICT and human development;
ii. Identifying ICT indicators reflecting human development concerns in achieving the eight MDGs;
iii. Construction of composite indices for capturing the ICT-linked progress in above-mentioned nine countries, in the context of attainment of the MDGs.

At the outset, the present paper provides an overview of the controversy concerning the measurement of development of ICT across countries and identification of major components and objectives of the analysis. The second section examines the pattern of interrelationship between the ICT indicators and those of human development and MDGs. This has been done at two points of time and for the changes registered in between. The empirical analyses and country studies conducted in less-developed countries, pertaining to the role of the ICT sector in national or regional development, are the subject of the third section, with special emphasis on the experiences of Asian countries. The fourth section makes an attempt to develop a framework for identification of appropriate indicators and their composition, on the basis of initiatives launched by various UN and intergovernmental organisations. Further, it presents a list of indicators and provides the rationale for their inclusion in the present study covering nine Asian countries. The next section presents the methodology for composition and gives the ranking of the countries, using the data for the latest year. The last section summarises the conclusions and provides a perspective for future exercises in assessing the development of the ICT sector in Asia.

2 Pattern of interdependence between development of ICT and attainment of the MDGs: A cross-country analysis

In the present study, the impact of the development of ICT on human development for achieving the MDGs has been examined by constructing correlation matrices[3] between the indicators of ICT and those of the MDGs across 175 countries at two points of time, viz., years 1991 and 2001. A set of indicators (See Appendix I) pertaining to the eight MDGs are taken from the Human Development Report (HDR) for the year 2003 (UNDP 2003). A few additional indicators such as level and growth of Gross Domestic Product (GDP) per capita, flow of Foreign Direct Investments (FDIs), flow of Overseas Development Assistance (ODA), number of radios and televisions in use have been compiled from World Development Reports (WDRs) for the years 1990 and 2000. All the indicators could not be obtained for these two specific years and a few pertain to either the previous or subsequent year. The reference years, 1991 and 2001, may be seen as the mid years around which information has been organised. Further, the number of indicators for the early 1990s is less than that for 2001 because of non-availability of data. The indicators of ICT are the number of (a) telephone mainlines, (b) cellular subscribers, (c) televisions in use, (d) radios in use, (e) personal computers, (f) internet users and (g) internet hosts, all represented relative to the population of the country. (See Appendix I for complete list of indicators).

In view of the wide disparity in terms of levels of economic growth as well as progress towards MDGs, besides other factors, the countries of the world have been grouped into four regions.[4] These are (a) Europe and the Organisation for Economic Cooperation and Development (OECD), (henceforth referred to as Europe), (b) Arab and Latin America (henceforth referred to as ALA), (c) Sub-Saharan Africa (henceforth referred to as Africa) and (d) the Asia-Pacific region (henceforth referred to as Asia). This grouping has been obtained by combining the categories reported in HDR 2003, for the purpose of the present study. Most of the countries in the Europe group (52 in all) have high levels of income as well as human development.[5] The other three regions (comprising 51, 44 and 28 countries in ALA, Africa and Asia, respectively) are differentiated, in terms of both level and pat-

[3] The correlation matrices are available at the UNDP website:http://hdrc.undp.org.in/initiatives/apri/ict.html

[4] It may be mentioned that this categorisation is in line with the UNDP scheme of grouping the less-developed countries and, further, identifying two specific categories (c & d) with regard to their progress towards attainment of MDGs (UNDP 2003, pp 1-13). It also suggests that the impact of ICT differs across different regions.

[5] The OECD countries with low or middle per capita income, i.e., Korea, Turkey and Mexico, have not been included in this category, following the UNDP classification in HDR for the year 2003.

tern of economic and human development. The analysis in this study is focused on Asia, in order to assess whether the pattern of interdependencies here is different from that noticed in the other regions or in the world as a whole.

In addition to the two-point analysis (1991 and 2001), a study of changes in ICT indicators during the intervening period and their relation to changes in MDG indicators has also been attempted to understand the dynamics of interrelationships exhibited in the process of development. This would be necessary, as ICT is a recent phenomenon and one has to examine the impact on the process of development, of its growth rather than of the levels it has reached. Correlation coefficients[6] between indicators, at the two points of time studied, as well as those reflecting change during the study period, therefore, provide interesting insights into the pattern of interdependency between ICT and development, in terms of attaining the MDGs, across the countries of the world.

2.1. Relationships between ICT and MDG-linked indicators: 175 countries of the world

2.1.1. Interrelationships in the early 1990s

For the year 1991, the indicators of ICT show positive and strong relationship with per capita income and Human Development Index (HDI). Most of the indicators pertaining to the attainment of different MDGs too have significant and desired patterns of interdependency with ICT indicators. For example, the correlations between ICT indicators and the indicators related to universal primary education, such as net primary school enrollment ratio, children reaching grade 5 and youth literacy rate, are all positive and statistically significant. The same is the case with the indicators reflecting empowerment of women. There also appears to be significant reduction in child mortality and improvement in maternal health with the development of ICT, across the countries of the world. This is evident from the strong negative correlation between television users, telephone and cellular mobile subscribers, etc. and rates of infant mortality, child mortality and maternal mortality. Further, percentages of people with sustainable access to water sources and urbanites having improved sanitation facilities show strong positive correlation with all the ICT indicators, the coefficients being statistically significant.

2.1.2. Interrelationships in the early years of the 21st century

The pattern of relationship between ICT indicators and indicators pertaining to income and HDI values has strengthened during the early years of 21st century, as may be inferred from the correlations in 2001. Of particular note is the impressive increase in the value of correlation coefficients between the use of personal computers and per capita income and HDI. The same is the case with respect to MDG indicators. The relationship of ICT indicators with the percentage of the non-poor is positive and improved over the years. It may not be possible to suggest a unidirectional causality and argue that eradication of poverty has been possible due to the development of ICT, since the impact could be the other way round. Indeed, developed countries that have low levels of poverty would have better access to ICT. ICT seems to have played a significant role in improving health standards across countries over time. Almost all the MDG indicators pertaining to health standards, including life expectancy at birth, exhibit stronger correlations with ICT in 2001, as compared to 1991. Even prevalence of HIV cases and other diseases shows a stronger negative correlation with the development and diffusion of ICT. The only two indicators that report weaker correlations in 2001 than in 1991 are access to improved sanitation and water in urban areas. This implies that ICT has not been used as a tool in improving urban facilities. The role of ICT in attracting foreign direct investment and overseas development assistance appears to be inconsequential as the correlation in the case of the former has become weaker, while that of the latter has turned negative. Understandably, mere increase in ICT is unlikely to improve the foreign investment situation as other socio-political factors play an important role here.

2.1.3. Changes in indicators during the 1990s and their interrelations

For the purpose of understanding the dynamics of the relationship of ICT indicators with MDGs and human development indicators, a correlation matrix has been constructed, based on the differences between the values of the indicators in years 2001 and 1991. It has been observed

[6] The correlations discussed in the text are those that are significant at 5 percent level.

that the progress in ICT contributes to the enhancement of human development across the countries of the world, as the correlation between them turns out to be highly significant. Interestingly, such correlation does not exist between the growth of ICT and income growth, which could be due to the fact that breakthrough in ICT is a recent phenomenon and has not yet made an impact on the economic growth in all the countries of the world. Especially in the case of the developing countries, there is a time lag between the adoption of ICT and registering the growth in income. Further, progress in ICT does not seem to make a significant impact in the progress towards achievement of universal primary education or reducing infant/child mortality.

2.2. Interrelationships between ICT and MDG-linked indicators across the four regions of the world

2.2.1. Interrelationships in the early 1990s

The analysis of interdependencies across countries belonging to the four categories (Europe, ALA, Asia and Africa) brings out certain striking features. In Europe, ICT made an impact on the process of economic development even in the early 1990s. This is evident from the highly positive correlation between the indicators of ICT and the indicators of per capita income and HDI. In the case of less-developed countries belonging to the ALA, Asia and Africa regions, ICT is mostly restricted to the use of radios, televisions and telephones. The diffusion of new forms of ICT took off since the mid-1990s only. Notwithstanding the time lag factor, the pattern of relationship of ICT indicators with those of per capita income and HDI work out to be similar to those noted in Europe. The coefficients obtained for the Asian region seem to be stronger than those obtained for the other categories. The strong pattern observed here implies that many low-income countries within Asia have not got very far in developing ICT; on the other hand, ICT initiatives are well taken by the high income countries. One may also note the presence of various socio-cultural factors inhibiting technology diffusion across countries in Asia.

The relationships between indicators of ICT and those of education-linked MDGs reveal contrasting patterns across the four categories of countries. Primary school enrollment ratio shows significant positive correlation with the development of ICT in Europe and Africa, but not in ALA and Asia. Further, there exists a strong correlation between indicators of ICT and children reaching grade 5 in the African countries, which is not there in any other region. Furthermore, there seems to be no interrelationship between ICT and youth literacy, as the correlation coefficients turn out statistically insignificant across all the regions. Given this pattern, one would infer that the impact of ICT in achieving universal literacy is not very significant.

Indicators pertaining to gender equality articulated through the enrollment ratio of girls to boys in primary schools and female to male ratio among literates have weak correlations with indicators of ICT in European countries during the early 1990s as there is no gender-based discrimination in accessing the technology. But in Africa, the relationship appears to be strong. On the other hand, the coefficients are weak in the case of Asia, possibly because of low levels of ICT in many of these countries.

An inverse relationship between ICT and child/maternal mortality rate is observed in all the four categories of countries in the early 1990s. Indeed, infant mortality rate shows strong and negative correlation with ICT in Asia as well as ALA and Africa. One would infer that the development of ICT provides better access to health facilities. In contrast, the indicators of environmental sustainability, such as access to improved water sources and sanitation facilities, particularly in urban areas, do not exhibit correlation with ICT in all four regions.

2.2.2. Interrelationships in the early years of 21st century

The relationships of ICT indicators with those of the MDGs have not, unfortunately, improved significantly across the regions in 2001, except in the case of per capita income and HDI. In the case of indicators linked with eradication of poverty and hunger, such as percentage of undernourished people and of underweight children aged below 5, the correlations turn out to be high and statistically significant only for ALA and Africa. In Asia, the interdependencies are insignificant. One would, therefore, infer that deployment of ICT in improving agriculture and food distribution systems and thereby impacting poverty and malnutrition, is not significant in Asia in 2001.

