United Nations E/CN.16/2011/3

Economic and Social Council

Distr.: General
9 March 2011

Original: English

Commission on Science and Technology for Development
Fourteenth session
Geneva, 23–27 May 2011
Item 3 (a) of the provisional agenda

Measuring the impact of information and communication technologies for development

Report of the Secretary-General

Executive summary

The present report discusses the importance of measuring the impacts of information and communication technologies (ICTs) for development, identifies key challenges and presents empirical evidence on the positive and negative impacts of ICTs in areas such as economic performance, health, education, employment and the environment. Several methodological approaches to measurement are discussed and compared.

The report draws on findings and suggestions of the Commission on Science and Technology for Development (CSTD) 2010–2011 intersessional panel, which makes several calls to enhance the availability and quality of ICT data, with a view to measuring the impacts of these technologies on development. It calls for strengthened international efforts on measuring ICT impacts under the aegis of the CSTD and the Partnership on Measuring ICT for Development.

Introduction

1. Information and communication technologies (ICTs) hold the promise of fundamentally changing the lives of much of the world's population. In their various forms, ICTs affect many of the processes of business and government, how individuals live, work and interact, and the quality of the natural and built environment. The development of internationally comparable ICT statistics is essential for governments to be able to adequately design, implement, monitor and evaluate ICT policies. This need was emphasized in the Geneva Plan of Action adopted at the first phase of the World Summit on the Information Society (WSIS):

> A realistic international performance evaluation and benchmarking (both qualitative and quantitative), through comparable statistical indicators and research results, should be developed to follow up the implementation of the objectives, goals and targets in the Plan of Action, taking into account different national circumstances.

2. While much progress has been made in measuring ICT infrastructure and use, measurement of the impact of ICTs presents a number of statistical challenges. At its thirteenth session, the Commission on Science and Technology for Development (CSTD) selected "Measuring the impact of information and communications technologies for development" as one of the priority themes for its 2010–2011 intersessional period.

3. In order to contribute to a further understanding of the issues, UNCTAD organized a panel 15–17 December 2010 in Geneva. The present report is based on the issues paper, findings of the panel, contributions by members of the CSTD and other relevant literature.

A. WSIS outcomes

4. WSIS outcome documents reaffirm the potential contribution of ICTs to internationally agreed development goals, including those in the Millennium Declaration.

5. The Geneva Plan of Action includes 10 targets to be achieved by 2015, of which six relate to improving connectivity (for instance, between villages, educational institutions, libraries, hospitals and government organizations). There are three targets on ICT access (radio and television, other ICTs and Internet) by the world's population and one target on adapting education curricula to meet the challenges of the information society.[1] From these targets, some important impact areas can be identified:

(a) Impacts of ICT access, especially on poor and rural communities;

(b) Impacts of ICT use on educational outcomes and the importance of school curricula in preparing students for the information society;

(c) Impacts of ICT networks on health institutions and health outcomes;

(d) Various impacts arising from the availability of e-government services; and

(e) Impacts of improving access to information and knowledge, by suitable access to electronic content.

[1] ITU assessed progress against the targets in 2010 (ITU, 2010a).

6. The Geneva Plan of Action also includes a number of “action lines” that can support sustainable development.2

B. The Partnership on Measuring ICT for Development

7. Much of the progress in measuring ICTs to date is linked to the work of the Partnership on Measuring ICT for Development and its member organizations.[3] The Geneva Plan of Action refers to the development of statistical indicators for “international performance evaluation and benchmarking”. The Partnership was subsequently launched at UNCTAD–XI in June 2004. The Tunis Agenda specifically mentions the Partnership and its role in the measurement of ICT impact.

8. The work of the Partnership is directed towards achieving internationally comparable and reliable ICT statistics that, inter alia, will help countries assess ICT impact (Partnership, 2008a). Its members are involved in various activities directed towards that goal, including developing and maintaining a core list of ICT indicators (Partnership, 2010), compiling and disseminating ICT data (Partnership, 2008b), and providing technical assistance to developing countries. The Partnership has several task groups, including the Task Group on Impacts, which is led by the Organization for Economic Cooperation and Development (OECD) and aims “…to give an overview of the economic and social impacts of ICTs, how these impacts can be measured and what the data requirements are.” Its terms of reference recognize both economic and non-economic impacts and a variety of methodologies and data sources.[4]

I. Key challenges

9. Demonstrating the impacts of ICTs statistically is challenging, for several reasons:

(a) There are various ICTs, with different impacts in different contexts and countries. They include goods (such as mobile phone handsets) and services (such as mobile telecommunications services), both of which change rapidly over time;

(b) Many ICTs are general purpose technologies, which facilitate change and thereby have indirect impacts;

(c) There is a diversity of impacts, in terms of intensity, scope, stage, time-frame, characterization (economic/social/environmental, direct/indirect, positive/negative, intended/unintended, subjective/objective), as illustrated in figure 1;

(d) Determining causality is difficult. There may be a demonstrable relationship and a positive correlation between dependent and independent variables. However, such a relationship cannot readily be proven to be causal.