The relationship between development of ICT and education also has not improved significantly in 2001 in any of the four regions. In Asian countries, the relationships were weak in 1991 and have remained so even after a decade. It is only in the case of the youth literacy rate that the relationship with ICT has improved and become significant. One would, therefore, argue that the progress of ICT may not have had a significant impact on the level of primary education across Asian countries.

Regarding the environmental sustainability indicators in terms of per capita emissions of carbon dioxide and CFC consumption, the trend unfortunately is of secular increase and shows strong positive relationship with economic development in all the four regions. Growth of ICT does not seem to help reduce air pollution. However, it has impacted positively on availability of drinking water and sanitation facilities in Europe, and to some extent in ALA as well as Africa. This unfortunately is not the case in Asia. Further, the correlations between indicators of ICT and flow of FDI are weak and have gone down over the years in Asia. The correlation of the flow of ODA (as percent of GNP) has remained negative and statistically insignificant in 2001, which confirms the marginal role played by ICT in development of a global partnership in this region.

2.2.3. Changes in indicators during the 1990s and their interrelations

The 'change indicators' built by taking the difference in the values of ICT and MDG indicators and HDI reveal an interesting pattern of interdependency. Highly significant correlations are observed between HDI and ICT indicators in all the regions, excepting Asia. Apart from indicators of ICT pertaining to use of television and telephones, no indicator is significantly correlated with HDI in Asia. The growth in per capita income shows strong correlation with growth of ICT only in Europe. These correlations are insignificant for ALA, Asia and Africa. Further, progress in ICT bears no relationship with changes in primary enrollment rate, gender disparity in education or representation in parliament. This is observed in Asia as well as ALA and Africa. However, it is encouraging that correlations between progress in ICT and improvement in life expectancy rate and maternal mortality rate are significant in Europe, ALA and Africa. Further, the indicators of child mortality, maternal mortality, incidence of malaria and other diseases exhibit strong negative relations with ICT indicators and this, in general, has strengthened over time. Unfortunately, this is not the case in Asia, as the relevant correlations are statistically insignificant and have not improved over the decade. Here, infant mortality rate and urban households with no access to drinking water and sanitation, exhibit no decline with progress in ICT. The incidence of HIV/AIDS, too, does not seem to decrease with the development of ICT, contrary to the pattern observed in other regions. One would, therefore, infer that growth of ICT in Asia has not been a critical factor in achieving the MDGs.

Correlations with indicators pertaining to gender equality follow a similar pattern. Improvements in interdependencies during the 1990s are noted as marginal and statistically insignificant.[7] Interestingly, in this context, the situation does not seem to be very distressing in Asian countries. Not only have female to male ratios gone up in enrollment rates at various levels of education and among literates, but even their correlations with ICT increased during the 1990s. This should be hailed as a positive development in gender relations, the credit for which may be partially attributed to ICT. The impact, however, remains at that level and does not go beyond. The share of females in non-agricultural wage employment has remained low and its correlation with ICT has weakened over the decade. Furthermore, no positive correlation exists between ICT and the share of seats held by women in the parliament.

3 Impact of ICT on socio-economic development as observed in developing countries

The literature on the role of ICT in promoting socio-economic development is rich in terms of empirical rigour and diversity of opinions, despite having a short history. Most of the studies [Brynjolfsson and Hitt 1996; Lehr and Lichtenberg 1999; Oliner and Sichel 2000; Jalava and Pohjola 2002; and Dewan and Kraemer (in press)]pertain to developed coun-

[7] The reasons for low correlation coefficients obtained in European countries can be attributed to the randomness of the distribution of indicators across the countries, as most of the countries have higher female to male participation in schooling.

tries[8] and suggested the positive impact of ICT on income and employment growth. However, it has been noted that this relationship is absent in several OECD countries. Also, in developing countries where non-ICT investments tend to have a higher payoff than ICT investments, a positive relationship is either weak or absent. In view of this, scholars have argued that growth of ICT should not become a 'techno-quick-fix' for solving development problems. It has unacceptable tradeoffs with MDGs in less-developed countries (Wilde 2003). These scholars believe that we are only beginning to understand how the application of ICT relates to the achievement of social goals and economic growth and there are serious doubts whether the benefits truly outweigh the costs (Kenny 2003, Wilde 2003).

The most powerful argument made against ICT is that it has resulted in sharp differentiation not only among countries but across groups of populations, and such differentiation is likely to be further accentuated. Existing inequalities, particularly in less-developed countries, in terms of access of households to natural and capital resources, have intensified with the launching of the programme of liberalisation. The legal and administrative structures that are considered important for providing equitable access to all sections of the population are yet to be institutionalised (de Soto 2000). Given these factors, it is understandable that introduction of a new technology strengthens the position of economic and political elites *vis-a-vis* others. They have larger resources at their command to own or access the technology, can acquire the necessary skills easily due to their higher levels of education and can establish links with other production and social sectors through ICT, for appropriating new facilities and opportunities. ICT has a requirement of specific skill and that comes in the way of its adoption by underprivileged groups/regions, even with general improvement of literacy in a country.

This proposition finds empirical substantiation in a study sponsored by the European Commission under its 'Information Society Program' (SIBIS Report 2001).[9] It identifies the absence of appropriate skills as a critical factor, constraining the access to ICT and resulting in a digital divide. What is more disturbing is that the divide has sharpened over the 1990s. Income emerges as yet another important factor responsible for the divide. It is only with regard to gender that the gap seems to be declining over the years. Although similar data have not been generated for Asian countries, impact of education and income disparity on access to information technology is likely to be equally, if not more, serious.

Scholars have also demonstrated empirically that diffusion of ICT in developing countries do not benefit the social sector in the same way as in industrial countries. This is because of the existence of barriers to knowledge and information asymmetry in the former. The absence of skilled human capital, lack of funds for modernisation, etc. in the social sectors becomes an impediment to the adoption of ICT and the dissemination of benefits throughout the country. These factors pose a serious question mark on the role of ICT in achieving the MDGs.

Those scholars who disagree with the above propositions have argued that harnessing the power of ICT and ushering in the 'digital revolution' can transform production processes, commerce, government and education and create new forms of economic growth that will benefit all sections of the population. Furthermore, ICT can contribute to the realisation of social goals through greater dissemination of health and reproductive information, training of medical personnel and teachers, equitable access to education and training facilities, opening up of opportunities for women and expanding scope for citizen participation. Taking a sample of 37 developing countries, Baliamoune (2002) established that ICT has a strong positive effect on the process of socio-economic development, provided a liberal political environment is maintained.

The proposition that specific skills and human capital are prerequisites for dissemination of ICT has been refuted, citing the case of Arab States which, despite low literacy, have registered high growth in ICT. Here, uneducated persons as well as the poor have been able to

[8] The first few rigorously empirical studies on this subject are those undertaken in the United States using firm level data on ICT investment and economic performance.

[9] The study has generated valuable information on digital literacy and use of ICT for various social and economic purposes for different OECD countries, using survey data.

access the technology as costs are relatively lower than those for accessing quality knowledge and formal information. Understandably, ICT has led to reduction in information asymmetry between the rich and the poor and between the educated and the uneducated. Indeed, people located in a given geographical area can access the technology (available as public facilities or in commercial joints) and benefit through spillover effects, irrespective of their socio-economic status.[10] There is no reason why ICT in Asian countries cannot reduce the existing barriers to knowledge and bring down the inequality in accessing the information base, which currently is extremely high as it is linked to income inequality.

For assessing the progress of Asian countries towards different MDGs, the country studies sponsored by UNDP are particularly useful. Nonetheless, quantitative assessment of the multiplier effect of ICT diffusion on poverty, illiteracy, ailment, gender divide, environmental degradation, etc. is extremely difficult and has not been attempted in any study. The difficulty lies in the multifarious and informal nature of linkages of ICT with the rest of the economy on which no data can be obtained from official sources.

The most important goal is poverty reduction, the impact of ICT in this context has generally been taken as positive because of its capacity to generate employment at a reasonable level of productivity and its growing share in incremental GDP. Although the volume of employment in the sector is not very high in most Asian countries, its growth rate over the past decade holds forth a promise. Despite occasional slumps in the market and pessimistic projections of growth within the formal sector, the expectation is that ICT will reduce poverty by creating numerous informal jobs. It is the semi-skilled and unskilled workers in the assembly lines (producing computers and linked gadgets), data processors, and operators in call centres, not the engineers and software programmers despite a likely increase in their number, who hold the key to poverty alleviation.

Despite the difficulties of capturing the direct and indirect impact of ICT, there is no doubt that it has given a boost to income and employment growth at macro level by improving productivity and competitiveness in non-ICT sectors as well. The resultant reduction in cost of production in the latter has resulted in higher demand for the products and services in the domestic as well as international markets, giving an impetus to growth and leading to substantial poverty reduction. Indeed, the jobs created directly in the ICT sector are of less significance (since computers to some extent are replacing labour) as compared to the multiplier effect created by it, through up-scaling activity levels in user sector pushing up the earnings of workers. Taking all the direct and indirect impacts into consideration, it can be assumed that ICT has a positive effect on poverty reduction in Asian countries.

ICT is expected to contribute towards the objective of poverty alleviation through appropriate designing, management and implementation of anti-poverty programmes. Irrespective of the composition, there is little doubt that growth and spread of ICT sector has increased the level of awareness about rights and responsibilities and also enhanced 'information' availability among the masses. As a consequence, the level of ICT can be taken as an indicator of progress towards poverty alleviation.

In the context of universal primary education, a few studies reveal that introduction of computers may not help improve the school system or reduce illiteracy in a country (Schware and Jaramillo 1998).[11] The country study for India shows that introduction of computers in schools has resulted in misallocation of resources and neglect of infrastructural facilities which should be a higher priority. Notwithstanding the specific examples, the total impact of ICT in eradicating illiteracy is significantly positive, as has been argued in the case of poverty alleviation. This is particularly so when its impact on non-formal education, like creating the awareness among people about society, government, market, etc., is taken into consideration.[12] Asian countries with low levels

[10] Households having no address in a city, for example, can have an e-mail address and access information or receive letters.
[11] They have shown this to be the case in Turkey.
[12] It is possible to argue that the process of awareness building can be used for political purposes. An overview of recent experience in Asian countries, however, reveals that the state has found it more convenient to deny access to information to people than provide them with wrong information. Once the channels of communication are opened, ensuring selectivity in information has generally been beyond the control of the public machinery.

of literacy and awareness of rights and responsibilities have certainly benefited through increasing use of radio, television, internet, etc., which have helped in awareness building and strengthening the formal education system. Of course, the impact would be higher if certain kinds of ICT application or their use by certain target groups in the population are encouraged, but it is hard to get reliable information on this subject.

Regarding the MDGs pertaining to the improvement in health situation, identification of indicators is extremely difficult because there are many factors other than communication technology that are relevant. Although temporal data on child mortality, maternal health and diagnosis and treatment of HIV/AIDS, malaria and other major diseases are available, it is difficult to apportion a part of the improvement observed during a certain period, to ICT. In combating HIV/AIDS and eradicating malaria and other diseases, however, most of the countries in Asia are in what may be termed as the first stage application of ICT. What is important at this stage is dissemination of information about the seriousness of the problem, causes, preventive measures and facilities for treatment. This is valid in the context of the programmes for reduction in child mortality or improving maternal health. With levels of literacy being very low in the region, ICT has a major role to play in the dissemination of information. While creating awareness in rural areas and distant towns should be a priority, the growth of media and communication systems at the national level is desirable, as awareness level is low even in large urban centers.

The role of ICT in promoting gender equality is perceived as positive through deductive reasoning as empirical data on this are not available at the national level (UNDP 2003a). Given the fact that women in Asia continue to be linked to family and household activities and face numerous social and cultural constraints restricting their mobility, their access to public places is limited as compared to men. Not only are cultural barriers far more binding on women in accessing health and education facilities, even geographical distance is relatively more restrictive. The ability to access a facility without being physically present at a fixed location would, therefore, be a big advantage for them. The studies reveal that the technology has indeed enabled women to access education and medical facilities much more effectively than before. Further, they are able to take up contract job work out of factory or office premises, sitting at their homes through this technology.

It may be argued that adopting ICT would be useful in monitoring the natural resources and handling of the stress and strain generated through the development process. The new technology is of help in adopting modern methods of environmental sanitation, and pollution control, etc. Unfortunately, data on these indicators are not available for Asian countries.

A strong relationship has been noted between ICT investment and the degree of openness to the world market. Scholars have argued that countries having an open-trade policy benefit more from development of ICT than those with a closed-door policy. Higher levels of ICT lead to greater international linkage and higher trade. However, there is not enough empirical evidence to confirm or to indicate how the ICT investment will help the less-developed countries achieve the MDG related to global partnership. Consequently, this aspect has not been brought within the framework for identification of the indicators.

This overview of the earlier studies suggests that determination of the impact of ICT in terms of MDGs is extremely difficult. The direction of relationship stipulated in these studies is often based on deductive reasoning, observance of such a pattern in some developed countries, or the stated objectives or claims made by certain ICT projects.

The other point emerging from the overview is that spatial inequality is a constraint in achieving social goals in Asian countries, as ICT is concentrated in a few large cities and regions. Lack of skills and affordability is another obstacle on the way of people in small towns and rural areas, restricting the generation of demand for knowledge-based products and benefiting from ICT. This assessment prompts us to consider alternate sets of indicators. For example, location-specific indicators like 'ICT facilities in rural areas and small towns' may be included for capturing its spatial spread. Similarly, choosing user-specific indicators like 'adoption of ICT in social sectors or ICT for defined purposes' would reflect greater success in moving towards the MDGs. Bringing in the nature and purpose of ICT would, thus, be important in the context of the MDGs.

4 Anchoring ICT in Millennium Development Goals

4.1. Overview of recent initiatives and limitations of existing data sources

The emerging need to assess the progress of ICT in achieving a set of socio-economic goals for the purpose of policy formulation has prompted a number of regional and international organisations to undertake studies and propose frameworks, despite serious methodological difficulties. These studies have the basic objective to operationalise a mechanism to monitor the progress of ICT and propose broad policy guidelines as and when required. An important contribution in this context is Orbicom's 'Monitoring the Digital Divide,[13] which assesses the magnitude of the digital divide, or more specifically, the progress of different countries toward the 'infostate' by building thematic clusters of indicators related to info-density and info-use. The other important study is 'Global Information Technology Report' brought out by the Global Economic Forum (2001), which again gives a framework for monitoring the progress of countries in adoption of ICT. This provides an index which comprises three elements: (a) environment for ICT; (b) readiness of stakeholders; and (c) usage of ICT amongst the stakeholders. But, they are not of great help in developing countries despite their claims to the contrary, due to enormous data requirements and the huge costs involved in bridging the data gaps through survey.

In education, progress in the development of indicators for cross-country comparison seems promising. The World Bank Institute together with the Educational Development Centre (EDC), Information Technologies Group at Harvard University has developed a survey-based information system. This will help determine the progress of developing countries in the integration of ICT into their education system. Further, 'Global Survey and Guide to ICT Planning in Education' is an important instrument in assessing ICT progress in the field of education.[14] Similarly, the World Health Organisation is working on a set of ICT-related indicators for the health sector.[15] Data on Asian countries from this source have not yet become available to researchers and policy makers.

The study by the European Commission discussed in the previous section has built Statistical Indicators Benchmarking the Information Society (SIBIS) for a large number of OECD countries. It provides the information on access of ICT by households for various purposes like business, education, health-care and the location of such access. Unfortunately, a similar exercise has not been carried out for Asian countries.

Scan-ICT project by Internation Development Research Centre (IDRC), Canada[16] gives, besides the supply indicators, the information on users and usages. The country reports brought out under this project provide user-based information content disseminated through ICT. They provide statistics on telemedicine, research, information systems, software application, distance learning, health promotion, etc. These statistics are very useful for building up indicators for cross-country comparison of the role of ICT in promoting human development for the achievement of the MDGs. Statistics on schools having computer and internet connectivity, and student/computer ratios can be obtained from this source. However, the database is restricted for the use by African countries only.

The most important initiative in this context is that of the United Nations ICT Task Force (referred to as the Task Force hereafter), established in March 2001 at the request of the Economic and Social Council to the UN Secretary-General. It has attempted to place the initiatives and research studies which analyse the development of ICT in the context of larger socio-economic goals, within a coherent policy framework. This is helpful in assessing the role of ICT to meet the MDGs. It provides an overview, largely in qualitative terms, of current applications of ICT in different countries and offers a set of indicators to chart progress. This promises to

[13] See wbln0018.worldbank.org/ict/projects.nsf/
[14] http://cyber.law.harvard.edu/itg/projects/
[15] As part of the UN ICT Task Force Action Plan, WHO has initiated a literature review on ICT/health projects (carried out by CIDA).
[16] See http://www.uneca.org/aisi/scanict.htm and http://www.connectivityafrica.ca

be of help in setting up targets for ICT, commensurate with the achievement of larger goals.

The Task Force has come up with a matrix that maps ICT with MDGs in eight key spheres. This matrix basically suggests a path, translating the MDGs into a set of indicators and then working out corresponding ICT goals. It then proposes construction of a set of compatible ICT indicators. Following the guidelines proposed by the Task Force, a list of the indicators under different MDGs has been worked out (Appendix II). The Task Force suggests that the views expressed and experiences documented in various international reports such as the UN Millennium Project and WSIS (World Summit on Information Society) should be taken into consideration in operationalisation of the indicators. Unfortunately, it is not possible to obtain information about Asian countries for many of these indicators, from international websites. Besides, fulfilling the data deficiencies through cross-country surveys, as proposed by the Task Force, would be highly expensive.

4.2. A framework for identification of indicators for construction of a composite index

The critical problem in anchoring ICT within MDGs is the choice of appropriate indicators and assigning weightages to these for composition. The earlier studies on this subject are largely restricted to industrialised countries. Since the problems involved in diffusion of technology across sectors, regions and populations are less serious here, there was not much of controversy. The indicators selected were mostly on the supply side, pertaining to usage of personal computers, internet facility, density of telephones, use of electronic goods, ratios of enrollment in, or of passing out from, technical institutions and so on. These data are easy to obtain and, in fact, are available for all the countries in international publications and worldwide websites. These indicators can, therefore, be easily constructed for Asian countries, although there are problems[17] of comparability of data in case of a few of them.

However, the above overview of interdependencies and country studies makes it amply clear that there is a strong case to go beyond supply-linked indicators in order to assess whether the technology is promoting the development process in the desired direction. One would have to collect information on ICT application, purpose of use, agencies involved and legal framework regarding adoption of ICT. It is only through such user-specific indicators that it is possible to assess whether the development of ICT is in harmony with promoting human development for achieving the eight MDGs.

In the case of Asian countries, the existing data sources do not permit building up of user-specific indicators for cross-country comparison. Further, generation of fresh data on ICT, classified by users and applications, would make difficult financial and administrative demands on the international statistical system. In addition, one can put forward analytical reasoning against use of extremely specific indicators. These countries are so very diverse in terms of levels of economic development, degrees of openness to the world market and socio-cultural specificities that it is difficult to draw generalisations and reach consensus on user-specific indicators.[18] Further, one may argue that a review of literature and analysis of interdependencies of ICT indicators in developing countries, are not enough for taking a position with regard to its role in future, particularly because ICT is still in its infancy.[19]

4.3. Identification of different dimensions of development and their constituent ICT indicators

In view of the difficulties in reaching general agreement on user/sector/region specific indicators,[20] one is constrained to use straight for-

[17] These problems are ignored in the present analysis, in view of the enormous costs involved in checking and ensuring comparability of the data generated through the national statistical system.

[18] Besides, the role of ICT in these countries would depend on the institutional and policy safeguards that they are able to evolve and it is hard to predict their capability, a priori. In this sense, achievement of socio-political objectives depend not merely on sector, region or gender-specific use of the technology but on the overall system of governance. It is, therefore, not possible to determine the appropriate indicators of ICT without bringing into consideration larger issues of governance.

[19] Countries like India and Pakistan are newcomers in the field and one would expect the impact of ICT to materialise on the ground only with a certain time lag.

[20] Given this perspective, the growth of ICT per se can be taken as desirable for achieving the MDGs, as it has been done in existing literature for developed countries, unless there is evidence to the contrary. This implies that importance of supply-side indicators of ICT may not be underplayed in the developing countries.

ward indicators reflecting the degree of availability of ICT[21] (See the list of supply-side indicators under the eight MDGs in Appendix II). These indicators may be combined with a few sector- or user-specific indicators that are easily obtainable from international documents or websites of UN agencies and the World Bank. The indicators, thus obtained, are classified into five categories (See Appendix III); (i) availability-or supply-linked — skill-independent; (ii) availability- or supply-linked — skill-dependent; (iii) efficiency and speed; (iv) targeting social sectors and (v) targeting vulnerable groups.