[2] These are e-government, e-business, e-learning, e-health, e-employment (including teleworking), e-environment, e-agriculture and e-science (ITU, 2005).

[3] The International Telecommunication Union (ITU), UNCTAD, the United Nations Department of Economic and Social Affairs (UNDESA), the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute for Statistics (UIS), the World Bank, the Organization for Economic Cooperation and Development (OECD), Eurostat and four United Nations regional commissions.

[4] For further information on the objectives and activities of the Partnership, see http://measuring-ict.unctad.org.

10. Many studies have categorized ICT impacts as economic, social or (less frequently) environmental. However, the picture is usually more complex than this. For example, while some direct impacts of ICT use can be described as economic, there may be indirect impacts that are social or environmental. In addition, direct impacts may be both economic and social, related through human capital. From the perspective of the economy, human capital is a necessary condition for economic growth and competitiveness (World Bank, 2009). ICT usage can enhance human capital in a number of ways, including through its roles in education, literacy, acquisition of knowledge and skills, and development of human networks. Economic and social benefits can accrue to individuals who are gaining skills and knowledge by using ICTs.

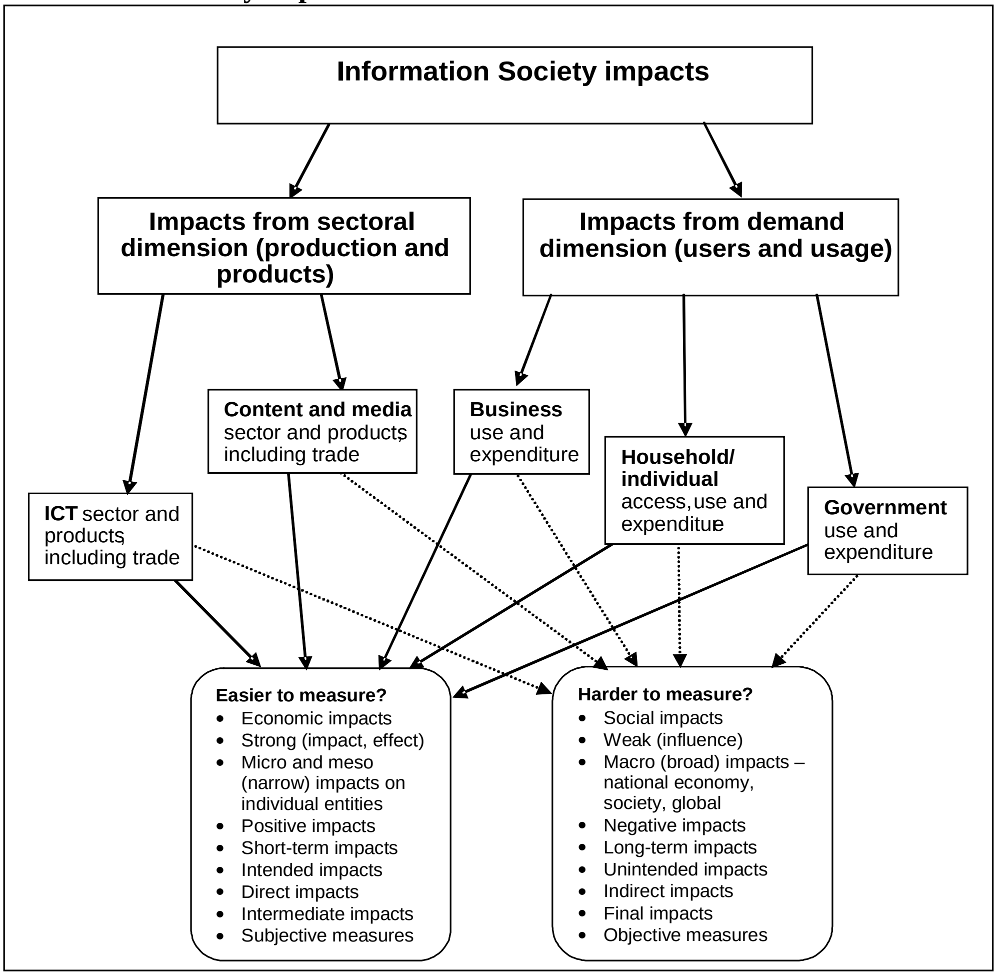
11. There are other economic benefits of ICTs resulting from their use by households and individuals, described by OECD (2009a) as follows:

(a) Final demand for ICT goods and services by households is an important component of overall demand, which may stimulate the growth of the ICT sector and industries that rely heavily on ICTs, for example, media and entertainment;

(b) The diffusion of ICTs among households may create a “critical mass”, allowing firms to realize the full benefits of switching to ICTs, for example, in the delivery of products; and

(c) Use of various ICTs at home may allow firms to introduce teleworking (which potentially brings economic, social and environmental benefits).

Figure 1
Information society impacts measurement model



Source: OECD, 2007.

II. Frameworks and methods for assessing ICT impacts

A. Conceptual frameworks

12. A number of frameworks have been developed to assess different impacts of ICTs. In the model used by OECD (2009a), the following interrelated segments are identified: ICT demand (use and users), ICT supply (the “ICT sector”), ICT infrastructure, ICT products, information and electronic content and ICTs in a wider socio-political context. From this model, OECD (2007) identified some of the impact components as follows:

(a) *Impacts of ICT access and use* on individuals, organizations, the economy, society and environment;

(b) *Impacts of ICT production and trade* on ICT producers, the economy, society and environment;

(c) *Impacts of use and production of "content"* (in particular, "electronic" or "digital" content, which only exists because of ICT) on the economy, society and environment; and

(d) *Influence of other factors* on ICT impacts, for example, skills, innovation, government policy and regulation, existing level of ICT infrastructure.

13. An "ICT4D value chain" model has been developed as a basis for impact assessments (Heeks and Molla, 2009) of ICT for development projects. In this context, the following three elements are distinguished when assessing impacts:

(a) *Outputs*: the micro-level behavioural changes associated with the ICT4D project;

(b) *Outcomes*: the specific costs and benefits associated with the project; and

(c) *Development impacts*: the contribution of the project to broader development goals.

14. ICT4D project impact assessment frameworks often include (Heeks and Molla, 2009) (a) cost–benefit analysis; (b) assessment against project goals; (c) assessment of the effectiveness of communications (on changing behaviour or attitudes); (d) assessment of the impact of ICTs on livelihoods; (e) assessment of whether ICTs meet information requirements; (f) cultural–institutional impacts; and (g) impacts on enterprise performance, relations and value chain.

15. An important aspect of measurement frameworks covers the definitions and classifications applying to its separate elements. The term "ICTs" covers a diversity of ICT products (goods and services) which are primarily intended to fulfill or enable the function of information processing and communication by electronic means, including transmission and display (OECD, 2009a). ICT products have been redefined by the OECD in terms of the United Nations' Central Product Classification (CPC) Version 2 and can be broadly grouped into (a) ICT equipment (computers and peripherals, communication equipment, consumer electronics and components); (b) manufacturing services for ICT equipment; (c) business and productivity software and licensing services; (d) information technology consultancy and services; (e) telecommunications services; and (f) other ICT services. ICT components are also present in a variety of non-ICT products, such as scientific and medical equipment, motor vehicles and manufacturing equipment.

16. The ICT sector includes industries in ICT manufacturing and ICT services (including wholesaling of ICT products).[5]

17. ICT demand can be broadly defined as including (OECD, 2009a):

(a) Use of various ICTs at different levels of intensity and for various purposes;

(b) Use of, and access to, ICTs by individuals, households, businesses, government and other organizations;

(c) Financial aspects, such as ICT asset value of, and investment by, individuals, businesses, government and other organizations; and

(d) Use of ICT components as intermediate inputs to production by the ICT and non-ICT sectors (for instance, electronic components embodied in domestic appliances).

[5] The current version is based on the international standard for classifying industries, the United Nations International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 4.

18. At the CSTD intersessional panel, a model of ICT impact assessment was proposed based on the premise that impacts of ICT arise through ICT supply and demand and, at a country level, are likely to be influenced by:

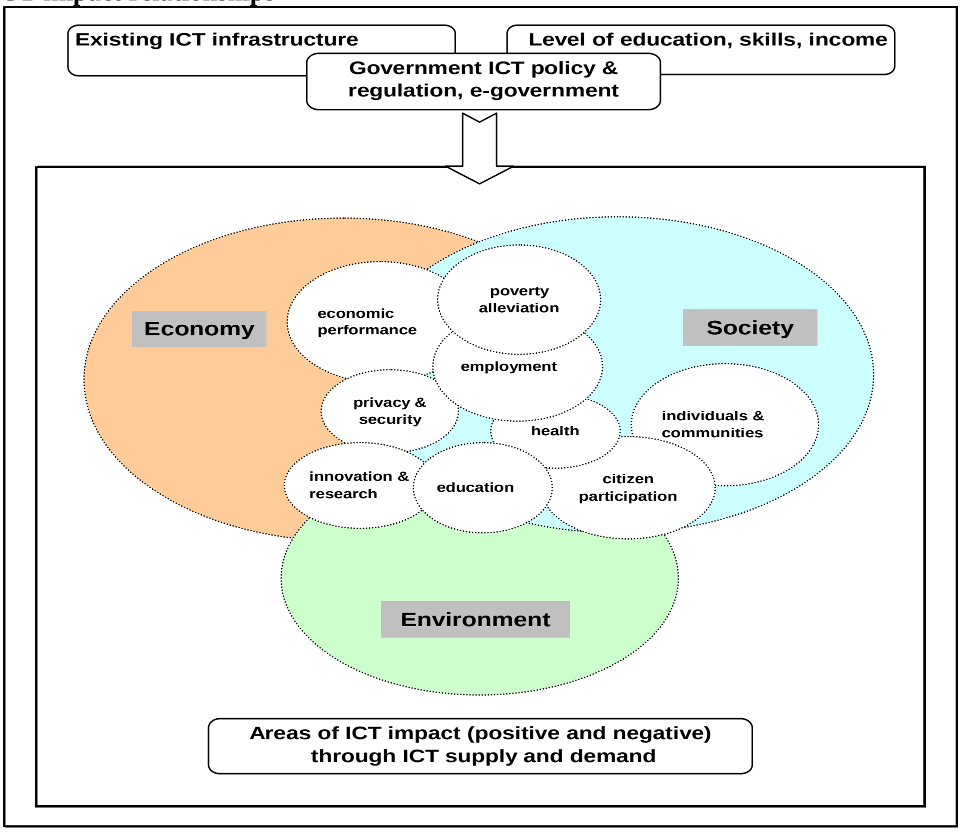
(a) Existing ICT infrastructure (which enables an ICT "critical mass" that can amplify impacts);

(b) Country-level of education, skills and income; and

(c) Government ICT policy and regulation, and the use of e-government.

19. Figure 2 indicates the web of relationships between impact areas and the broader economy, society and environment.

Figure 2
ICT impact relationships



B. Measurement approaches

20. There are several different approaches to assessing the impacts of ICTs for development. The main methodologies are analytical techniques, case studies, controlled experiments, statistical surveys, panel studies and use of administrative data. These approaches are not mutually exclusive. For example, analytical techniques will generally use existing survey or administrative data, and case studies may use data from several sources.

1. Analytical techniques

21. Various analytical techniques have been used to measure the economic impacts of ICT at the macro-economic, sectoral and micro-economic (firm) level. The main techniques are econometric modelling using regression, growth accounting and input-output analysis.

22. Common objectives of an economic impact analysis are to examine the relationship[6] between ICTs and productivity, economic growth or employment. The analysis usually includes other determinants such as labour, non-ICT capital and, for firm–level studies, factors such as firm characteristics, skills and innovation. The role of ICTs can be studied from the supply side – i.e. from the sector producing ICT goods and services – or from the demand side, measured by ICT investment and/or use. Productivity measures relate output (gross output or value added) per unit of inputs. Economic growth is usually measured in terms of change in gross domestic product (GDP) or value added. Employment refers to jobs generated through the direct and indirect impacts of ICTs.

23. The methodological approaches to measuring productivity can be categorized as parametric (such as econometric techniques) and non-parametric (such as growth accounting) (OECD, 2001). Econometric techniques estimate parameters of a production function using a regression model. Growth accounting attributes growth in GDP to increases in physical inputs, such as capital and labour, and advances or improvements in production technology (ITU, 2006). It measures multi-factor productivity (MFP) growth residually (OECD, 2001). Input-output (I/O) matrices can be used to calculate the multiplier effects of ICTs.

24. Many ICT impact studies examine labour productivity – that is, how productively labour is used to generate output. While relatively easy to measure, productivity changes capture the joint influence of a number of factors and change cannot be attributed to any one factor (such as technological change or productivity of individual workers) (OECD, 2001).

25. In recent years, much attention has been paid to firm-level studies of ICT impacts. Such studies can provide insights not available from macro-level data, for example, the complementary roles of skills and organizational change (OECD, 2004). Firm-level studies are based on analysis (usually based on econometric regression models) of data at the individual firm level. Data include firm performance, ICT investment, ICT use (varying from use of computers to advanced e-business applications), firm size and age, skill level, organizational factors and innovation. In some countries, these data are brought together in longitudinal databases. Economic impacts studied include labour productivity, multifactor productivity and value added.

2. Case studies

26. Much of the work on measuring ICT impact is based on case studies, often small-scale and project-based. They may be longitudinal, examining changes over time. They are often very detailed and can involve a number of qualitative and/or quantitative data sources. They can take advantage of a number of existing data sources as well as use collected data. Case studies can be used to explore causation within their scope.

[6] Most analytical techniques are unlikely to be able to demonstrate a causal link, though they can demonstrate strong relationships, some of which may be attributed to "two-way causality".

3. Controlled experiments

27. Controlled experiments are designed to establish causality, by having all independent variables under control. However, in ICT-related studies, the experimenter cannot usually control all the conditions and therefore controlled experiments are rather rare in this field (however, there are some notable exceptions, described below).