4.3.1. Availability-linked indicators

Availability-linked ICT indicators have been placed in two sub-categories: skill-independent ICT and skill-dependent ICT. The first includes popular ICT tools such as (i) telephone mainline connections, (ii) cellular subscribers, (iii) television sets, and (iv) radio sets, all being presented per 1,000 people. Under skill-dependent ICT category[22] the indicators identified are (i) internet users per 100 persons, (ii) personal computers per 100 persons, and (iii) per capita ICT expenditure. Higher expenditures would imply greater use of the technology by larger sections of the population as they cover purchase of ICT products for business, households, governments and educational institutions, including telecommunication facilities. Two separate categories have been kept on the supply side so as to increase the importance of availability-linked indicators in the overall aggregation scheme. Skill-independent ICTs require no or very low level of skills to use while using or adopting the skill-dependent ICTs call for certain skills.

4.3.2. Indicators of efficiency and speed

It has been possible to build up the following efficiency indicators, using available official data sources: (i) internet service provider charges; (ii) telephone usage charge for internet; (iii) cost of peak rate local call per three minutes from the fixed line; (iv) cost of peak rate call to the United States per three minutes; (v) internet speed and access; and (vi) IT training and education. Information on these indicators are compiled from the World Bank website on data and statistics[23] and the Global Competitiveness Report (GCR), 2001-02 (World Economic Forum 2001). Internet service provider charge is the monthly dial-up access charge for 20 hours of use and telephone usage charge is the telephone call charge for 20 hours of access. Understandably, higher costs would imply lower efficiency and less access. The last two are positive indicators of efficiency as they assign higher values to countries where ICT facilities are relatively more efficient, as manifest in greater speed of access and higher expenditures incurred in training of personnel.

4.3.3. Indicators of targeting social sectors

Indicators capturing coverage of social sectors through ICT (or sectoral diversification of ICT) comprise (i) internet access in schools, (ii) computers in educational institutions per 1,000 students, (iii) prioritisation of ICT by the government, and (iv) government online services availability. In view of the importance of universal literacy among the MDGs, one can justify inclusion of two educational indicators. Similarly, two government-linked indicators have been included, as the state continues to play a major role in promoting social development in Asian countries. Data on computers in educational institutions are obtained from the World Bank website and all other indicators are compiled from GCR 2001-02. These indicators simply show the 'rating' of the countries, as assigned by GCR. It may be pointed out that these ratings, reflecting the performance of the countries, are based on an opinion survey of 4,600 senior business leaders from 75 countries.[24]

4.3.4. Indicators of targeting vulnerable groups

Lastly, the following five indicators have been identified to assess ICT's contribution to socially deprived sections of the population: (i) percentage of women among professionals and technical workers;[25](ii) public access to internet; (iii) gov-

[21] Given the absence of a clear policy perspective in many Asian countries, it may be proposed that each country designs a system of incentives and controls that would lead to the desired social outcome.
[22] The institution of hosts has not developed due to different organisational structures and does not affect growth of these technologies. So this indicator is not included in the construction of the ICT index.
[23] These data are compiled from the International Telecommunication Union (ITU), UNESCO and WITSA. See http://www.worldbank.org/data/countrydata/ictglance.htm
[24] Ratings range from 1 to 7; the higher the value, the better is the country in terms of ICT diffusion to other spheres of activity.

ernment's success in ICT promotion; (iv) competition in provision of internet services; and (v) efficacy of laws relating to ICT use. Data on women professionals and technical workers have been taken from Human Development Report, 2003 and the information on other indicators, showing the 'rating' of the countries, is from GCR 2001-02. Public access to internet facilities and high competition among service providers are expected to lead to greater diffusion of technology, lowering of the price and improvement in accessibility, resulting ultimately in the increased access by the poor. Further, greater competition is likely to generate greater employment in the informal sector, which again would benefit the poor and vulnerable groups like women. Government's success in ICT promotion as also the greater sensitivity in the legal system to e-commerce, consumer protection, etc., would reflect the outreach of technology. This too,one may argue, will benefit the vulnerable sections of the population that tend to get marginalised under the free functioning of the market, without adequate protection from state or legal institutions.

4.4 Rationale for selection of indicators

It is important to discuss the extent to which selected indicators can map the attainment of MDGs. In the context of goals like eradication of poverty, the important question is whether the income and employment effect of ICT has a bias in favour of the poor that could help them rise above the poverty line. Despite opinions on the matter being equivocal, there is adequate empirical evidence to suggest that the overall impact of the availability of ICT has been positive for the poor. This would justify inclusion of availability-linked and efficiency indicators of ICT development. Besides, the state playing a role in providing public access to internet and in ensuring competition among service providers, and the legal system promoting ICT development will contribute to better penetration of technology among the masses[26] and lead to a reduction in poverty. It would be useful to construct other indicators articulating whether i) the technology being adopted is poor-friendly or accessible to the poor; ii) it is reaching the backward areas and economically underprivileged groups. But this is not possible using the existing official as well as non-official data sets.

The role of ICT in improving education has been noted as positive and justifies inclusion of the availability-linked and efficiency indicators, in the context of meeting the education-related MDG. In addition, internet access in schools and computer use in educational institutions have been considered as extremely useful sectoral indicators in articulating the progress of countries in achieving universal primary education.

Statistics on women's access and usage of ICT relative to that of men are useful in understanding the gender divide. These are available in 'The World's Women 2000', by United Nations with citations from Cyber Atlas.[27] Unfortunately, there are serious information gaps and problems of reliability, as the data sources are of different quality for Asian countries (UNIFEM 2000). There are also anomalies and inconsistencies with regard to data collection procedures adopted by different countries, particularly for temporal comparison (Hafkin, 2003). One alternative is to take percentage of women with tertiary level of education like university degree, teachers' training, professional degree, or enrollment of women in science and engineering,[28] as the indicators, but this would be a bit remote for capturing gender sensitivity in ICT. It is, therefore, proposed to capture this dimension through the percentage of females among professionals and technical workers.

In the context of maternal and child health, access to basic amenities including sanitation facilities and other social sectors, indicators pertaining to the role of government, such as public access to internet, success of the state in internet promotion and efficacy of laws in ICT use, etc., have been considered useful as the state plays a key role in social development in Asian countries. These indicators may be included here to indirectly reflect the coverage of social sectors, as disaggregated data on use

[25] The information on percentage of female workers in IT sector is not available. Hence, this indicator is taken as a proxy.
[26] The Bank has also given a ranking to countries based on the existence of a highly skilled IT job market. However, this may not be very useful in our analysis as its impact in terms of poverty alleviation or meeting other MDGs would be marginal.
[27] See www.nua.ie
[28] These data are available from Women's Indicators and Statistical Database, Wistat, Version 4, United Nations.

of ICT in these sectors are not available.[29] Besides, one would have to depend on availability-linked indicators since the growth of ICT per se can help in achieving these goals through the functioning of the market. This indeed is possible if countries follow certain kinds of ICT policy which as our overview suggests, is still in the formative stage in most of the Asian countries.

It may be pointed out that the Task Force concedes the point that selection of indicators at any point of time would be guided by availability of data. It argues in favour of maintaining a certain amount of flexibility in the methodology so that experiences gained over the years can be brought in to improve and refine indicators over time. Further, it recognises its own limitation of not being able to put together hard empirical evidence to justify the selection of indicators or determine their relative importance. It, therefore, argues that assembling anecdotal evidence and success stories would be useful and complementary in the direction of developing an analytical framework for the exercise. It is in line with this perspective that an attempt has been made in the following section to work out a few composite indices reflecting various dimensions of ICT development as well as its overall progress.

5 Working out component indices pertaining to different aspects of ICT development and the aggregate index

5.1. The methodology

In view of the growing popularity of composite indices and the possible usage of ranking of countries in national and international policy debates, it is proposed not to use complex multivariate tools in the composition exercise. The methodology attempts aggregation of the indicators at several stages, as has been done by UNDP in working out the Human Development Index (HDI). The method of assigning weightages on the basis of a correlation matrix, such as Principal Component Analysis, has not been considered appropriate here since the pattern of interdependencies is likely to change as the technology takes firm root in the region. As one has no other empirical basis to work out the relative importance of indicators, it has been decided to assign the equal weights to all the indicators.[30]

The other important problem to be sorted out is the elimination of the bias of scale that characterises each indicator. In computing HDI, UNDP adopts the Range Equalisation (RE) method wherein each indicator is divided by the range (after subtraction of the lowest value) so that scale-free values vary between 0 and 1. In recent years UNDP has changed its methodology slightly as it uses a fixed range computed on the basis of predetermined 'goalposts' reflecting the feasible upper and lower limits to the values. This enables one to make temporal comparisons, not only of the rank scores of countries but also of their HDIs. The disadvantage in this method is that the three constituent indices pertaining to life expectancy, education and GDP have lost the feature of having a fixed range of unity. The highest value in each index falls short of unity as the value for the top-ranking country is below the goalpost. The same explanation holds for the minimum value being higher than zero. In view of the familiarity and popularity of this method among practitioners and policy makers, it has been the first choice for constructing composite indices in the present analysis.

It may nonetheless be pointed out that fixing the range of the constituent indices through division by range discriminates against indicators that have greater disparity. Moreover, as inequalities in different indicators show different trends, it would be inappropriate to force these to have uniform and constant range over time. Indeed, with the introduction of the concept of goalposts to compute the range, the (scale-free) values of the indices no longer have the constant range of unity (and thereby have lost their unique property). However, the maximum and minimum values have been specified, based on the possible values over recent years and division by range is expected to ensure that the difference in disparity of the constituent indicators does not get reflected in HDI. Furthermore, there can be disagreements in fixing the goalposts for indicators like GDP per

[29] The role of the government is likely to be significant in the context of achieving other MDGs as well.