4. Statistical surveys

28. Data needed to measure ICT impacts can come from various statistical surveys, including:

(a) Household surveys that collect information about the household entity, including its characteristics, income, expenditure and access to ICTs;

(b) Household surveys that collect information from individuals, including their characteristics, income, expenditure, how they spend their time, how they use ICTs and their perceptions of particular ICTs;

(c) Business surveys that collect information including employment, economic performance, innovation, expenditure on ICTs, use of ICTs and perceptions of ICT impacts; and

(d) Surveys of other entities such as government organizations, collecting information such as employment details, economic performance, expenditure on ICTs, use of ICTs and electronic services offered.

29. Perception questions provide causal information on the impacts of ICTs, but may lack objectivity. However, in respect of individuals' perceptions, it has been argued that without subjective indicators, measurement efforts are bound to be inadequate (ESCWA, 2009).

5. Panel studies

30. Panel studies are longitudinal and may be survey-based (they contrast with "cross-sectional surveys", which collect data at a point in time across a population). A panel is selected at the start of the study and data are collected about its members (e.g. individuals or businesses) during successive periods. Such studies can be useful in examining impacts as they can provide good baseline data and account for time lags.

6. Administrative data

31. Another important data source in the field of ICT statistics is administrative data. The main examples are telecommunications/ICT infrastructure data collected by the International Telecommunication Union (ITU) from member governments, goods trade data compiled by the United Nations Statistics Division (UNSD) and ICT-in-education data compiled by the United Nations Educational, Scientific and Cultural Organization's (UNESCO's) Institute for Statistics (UIS).

C. Strengths and weaknesses of the different approaches and data sources

32. Each of the different methodological approaches and data sources used in the measurement of the impacts of ICTs has strengths and weaknesses as described below.

33. The main analytical techniques to measure the impact of ICTs are econometric regression techniques, growth accounting and input–output analysis. They use existing data and are therefore likely to be inexpensive compared with other approaches. However, a

number of data problems relating to use of analytical techniques for measuring ICT impacts should be noted (OECD, 2001 and 2004):

(a) Measurement of hours worked for productivity measures, especially by industry;

(b) Data from input–output tables may be missing, dated or not integrated with national accounts;

(c) Lack of comparable data on ICT investment (especially software), and deflators adjusted for quality change (hedonic price deflators[7]);

(d) A number of assumptions are required to estimate the services from ICT capital;[8]

(e) In studies of the ICT sector, lack of value added and/or production data and hedonic deflators of output for industries in the ICT sector;

(f) In respect of firm level studies, comparability between countries is challenging because of the diversity of input data and methodologies used. A number of problems arise from the use of unit record data, including confidentiality constraints, difficulties linking records from different data sources, and small (and possibly biased) samples because of limited overlap between sources.

34. Case studies can be flexible and findings are bound by the context in which they are conducted. While their results will not usually be generalizable beyond their context, they may indicate hypotheses or topics that could be assessed more broadly.

35. Controlled experiments are problematic for this topic, as the number of complementary factors involved in an ICT impact can be large, and some unknown. However, when available, the results of such studies provide valuable information.

36. Statistical surveys that are well conducted are able to provide representative data about the population being measured. While surveys are generally expensive to conduct, their results are essential input to many of the analyses required. National statistical surveys of households and businesses are the basis for the Partnership’s core indicators on ICT use. However, a high degree of harmonization of statistical standards is required to enable international comparison of survey output.

37. Panel studies can be useful in following change over time in individual units. One of their advantages is that such data enable investigation of causality where the phenomena being investigated are subject to time lags. However, panel studies are often expensive, especially if the panel is large, and suffer from attrition, i.e. loss of units over time.

38. ICT administrative data form the basis of many of the Partnership’s core indicators. They are often more widely available and may be used as inputs in analyses or case studies. At the same time, their usefulness may be limited because their primary purpose is not statistical. For example, subscription data from ITU’s telecommunications/ICT indicators are often used to measure the penetration of ICTs.

[7] A hedonic deflator adjusts for price and quality, e.g. for computers, the deflator takes changes in speed and memory into account.

[8] Data on the flow of capital services are used in growth accounting to measure the contribution of ICT to economic growth. OECD (2004) Chapter 4 discusses the estimation of capital services.

III. Impacts of ICTs

39. To date, empirical evidence on the impact of ICTs exists in a number of areas, including economic performance, employment, privacy and security, education, health, citizen participation, individuals and communities, and the environment.

A. Economic performance

40. The impact of ICTs on economic growth and productivity can be examined at the aggregate, sectoral and firm level. Effects on poverty alleviation are also considered, although the concept of poverty extends beyond the economic dimension. Empirical evidence on the impact of ICT in economic performance shows positive macro-economic effects as follows OECD (2004, 2008):

(a) Increases in the size and productivity of the ICT sector, and associated effects such as growth in industries that provide inputs to ICT production;

(b) ICT investment across the economy contributes to capital deepening and leads to an increase in labour productivity. However, there may be a "critical mass" limitation for developing countries, whereby impacts of ICT use will only be seen once a certain level of ICT penetration is reached;

(c) MFP growth across the economy arises from the role of ICTs in helping firms innovate and increase their overall efficiency.

41. A growing ICT sector can contribute to aggregate increases in productivity, GDP and trade. An analysis from OECD (2004) reported increases in aggregate labour productivity (value added per person employed) attributable to a strong ICT sector in some OECD countries between 1990 and 2002. For example, the contribution of ICT manufacturing industries for Finland was 0.2 percentage points during 1990–1995 and 0.8 percentage points during 1990–1995. In the case of the Republic of Korea, the relative figures were 0.8 and 1.0 percentage points. The contribution of ICT services industries to aggregate labour productivity growth was typically less than for ICT manufacturing in the same periods.

42. Macro-level research has generally shown a positive link between ICT investment and growth in GDP. Similarly, there have been increased gains attributable to ICTs. OECD (2008) estimated multiplier effects of ICTs in order to study the contribution of ICTs to total GDP and the contribution of ICT industries to economic growth. It was found that, on average, ICT accounted for 2.1 percentage points of the yearly growth of total output of the countries observed (from 2001 to 2006).

43. Most of the analysis on the economic impact of ICTs has been done for OECD countries, although there is some literature on Latin America. A review of research on macro-economic impacts of ICT found that productivity gains in developing countries were mainly generated by the ICT sector, rather than through ICT use. The opposite has been noted for developed countries (UNCTAD, 2007).

44. In respect of developing countries, UNCTAD (2010) notes the recency of deployment of ICT networks and the lack of available data to perform extensive macro-level analysis of the impact of ICT diffusion. The "critical mass" effect,[9] whereby impacts

[9] This arises because of the network nature of ICT – the more people and firms using the network, the more benefits are generated (OECD, 2004).

of ICT use will only be seen once a certain level of ICT penetration is reached, is likely to affect the outcome in developing countries.

45. There is some evidence that the development of a strong ICT sector has led to poverty reduction, although there are few targeted studies on this (UNCTAD, 2010).

46. ICTs enable firms to adopt innovation. Specifically, a study covering OECD countries found that ICTs enable product and marketing innovation. Nevertheless, results suggested that ICTs do not affect the firm's capabilities of invention (OECD, 2010a).

47. Firm-level studies have been used extensively, especially in developed countries, to examine the impact of ICTs on firm performance. They typically involve a number of variables covering ICTs, firm performance and non-ICT factors that might affect performance. There have been a large number of studies in developed countries, which found that use of computers, the Internet and broadband have a positive relationship with productivity. However, this varies among individual businesses according to other factors such as skills and innovation. A particular challenge of firm-level studies is measuring the effect of intangibles such as good management and marketing (UNCTAD, 2007). It is important to highlight the importance of complementary factors such as skills and organizational change and other forms of innovation.

48. The results from developed-country firm-level studies may not always be generalizable to developing countries. One difference is the level of sophistication of ICT use. In developed countries, firm-level studies are increasingly focusing on higher level ICTs such as networks and broadband. In developing countries, lower level ICTs such as computers are likely to be at least as significant (UNCTAD, 2008). For an example of a firm-level study in a developing country, see box below.

Firm–level impacts in Thailand

A 2007 study by UNCTAD and the Thai National Statistical Office analysed the impact of ICT on labour productivity in urban firms with 10 or more employees in the manufacturing sector in Thailand. A simple comparison showed that firms with ICT had higher sales per employee than those without ICT and that sales increased with use of more sophisticated ICTs (computer to Internet to Web presence). An econometric analysis, controlling for non-ICT factors, showed that firms with a combined use of computers, the Internet and the Web had on average 21 per cent higher sales per employee than firms without any of these ICTs. The greatest increase was noted for firms with computers. The study also found that the link with ICT is strongest in large firms, though Internet access had the most effect on small firms, and the link with computers was greatest in young firms.

Source: UNCTAD, 2008.

49. Case study evidence indicates that small and micro-enterprises in low-income countries can benefit from mobile phones used for business purposes; including improving communication with customers and obtaining information on inputs and markets (UNCTAD, 2010). Experience in rural areas suggests that diffusion of mobile phones can improve access to agricultural inputs and market information, monitoring financial transactions and dealing with agriculture emergency situations.