[30] It is hoped that the Theory of Large Numbers will tend to minimise the bias implicit in the methodology, over a large number of such applications.

capita and life expectancy as the issues involved here are empirical. The two bounds for literacy and gross enrollment, on the other hand, are mathematical. While inequality in the latter two indicators would decline over time as the maximum value is fixed, the same may not be the case with per capita income (Kundu 2003). Notably, the RE methodology treats the two types of indices in an identical manner. The popularity and acceptability of the HDI among policy makers seems to have come in the way of these issues being investigated adequately in the literature. It is therefore proposed to use an alternate method that permits the coefficients of variation of different indicators to remain different even after making them scale free, and lets these differences be reflected in the composite index and ranking. To achieve this, all the indicators have been made scale free (See Appendix IV) through division by their own mean which may be called the Division by Mean (DM) method.[31] The coefficients of variation of the original indicators, thus, become the standard deviations of the scale-free indicators, which then are carried into the composite indices.

Another important point is temporal comparability of the indices. As the present exercise is undertaken to make comparison only across countries, elimination of scale effect has been done by dividing each indicator by range or mean, computed for the chosen year. In case such comparisons are to be made over time, it would be necessary to fix the values of the divisors, as is now being done in computing HDI in Human Development Reports. Indeed for computing ICT composite indices for any future year, it would make sense to use the same means as in the base year in the denominator for each indicator. However, in case the base year is not considered representative of the early years of the 21st century, it should be possible to work out the mean of the first three years, say 2001, 2002 and 2003, and fix these as the denominators for eliminating the scale bias for all subsequent exercises.

Five component indices have been constructed by the RE method as well as the DM method of indexing, in the first stage. These pertain to the five sets of indicators discussed above: (i) skill-independent ICT; (ii) skill-dependent ICT; (iii) efficiency and speed of ICT (iv) social sector targeting; and (v) vulnerable group targeting. Before composition, all the indicators need to be made uni-directional within each category. Indeed, the indicators reflecting the costs of communication, such as internet service provider charges, telephone usage charge for internet, cost of local call and cost of call to U.S., cannot be combined with those articulating internet speed or IT training. It has, therefore, been considered proper to reciprocate these cost figures so that efficiency indicators get defined as (i) internet time available per dollar, (ii) telephone time for internet usage per dollar, (iii) local telephone time (at peak period) available per dollar, and (iv) US telephone time per dollar. This has been done on the basis of the understanding that the higher the accessibility of ICT time per unit of money, the greater is the efficiency of the system. This problem does not exist in case of any other category of indicators. Lastly, the aggregate index of development of ICT in the context of MDGs has been obtained by combining the five composite indices.

5.2 Indices obtained through range equalisation method

Following the RE method, the component index for a category has been obtained by first making each indicator scale free by subtracting its minimum value from each observation and then dividing it by its range. The average of these values across the indicators (within the category) for each country then becomes the value of its component index. If a country has maximum values for all the indicators in a category, it will score an index value of 1. Similarly, a country will obtain a component score of zero only when it has the minimum value for all the indicators. The larger the value of group-specific or aggregate index, the higher the role played by ICT towards attainment of MDGs in the country. Furthermore, an aggregate index for ICT development has been computed with the same methodologies used for computing the category-specific indices.

The indices of skill-dependent and skill-independent ICT availability measure the rela-

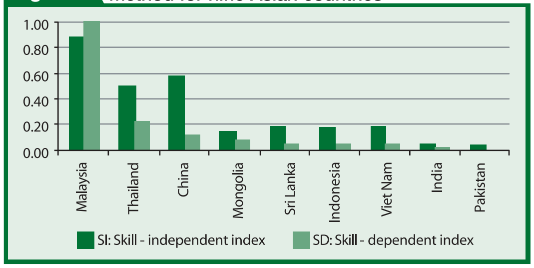
[31] The mean for each indicator has been obtained by adding up the values of all the countries and dividing the total by nine. The new or scale-free value of each country, obtained through the division by mean, shows its relative position *vis-à-vis* the average of the nine countries, on that indicator. See Appendix IV.

Table 1. *Five component indices and the aggregate index as obtained by range equalisation method for nine Asian countries*

Country	Skill-independent ICT index	Skill-dependent ICT index	Efficiency and speed index	Social sector targeting index	Vulnerable group targeting index	**Aggregate index**	**Rank**
China	0.57	0.12	0.46	0.87	0.39	**0.48**	**2**
India	0.04	0.01	0.62	0.65	0.76	**0.42**	**4**
Indonesia	0.17	0.04	0.38	0.14	0.40	**0.22**	**7**
Malaysia	0.87	1.00	0.67	0.59	0.68	**0.76**	**1**
Mongolia	0.14	0.06	0.31	0.09	0.37	**0.19**	**8**
Pakistan	0.03	0.00	0.57	0.36	0.48	**0.29**	**5**
Sri Lanka	0.18	0.04	0.62	0.10	0.33	**0.25**	**6**
Thailand	0.49	0.21	0.50	0.57	0.59	**0.47**	**3**
Viet Nam	0.18	0.04	0.29	0.06	0.24	**0.16**	**9**

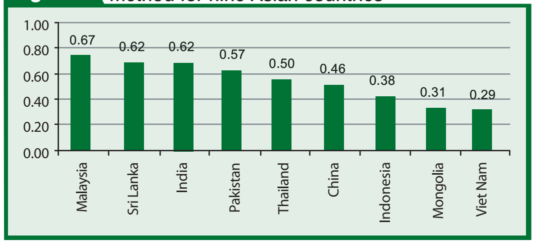
tive position of the countries pertaining to the availability of different types of facilities. Malaysia obtains the top position in both skill-independent and skill-dependent ICT categories (Table 1). The value of its skill-dependent ICT index is unity as it secures the highest value in all the indicators belonging to this category. More importantly, Thailand and China, which follow Malaysia, are way behind. The value of the skill-independent ICT index for Malaysia is also very high, but the gap with the second and third position countries is less than in the previous case. The availability of ICT across countries, therefore, exhibits wide inter-country variation, as evident from Figure 1.

Figure 1 Availability-linked component indices by RE method for nine Asian countries



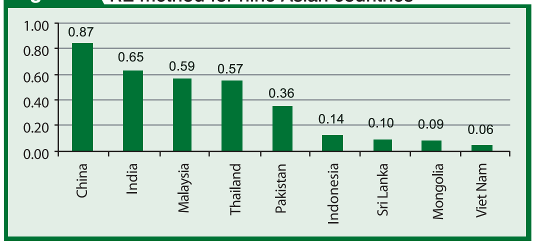
The efficiency index depicts the positions of the country's ability in providing access to high-speed ICT at low costs. Here, too, Malaysia obtains the highest position (Figure 2). However, its relative position *vis-a-vis* other countries is not as high as in the case of ICT-availability indices due to (i) the high cost of providing internet facilities and (ii) a call to the US being more expensive as compared to other countries (the two indicators belonging to this category). Interestingly, Sri Lanka, India and Pakistan report high values (fairly close to Malaysia), although these have very low levels of ICT availability.

Figure 2 Efficiency and speed component indices by RE method for nine Asian countries



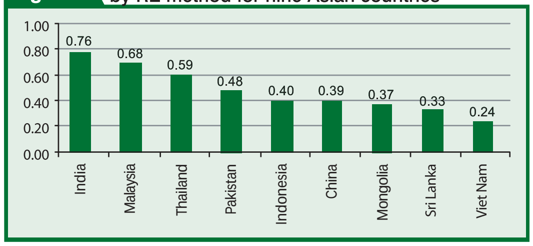
The index of social sector targeting reflects the performance of countries in promoting ICT in certain specific direction for the well-being of people. The idea is to assess whether benefits of technology have remained restricted to a few or have percolated down to several sectors, that is, to reach larger sections of the population. Interestingly, China obtains the highest position here, followed by India and Malaysia. The high value obtained by China is largely due to the indicators pertaining to the deployment of computers in the field of education and to the government giving ICT a high priority (Figure 3).

Figure 3 Social sector targeting component indices by RE method for nine Asian countries



The index of vulnerable group targeting measures the efficacy of the system in extending the benefits of ICT to women and other vulnerable sections through legal and governmental support systems. India is placed in the top position here, followed by Malaysia, and this is due to the high values reported in (i) public access to internet, (ii) government's success in ICT promotion, (iii) competition among internet service providers, and (iv) a developed legal system concerning ICT use (Figure 4).

Figure 4 Vulnerable group targeting component indices by RE method for nine Asian countries



The aggregate index is a summary measure of the five composite indices, discussed above. It may, therefore, be taken to reflect the overall progress a country has made in promoting the ICT in the context of goals of human development or millennium development. Malaysia obtains the highest value, followed by China and Thailand (Figure 5). India obtains the fourth position, which is due to its high values in categories other than availability of ICT. Pakistan, Sri Lanka and Indonesia have values in the middle level, indicating a modest role for ICT in promoting socio-economic development. Mongolia and Viet Nam have a long way to go in promoting the ICT, particularly in targeting social sector and vulnerable groups.

5.3 Indices obtained through division by mean method

In applying the DM method, the indicators in each category have been divided by their respective means. The values thus obtained have been added for each country to obtain the component index for the category. An identical procedure has been adopted for computing the aggregate index of ICT development, based on the category-specific component indices.

The unique position of Malaysia in terms of ICT development emerges in all categories of indicators, excepting the social sector targeting index where China seems to take the initiative (Table 2). The position of Malaysia is particularly impressive in the case of availability of skill-dependent ICT for which the value works out to be about 25 times that of the Indo-Pak average, the two countries occupying the bottom positions. In skill-independent ICT again, Malaysia has a very high value (followed by China), exhibiting a huge gap with India and Pakistan (Figure 6).