50. Other case studies have indicated that provision of Internet access alone may not bring significant benefits to micro-enterprises; other support and tailored information appear to be needed. The Internet is generally far less accessible to poor communities than mobile phone technology, especially in rural areas. However, the Web and Internet e-mail offer significant potential for communication and information delivery. It appears that use of the Internet by small businesses for more advanced applications (such as e-commerce) in

developing countries is still rare. Several projects have successfully used combinations of technologies in agricultural areas of developing countries, for instance, using mobile phones and radio programmes to provide information and Web platforms to sell produce (UNCTAD, 2010). On the contrary, larger enterprises in developing countries may benefit from use of more sophisticated ICT applications (such as web-based e-commerce and other e-business applications).

51. There may also be spillover benefits. For instance, in Uganda in the cut flower industry, ICT investment in a larger enterprise benefited the whole sector, expanding employment opportunities for growers (InfoDev, 2008). There may furthermore be gains from ICT diffusion along the supply chain (though suppliers who are not connected may be disadvantaged) (UNCTAD, 2010).

52. Broadband is essential to enable enterprises to make full use of Internet-based services and applications. Several studies have indicated that, under the right conditions, more advanced ICTs such as broadband can have a greater economic impact than simpler technologies (e.g. World Bank, 2009). At the same time, many low-income countries still have very limited access to the Internet, especially at broadband speeds (ITU, 2010a). Thus, in these cases, more widely diffused ICTs, such as radios and mobile phones, may offer the greatest scope to contribute to poverty alleviation in the short term, including in combination with other ICTs (UNCTAD, 2010).

53. In 2008, the World Bank conducted an econometric analysis across 120 countries to investigate the impact of higher penetration of broadband and other ICTs on economic growth (the average growth rate of per capita GDP) between 1980 and 2006 (World Bank, 2009). It estimated that impacts for developing countries were a little higher than for developed countries. For developing countries, every 10 percentage point increase in the penetration of broadband services was associated with an increase in per capita GDP of 1.38 percentage points; Internet and mobile phone penetration were associated with a 1.12 and 0.81 percentage point increase respectively. The author made the point that the results of such an analysis may in part be attributed to "two-way causality" (where demand for ICTs rises with wealth, which leads to increased penetration, which then increases wealth).

54. There has been relatively little focus on the negative economic impacts associated with ICT diffusion. Negative economic impacts include various privacy and security impacts (these are discussed below), systems failures (which could be potentially catastrophic) and loss of productivity because of employees' use of ICTs (particularly the Internet) during work time.

B. Employment

55. ICTs have roles in the creation of employment and self-employment opportunities. Several impact channels can be identified; some are direct, through growth of the ICT sector and ICT-using industries, and others indirect through multiplier effects. Case study evidence in developing countries indicates positive impact of ICT skills on employment prospects. Arguably, ICTs can also lead to loss of employment as tasks are automated.

56. In respect of the ICT sector in low-income countries, telecommunications services might offer the greatest opportunities for employment creation (UNCTAD, 2010). Only a small number of developing countries have a well-developed ICT sector. For those that do, ICT manufacturing can be significant in employment terms, sometimes involving the poor. In China, for example, the ICT sector provides employment to some 26 million internal migrant workers, with evidence that a large portion of their earnings is remitted to poor rural and remote areas.

57. Broadband penetration can increase employment in at least three ways (Katz, 2009). The first is the direct effect of jobs created in order to develop broadband infrastructure; the second is the indirect effects of employment creation in businesses that sell goods or services to businesses involved in creating broadband infrastructure; and the third is induced effects in other areas of the economy. Data presented for Argentina and Chile, comparing regional broadband penetration and employment growth, show a moderately positive linear relationship.

58. Evidence from six Latin American countries suggests that Internet use by individuals is associated with increased earnings (Navarro, 2009). The study found significant differences between salaried and self-employed workers. For the former, there was a large and statistically significant positive return to Internet use on earnings for all countries except Paraguay (where the difference was large but not statistically significant). The earnings advantage ranged between 18 per cent (Mexico) to 30 per cent (Brazil and Honduras). Results showed a positive and statistically significant effect of use only at work and this was always greater than the return to use only at other places (including home). However, use at work as well as other places displayed higher returns than use only at work. For self-employed workers, results were similar, with Internet users having higher earnings. Difficulties controlling for pre-existing characteristics indicate that the results show an upper bound on the impact of Internet use on earnings.

C. Privacy and security

59. There are a number of potential adverse impacts of ICTs on the privacy and security of individuals and organizations. These include commercial losses from denial of service attacks, data loss through theft or corruption, and disclosure of confidential information. The OECD model business and household surveys (OECD, 2009a) and Eurostat’s 2010 model community surveys of enterprises and households (Eurostat, 2010) included questions on the incidence of harmful security incidents. Such questions do not quantify the extent of the impact, although they are useful in measuring how widespread the problems are. Far more serious potential negative impacts could arise because of the increasing reliance of critical infrastructure on ICTs and the serious consequences of failure.