Figure 6 Availability-linked component indices by DM method for nine Asian countries

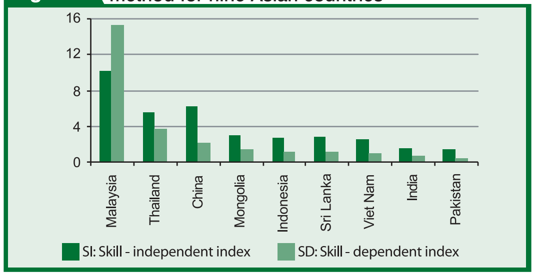


Figure 5 Aggregate index of ICT component indices by RE method for nine Asian countries

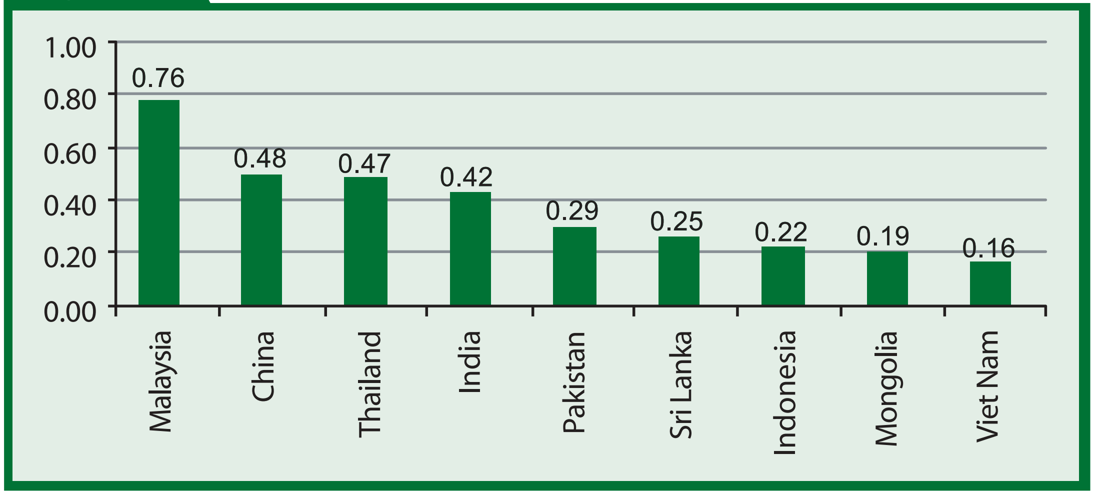
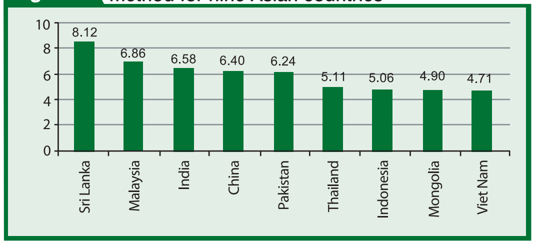


Table 2. *Five component indices and aggregate index obtained by division by mean method for nine Asian countries*

Country	Skill-independent ICT index	Skill-dependent ICT index	Efficiency and speed index	Social sector targeting index	Vulnerable group targeting index	**Aggregate index**	**Rank**
China	6.18	2.20	6.40	10.14	4.81	**1.37**	**2**
India	1.64	0.71	6.58	4.36	5.59	**0.79**	**5**
Indonesia	2.65	1.12	5.06	2.75	4.79	**0.71**	**7**
Malaysia	10.12	15.24	6.86	3.84	5.61	**2.17**	**1**
Mongolia	2.91	1.42	4.90	2.50	4.82	**0.72**	**6**
Pakistan	1.50	0.51	6.24	3.14	4.88	**0.67**	**8**
Sri Lanka	2.83	1.12	8.12	2.47	4.67	**0.80**	**4**
Thailand	5.63	3.62	5.11	4.31	5.36	**1.12**	**3**
Viet Nam	2.53	1.06	4.71	2.49	4.48	**0.66**	**9**

Figure 7 Efficiency and speed component indices by DM method for nine Asian countries



In the case of ICT efficiency, both India and Pakistan show impressive performances, almost similar to Malaysia and China. Interestingly Sri Lanka, which secures modest values in availability-linked indicators, attaining the top position in terms of efficiency. This index does not show much variation across the countries (Figure 7), as costs are becoming similar around the world, under the impact of globalisation of the technology. In targeting social sectors, China secures the highest value and this is basically because of ICT being used in a big way in educational institutions and government assigning it a high priority, as noted earlier. It is only in this category that we see Malaysia sinking very low (Figure 8), going below the average of the series while India and Thailand notch significantly higher positions. In targeting vulnerable sections of the population, India and Malaysia seem to be doing well (Figure 9). In both countries, the state seems to be playing an important role in prioritising ICT as also creating a fair competitive environment among the service providers. Here again, inter-country disparity does not show any alarming proportions because of the nature of the indicators.

Understandably, Malaysia has the highest value in the aggregate composite index, followed by China and Thailand, the countries that have been a part of the globally linked rapid development process, at least for some time during the past two decades. India and Sri Lanka come next (Figure 10). They are at about the same level but the latter gets past the former by reporting significantly higher values in availability and efficiency linked indicators. Immediately following them are Mongolia and Indonesia. Interestingly, these two report medium level values in all the five categories of ICT development. Pakistan and Viet Nam are at still lower level

Figure 8 Social sector targeting component indices by DM method for nine Asian countries

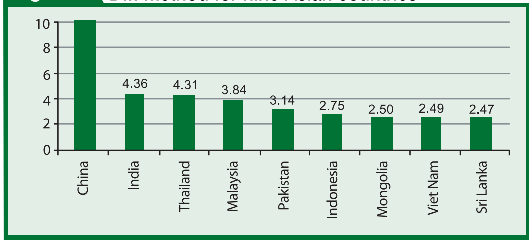


Figure 9 Vulnerable group targeting component indices by DM method for nine Asian countries

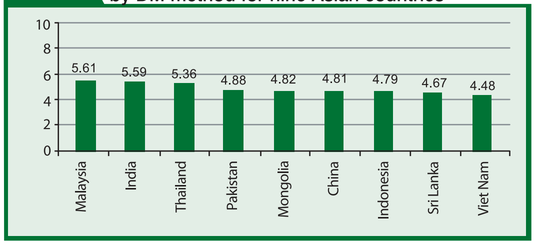
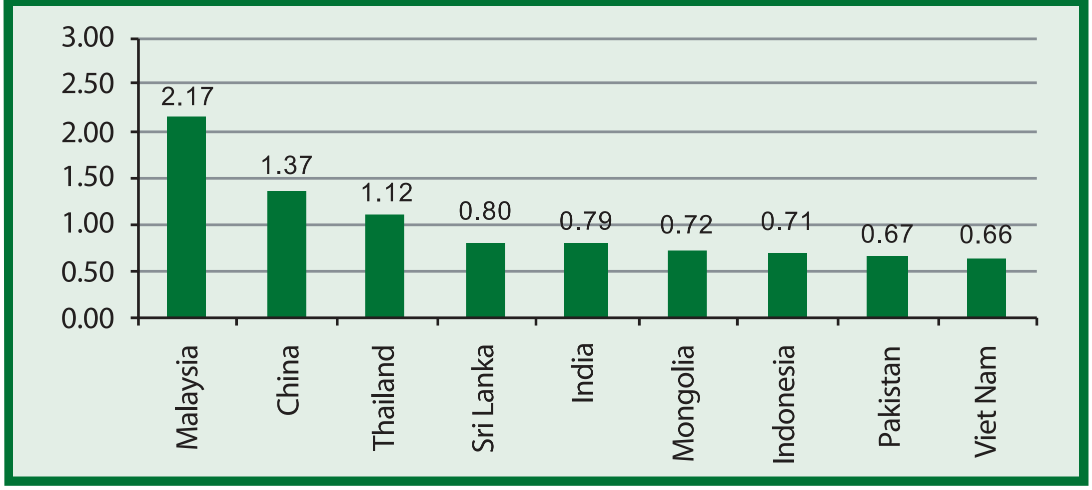


Figure 10 Aggregate index of ICT component indices by DM method for nine Asian countries



in terms of the final aggregate index. The two reflect opposite development patterns, the former showing higher values in efficiency and targeting while the latter has a significant edge in availability.

5.4. Comparison of the alternate sets of indices

A quick comparison of the rankings obtained from the aggregate indices arrived at, by two different methods suggests that the results are not very different. The top three positions are occupied by Malaysia, China, and Thailand and the bottom by Viet Nam in both methods. There are a few changes in the ranking of the middle order countries that may be considered marginal. One may, therefore, argue that since the proposed method gives similar results as that of the RE method, the credentials of this alternative need to be noted in the literature of aggregate indices. The objective of comparing the two sets of results obtained through different methods, however, is quite different. It is to identify and focus on the differences that have emerged from the two exercises, and analyse the reasons in the context of the dynamics of ICT development in Asian countries.

The first major difference noted is that despite the ranks of the countries being similar, the gaps in the values of the indices are quite different. One may, for example, consider the differences between China, Thailand and India, obtained by the RE method, to be insignificant and treat them at par. This, however, is not the case by the DM method. Of particular importance here is the gap between India and the other two countries, which is due to the low level of the former in terms of two component indices (skill-independent and skill-dependent indices) of ICT availability. It is important to note that the DM approach succeeds in retaining the inter-country variation with respect to these two component indices (Table 2); this variation gets reflected in the aggregate index which brings down the figure for India. Unfortunately, the RE method implicitly reduces their importance by treating them at par with other (component) indices that do not exhibit significant inter-country variation. Similarly, Mongolia and Viet Nam score very low values in the aggregate index by the RE method, which is not the case with the alternative. This again is because the availability indicators, in which these two countries record reasonably high values, receive implicitly low weightage in the RE method of aggregation used in HDI calculations.

Another major difference is in the ranking of Pakistan *vis-a-vis* Sri Lanka in the aggregate index by the two methods. The higher scores of the latter on availability get reflected in the aggregate index by the DM method, with a relatively higher weight, giving it a higher rank. In the RE method, however, the importance of the availability indices (with high disparities) are implicitly reduced, which is responsible for reversal in ranking. As noted above, division by mean gets rid of scale bias but not disparity. One may note here that Sri Lanka has higher scores than Pakistan in a larger number of indicators and by a huge margin in absolute as well as relative terms.

The difference in ranking occurs even in category-specific component indices. Sri Lanka and China get top positions in terms of efficiency and targeting social sectors respectively by the DM method, leaving behind Malaysia (which is placed at number one position in both, by the RE method). It may be observed that most of the indicators in the two categories have low inter-country variation. All the countries have similar values except for telephone charge for internet services and computers installed in educational institutions. Both the indicators are important within their respective categories and are responsible for much of the variation among countries. The advantage of Sri Lanka lies in charging a low price for internet services while that of China is in promoting computer education in schools. The DM method, by implicitly giving higher weightage to these indicators, has placed the two countries above all the others in the categories mentioned above. Similarly, Malaysia is able to get past India in terms of targeting vulnerable group index (the latter having the top position by RE method) as it has a higher percentage of female professionals among workers and the method implicitly gives a higher weightage to the indicator because of its higher disparity.

It is not the purpose of the statistical exercise attempted here to establish the superiority of one method to the other as their suitability would very much depend on the objectives of the exercise and the empirical regularities observed in the region under investigation. The above discussion makes it clear that change in the methodology of composition can and does bring about significant changes in the values of component indices and alters even the ranking of the countries. Issues of value judgment, implicit in the methodology cannot, therefore, be dismissed.

It has been demonstrated that the RE method implicitly gives lower weightages to indicators pertaining to availability and a few other aspects of ICT development that are observed to have high disparity. The disparity, in the countries under consideration, has been caused through the process of development, mediated largely through the market, with limited control being exercised by the government. In the earlier sections on the process of development, it has been argued that ICT here is still in the initial stages of development and consequently, increase in its availability itself could prompt socio-economic development. Several economic, social and cultural factors are currently inhibiting the process of growth and an increase in the availability of this technology would help in giving exposure to policy makers, administrators and common people to the global information system. Further, this would lead to the establishment of better communication networks even within countries and facilitate decision making of public and private agencies. Importantly, supply of ICT has been strongly linked with economic affordability of the countries, resulting in high disparity in the former. In future, economic factors affecting affordability would also be important for the development of ICT. This is a fact which cannot be denied at the present time. In view of all this, giving high importance to availability indicators does not appear to be misplaced.

It is indeed true that national governments in the Asian region have tried to give a direction to the development of ICT by intervening in the market, controlling prices, introducing it in social sectors, fixing priorities, strengthening the legal structure for ensuring access to all, etc. The cross-country differences in the indicators are not very high, as may be inferred from the low coefficients of variation of the indicators (Appendix V) belonging to the third, fourth and fifth categories. Irrespective of socio-political structures, each country has taken measures to give a push to the dissemination of technology in the desired direction. Indeed, there are specific measures adopted by individual governments to direct ICT towards MDG objectives but it is impossible to generate comparable cross-sectional data on this aspect. Also, the success of such measures has been limited and uneven across countries, due to the overwhelming nature of the market which has proved formidable. This is reflected in unbalanced sectoral and spatial growth of ICT, evident from the high disparity in the first and second categories of the indicators of availability.

In view of the above observations, maintaining the inter-country variation of indicators (by making the standard deviation of the original indicator the coefficient of the scale-free indicator) and then giving equal weightage to their variations in the aggregation scheme appears to be more appropriate. Studies have shown that the indicators that play a significant role in the development dynamics of less-developed countries like India exhibit high disparity in space (Kundu 1984). Undoubtedly, this kind of regularity observed in certain contexts cannot become an axiom as it cannot claim universality. However, given the pattern of development noted through correlation analysis and review of literature pertaining to the Asian region, one can, with some degree of confidence, justify retention of the variation in availability indicators in the process of composition. Understandably, this implies giving implicitly higher weightage to availability-linked indicators, the rationale for which has been discussed while analysing the development dynamics in the region.

6 In brief

ICT indicators have shown strong positive relationships with per capita income and HDI across the countries of the world in 1991. The MDG indicators related to health and education, such as net primary school enrollment ratio, children reaching grade 5, youth literacy rate, reduction in child mortality and improvement in maternal health, have also shown a significant and desired pattern of interdependency with ICT indicators. Similarly, the percentage of people with sustainable access to water and sanitation facilities (in urban areas) is highly correlated with ICT indicators.

In 2001, the pattern of relationships between ICT indicators and those of income and HDI across countries, has strengthened. Further, the correlations between ICT and MDG indicators related to health and education have improved over time. Importantly, the positive relationship between ICT indicators and the percentage of the non-poor, has improved significantly. The correlation of ICT with MDG indicators related to environmental sustainability, particularly to water and sanitation in urban areas has, however, weakened over the decade.

For indicators of growth or change in the level of ICT and progress towards MDGs during the 1990s, no regular pattern of relationship is discernible. One may argue that diffusion of ICT to different social spheres is a recent phenomenon and its manifestations would be visible only with a certain time lag. In any case, the positive impact of growth in ICT on the process of socio-economic development has not yet become statistically visible.

Classifying the countries of the world into four categories such as Europe and OECD, Arab and Latin America, Asia-Pacific and Africa, an attempt is made to examine the the nature of interrelationships between ICT indicators and MDGs across regions. Expectedly, one notices high correlations of ICT indicators with per capita income and other manifestations of economic development in Europe, even in the early 1990s. This is true in the other three less-developed regions as well, although ICT here was restricted to use of radios, televisions and telephones. Importantly, the interdependency of ICT indicators with MDGs emerges as positive in the case of Europe. This, however, is not the case in the less-developed regions of Arab and Latin America, Africa and Asia. MDG indicators pertaining to primary education, health, gender equality and environmental sustainability, for example, have shown strong interdependency with ICT in Europe. These are either weak or do not exhibit any pattern in the other three regions of the world in 1991.

The relationships of ICT indicators with those of MDGs, in 2001, are similar to or stronger than those of 1991 in Europe. In the less-developed regions, this is not the case. For Arab and Latin America, and Africa, the correlations between ICT and certain social development indicators, such as access to education, child and maternal health and availability of drugs, show desirable signs and are statistically significant. This is not so in Asia as most of such interdependencies have been estimated to be insignificant, including those between ICT and education-linked MDGs. Furthermore, ICT is strongly correlated with the availability of drinking water and sanitation facilities in Europe in 2001. This, to some extent, is the case in Arab and Latin America and Africa as well. However, the same, is not observed in Asia.

The indicators articulating change or growth in the level of ICT or progress towards MDGs, over the decade from 1991 to 2001, exhibit no discernible pattern of interdependency. The indicators of change in the level of ICT show no positive correlation with change in primary school enrollment rate or gender disparity in education in any of the four regions. Importantly, the correlations between progress in ICT and that in

MDGs related to child and maternal health have the desired signs and are significant in the case of Europe, Arab and Latin America and Africa. Unfortunately, this is not so in Asia. Further, the infant mortality rate, urban households not having access to drinking water and sanitation here, exhibit no decline with progress in ICT. One would, therefore, infer that growth of ICT in Asia has not been the critical factor in progress towards the attainment of MDGs in the recent past.

In order to assess the impact of ICT development on progress towards the achievement of MDGs, 22 indicators have been identified under five dimensions or broad categories of ICT development. Component indices have then been worked out for each of the categories by aggregating the constituent indicators after eliminating the scale bias. This has been done with the range equalisation method used by UNDP in computing HDI and also by the division by mean method. In each method, an aggregate index has been computed on the basis of category-specific component indices. A comparison of indices represents the relative positions of countries in the development of ICT in the context of the attainment of MDGs.

Malaysia presents the highest values for most of the category-specific component indices as also for the aggregate composite index, followed by China and Thailand. Malaysia's unique position is because of its high values on availability indicators pertaining to both skill-independent and skill-dependent ICT. Closely following it in most of the individual indicators as well as in the component indices are China and Thailand. However, in social sector targeting, China goes past Malaysia and occupies the top position by both the methods, due to its emphasis on the use of ICT in education. Thailand is at par with China and Malaysia but gets a lower aggregate value due to deficiencies in availability indices. At the lower end are Mongolia and Viet Nam, although they are fairly high in terms of availability indicators - way ahead of India or Pakistan. These two countries, however, have an advantage in terms of efficiency and targeting social sectors and vulnerable groups. The third South Asian country, Sri Lanka, has fairly high values for availability and most significantly, occupies the top position in terms of ICT efficiency, as revealed by the division by mean method. Indonesia has middle level values in almost all the indicators and figures at the middle level in category-specific as well as aggregate composite indices.

An important point emerging from the analysis is that in assessing the progress of ICT in the context of achieving any set of socio-economic goals, there would have to be an emphasis on availability indicators. In addition, several efficiency-linked and user-specific indicators would have been included in the analysis. For that, information must be gathered covering aspects of affordability, access and utilisation of ICT. These indicators should bring in the demand side and reflect the spread of technology, not only across economic and social classes but also regions, sectors and gender categories. Indicators, for example, may be built to articulate what percentage of households in certain social, economic or regional group are able to make use of ICT. They should also reflect the percentages of people using ICT for a socially more desirable purpose. Alternately, one can try to build up 'surrogate endpoints' such as better information flows and better management of education, health and public delivery systems through ICT, for assessing progress towards achieving MDGs.

Appendices

Appendix I: List of indicators used for correlation analysis

1. *ICT indicators*
   i. Internet users (per 100 people)
   ii. Internet hosts (per 1,000 people)
   iii. Personal computers in use (per 100 people)
   iv. Telephone mainlines (per 1,000 people)
   v. Televisions in use (per 1,000 people)
   vi. Cellular subscribers (per 1,000 people)
   vii. Radios in use (per 1,000 people)

2. *Indicators of economic and human development*
   i. GDP per capita (PPP US$)
   ii. Human development index (HDI)

3. *Indicators reflecting poverty (related to MDG 1)*
   i. Undernourished people (% of total population)
   ii. Population surviving on less than one dollar per day (%)
   iii. Poverty gap ratio (%)
   iv. Share of poorest 20% in national income or consumption (%)
   v. Children underweight for age (% of children under 5years of age)

4. *Indicators pertaining to education (related to MDG 2 and others showing broad educational statistics)*
   i. Adult (age group 15–49) literacy rate
   ii. Children reaching grade 5 (%)
   iii. Net primary enrollment ratio (%)
   iv. Net secondary enrollment ratio (%)
   v. Combined primary, secondary and tertiary gross enrollment ratio (%)
   vi. Tertiary level students in science, maths and engineering (as % of all tertiary level students)
   vii. Youth literacy rate (% of age group15–24)
   viii. Scientists and engineers in R&D (per million people)

5. *Indicators promoting gender equality and empowerment of women (related to MDG 3)*
   i. Ratio of literate females to males (age group 15–24)
   ii. Seats in parliament held by women (% of total)
   iii. Female share of non-agricultural wage employment (%)
   iv. Ratio of girls to boys in primary education
   v. Ratio of girls to boys in secondary education
   vi. Ratio of girls to boys in tertiary education

6. *Indicators pertaining to reduction of child mortality, improving maternal health and combating HIV/AIDS, malaria and other major diseases (related to MDGs 4, 5 & 6)*
   i. Infant mortality rate (per 1,000 live births)
   ii. Life expectancy at birth (years)
   iii. Births attended by skilled health personnel (%)
   iv. Physicians (per 100,000 people)
   v. Population with sustainable access to affordable essential drugs (%)
   vi. One-year-olds fully immunised against measles (%)
   vii. Maternal mortality ratio (per 100,000 live births)
   viii. Under five mortality rate (per 1,000 live births)
   ix. Tuberculosis-related mortality rate (per 100,000 people)

x. Malaria-related mortality rate (all ages)
xi. Malaria-related mortality rate (children aged 0–4)
xii. Malaria cases (per 100,000 people)
xiii. Tuberculosis cases (per 100,000 people)
xiv. Tuberculosis cases cured under direct observation treatment (DOTS) (%)
xv. Tuberculosis cases detected under direct observation treatment (DOTS) (%)
xvi. Adults living with HIV/AIDS (%)
xvii. Women living with HIV/AIDS (%)
xviii. Children living with HIV/AIDS (%)

7. *Indicators on environmental sustainability (related to MDG 7)*
    i. Consumption of ozone-depleting chlorofluorocarbons (ODP metric tons)
    ii. Carbon dioxide emissions per capita (metric tons)
    iii. GNP per unit of energy use (PPP US$ per kg of oil equivalent)
    iv. Land area covered by forests (%)
    v. Ratio of protected area to surface area
    vi. Urban population with access to improved sanitation (%)
    vii. Population with sustainable access to an improved water source in rural areas (%)
    viii. Population with sustainable access to an improved water source in urban areas (%)

8. *Indicators on developing a global partnership for development (related to MDG 8)*
    i. Flow of foreign direct investment funds (FDI) (in million US dollars)
    ii. Overseas development assistance (ODA) as percentage of gross national product (GNP)

[32] Development of ICT, besides playing a role in achieving the other MDGs, has been considered as a goal in itself. This would enable inclusion of a large number of supply-side indicators pertaining to ICT, as listed

Appendix II: Indicators of ICT development under different Millennium Development Goals (MDGs), as per the guidelines of the UN ICT Task Force

MDG 1: Eradication of extreme poverty and hunger

i. Average income from ICT as percentage of GDP
ii. Number of ICT initiatives related to the eradication of extreme poverty and hunger
iii. Preps (poverty reduction strategy papers) that include development of ICT (IMF)

MDG 2: Achievement of universal primary education

i. ICT access and usage in primary school
ii. Number of teachers trained in the usage of ICT
iii. Initiatives related to ICT use in primary education
iv. Presence of ICT-related content in primary education, particularly in terms of availability of learning materials in digital form in local languages, educational websites, e-learning products/services, etc.

MDG 3: Promotion of gender equality and empowerment of women

i. Women's ICT access and usage
ii. ICT literacy among girls
iii. Sensitivity of ICT policy environment to gender issues assessing importance of women in ICT planning, policy or strategy (Hafkin 2003)
iv. Role of women in ICT policymaking
v. Percentage of female IT workers or female technical workers
vi. Initiatives to bring about women's advancement through the use of ICT

MDGs 4, 5 & 6: Reduction of child mortality, improving maternal health and combating HIV/AIDS, malaria and other major diseases

i. Initiatives promoted through ICT for sensitisation of population on health-related issues like child mortality, maternal health, HIV/AIDS, malaria and other major diseases
ii. Investment, penetration, usage of ICT in health institutions and by medical professionals and other health workers
iii. Importance given to health and healthcare needs in terms of allocation of resources and setting perspectives, in country's ICT plan
iv. Number and coverage of specific programmes and campaigns related to ICT in health sector

MDG 7: ICT impact on environmental sustainability

i. Presence of content related to environmental protection and sustainability including climate change biodiversity, etc. in education and information, disseminated through ICT
ii. Indicators pertaining to prevention/monitoring of environmental disasters
iii. Initiatives related to reduction in consumption of energy, water and other essential resources through introduction of ICT

MDG 8: Developing a global partnership for development[32]

i. Number of telephone connections
ii. Number of personal computers
iii. Number of people trained in ICT (local capacity building)
iv. Number of local companies registered with ICT as main/major business
v. Number of domain names registered locally or domain addresses registered to an address in a country

[32] Development of ICT, besides playing a role in achieving the other MDGs, has been considered as a goal in itself. This would enable inclusion of a large number of supply-side indicators pertaining to ICT, as listed

vi. Number of PCs, phones, mobiles, radios, radio stations, etc.
vii. Degree of competitiveness and regulatory controls in the market
viii. Number of internet service providers (ISPs)
ix. Patents registered related to local ICT
x. Number of registered software licenses
xi. Number of health and educational institutions connected electronically
xii. Number of web pages in major local languages
xiii. Number of IP addresses, domain names and e-mail accounts
xiv. Number of people employed in ICT sector

Appendix III: Indicators used for construction of indices pertaining to ICT development

1. *Availability or supply-linked — skill-independent*
   - i. Telephone mainlines (per 1,000 people)
   - ii. Cellular subscribers (per 1,000 people)
   - iii. Television sets (per 1,000 people)
   - iv. Radios (per 1,000 people)

2. *Availability or supply-linked — skill-dependent*
   - i. Internet users (per 100 people)
   - ii. Personal computers in use (per 100 people)
   - iii. ICT expenditure per capita (in US dollars)

3. *Efficiency and speed*
   - i. Internet service provider charges (in US dollars)
   - ii. Telephone usage charge for internet service (in US dollars)
   - iii. Cost of local call per 3 min (in US dollars)
   - iv. Cost of call to US per 3 min (in US dollars)
   - v. Internet speed and access
   - vi. Training and education in IT

4. *Targeting social sectors*
   - i. Internet access in schools
   - ii. Computers installed in education (in thousands)
   - iii. Government prioritisation in ICT
   - iv. Government online services availability

5. *Targeting vulnerable groups*
   - i. Female professional and technical workers (% of total female workers)
   - ii. Public access to internet
   - iii. Government's success in ICT promotion
   - iv. Competition among internet service providers (ISPs)
   - v. Laws related to ICT use

Appendix IV: Methodology for construction of composite indices

Range Equalisation (RE) method

Step 1: Making the indicators scale free

i. Computation of the range for each indicator. For the *j*th indicator belonging to the *r*th category, the range R^*_{rj} would be $(X_{rjmax} - X_{rjmin})$ where X_{rjmax} and X_{rjmin} are the maximum and minimum values for the *j*th indicator in the *r*th category.

ii. Compute $(X_{rij} - X_{rjmin})$ and divide each value by R^*_{rj}. We thus obtain the scale-free values of the *j*th indicators as $(X_{rij} - X_{rjmin})/R^*_{rj}$ for all *i* where $i = 1,2,\ldots Z$. *Z* is the number of countries, which is *9* in the present case for each indicator in each category.

Step 2: Adding up the scale-free values of the indicators within each category for each country. The group 'skill-independent ICT availability' (category 1), for example, has 4 constituent indicators and hence we shall have N_1 as equal to 4. The component index for skill-independent ICT availability Y_{1i} for the *i*th country would then be computed as

$$Y_{1i} = \Sigma(X_{1ij} - X_{1jmin})/R^*_{1j}\ , j = 1 \ldots N_1.$$

Describing Y_{ri} as the component index for the *r*th category for the *i*th country, one would write

$Y_{ri} = \Sigma(X_{rij} - X_{rjmin})/R^*_{rj}$, for each $j = 1 \ldots N_r$ where N_r is the number of indicators in the *r*th category.

The aggregate index for the *i*th country Y_i would be $\Sigma Y_{ri}/N$, where N is the number of categories which in the present exercise is 5.

Division by Mean (DM) method

Step 1: Making the indicators scale free

i. Computation of the mean for each indicator. For the *j*th indicator belonging to the *r*th category, the mean X^*_{rj} would be $\Sigma X_{rij}/Z$ where X_{rij} is the value of the ith country for *j*th indicator in the *r*th category and $i = 1,2,\ldots Z$. *Z* is the number of countries, which is 9 in the present case for each indicator and each category.

ii. Division of each observation of the indicator (X_{rij}) by respective mean (X^*_{rj}). We thus obtain X_{rij} / X^*_{rj}. These may be called the scale-free values of the indicators.

Step 2: Adding up the scale-free values within each group for each country. 'Skill-dependent ICT availability' (category 2), for example, has 3 constituent indicators. The skill-dependent availability index Y_{2i} for the *i*th country would then be computed as

$Y_{2i} = \Sigma(X_{2ij} /X^*_{2j}), j = 1 \ldots N_2$. N_2 would be 3 as there are only 3 indicators in this category.

Describing Y_{ri} as the component index for the *r*th category for the *i*th country, one would write

$Y_{ri} = \Sigma(X_{rij} / X^*_{rj})$, for each $j = 1 \ldots N_r$ where N_r is the number of indicators in the *r*th category .

The aggregate index for the *i*th country Y_i would be $\Sigma Y_{ri}/N$, where N is the number of categories, which is 5.

Appendix V: Mean and coefficient of variation of the indicators pertaining to different aspects of ICT development*

	Mean	Coefficient of variation
Skill-independent ICT		
Telephone mainlines (per 1,000 people)	73.78	80.28
Cellular subscribers (per 1,000 people)	80.22	122.31
Television sets (per 1,000 people)	144.67	51.68
Radios (per 1,000 people)	182.00	57.07
Skill-dependent ICT		
Internet users (per 100 people)	4.70	183.65
Personal computers in use (per 100 people)	2.52	152.63
ICT expenditure per capita (US$)	59.09	132.94
Indicators of efficiency		
Internet time available (per US$)	0.10	51.92
Telephone time for internet (per US$)	6.45	82.51
Local telephone time (at peak period) available (per US$)	65.48	53.3
US telephone time (per US$)	0.29	35.24
Internet speed and access	3.54	15.7
IT training and education	3.99	20.89
Sectoral diversification in ICT		
Internet access in schools	2.76	17.53
Computers installed in education (in thousands)	318.67	210.93
Govternment prioritisation in ICT	4.58	14.31
Government online services availability	2.78	26.75
User group specific indicators		
Female professional and technical workers (as % of total female workers)	44.71	25.99
Public access to internet	3.20	13.62
Govternment success in ICT promotion	3.98	13.34
Competition among internet service providers	4.18	15.37
Laws relating to ICT use	3.34	23.84

Note: * The indicators are available at UNDP website: http://hdrc.undp.org.in/initiatives/apri/ict.html

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