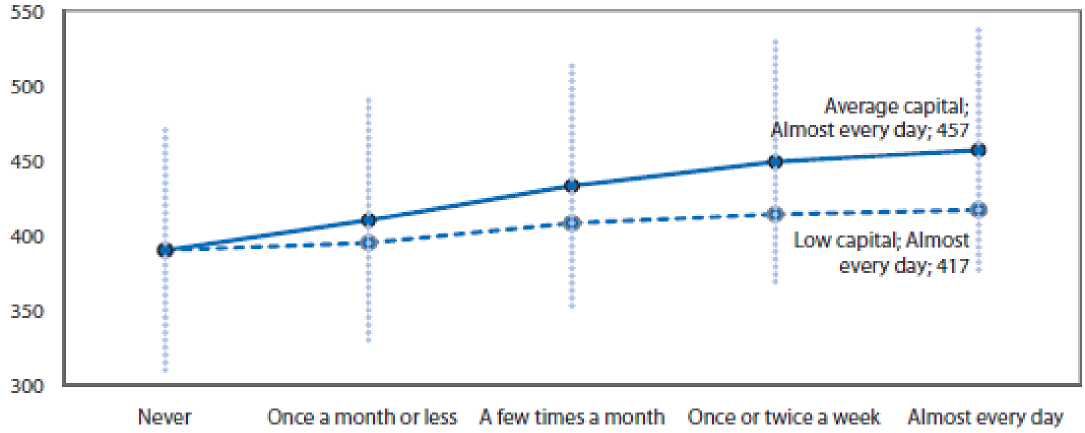
D. Education

60. There is considerable policy interest in the benefits that ICTs can bring to education, which is a particular focus of the Millennium Development Goals (MDGs) and the WSIS outcomes.

61. Potential benefits of ICTs in education include tools for teaching and learning processes, provision of skills needed in an information society, motivation for learning, development of teacher’s technology skills, and increased access of the community to adult education and literacy.

62. Impact of ICTs on school performance is a complex topic and not easily measured. It has been observed that increased use of computers among students improves student performance only if accompanied with policies that also improve skills, capital (economic and cultural resources, personal characteristics, school resources, and ICT access), and stimulate students’ interests and attitudes (OECD, 2010b).

Figure 1
Increase in science scores due to computer use: average and differential



Source: OECD 2010b.

63. Empirical experiments that are highly controlled can help establish causal relationships between ICT use and educational outcomes (Kozma, 2005). In Vadodara, India, in 2000, 100 primary schools were each provided with four computers. A controlled experiment commenced in 2002–03 and ran for two years. Half the schools were randomly allocated with training and educational software. Students in those schools played educational computer games for two hours a week and scored significantly higher on mathematics tests than students in the control schools. The bottom group of students benefited most, with girls and boys benefiting equally (Abhijit *et al*., 2007). Controlled experiments from the United States, Kenya and Uganda also showed positive impacts on student learning arising from some types of use of computers in specific school subjects, while more general availability and use of computers at school did not affect student learning (Kozma, 2005). Analysis of learning outcomes from the Khanya project in South Africa showed a positive relationship between use of the ICT-based Master Maths programme and mathematics scores on standardized tests (James and Miller, 2005). The analysis was controlled, with comparisons made between a random sample of "experimental" and "control" schools. The study found that scores for learners on the ICT-based mathematics programmes were significantly better than for other students.

E. Health

64. ICTs are expected to bring benefits in health from use of electronic health records, telemedicine and mobile health, as a source of information and as enabling complex and networked medical equipment. Evidence from case studies indicates positive impacts of ICTs in health by benefits to individuals through broadband-enabled telemedicine, cost-saving benefits to health systems, and interoperability between electronic health records and other clinical and non-clinical systems.

65. The World Health Organization, through its Global Observatory for eHealth, has plans to establish indicators for monitoring e-health and assessing the impact of eHealth on health systems (WHO, 2010).

66. The World Bank (2009) described the impact of mobile phones on health outcomes in developing countries. It cited examples of drug inventory management and monitoring programmes, using the mobile phone as an interface. According to the same study, broadband-enabled telemedicine is widespread in developed and developing countries, yet

there are few studies on its effectiveness. It described an eye hospital in southern India that connects rural communities using a wireless broadband network. The rural clinics screen about 1,500 patients a month using a Web camera. Doctors at the hospital are able to diagnose problems and distinguish minor problems, which can be treated locally, from more serious problems. This is of great benefit to individuals, providing rapid diagnosis and treatment, and in many cases saving the cost and inconvenience of travel.

67. The socio-economic and financial impacts of interoperable electronic health record (EHR) and ePrescribing systems were investigated via several case studies in Europe and the United States (European Commission (EC), 2010). Evaluation was based on cost-benefit analyses and, for all cases, the socio-economic gains to society exceeded the costs. A common feature of all the studies is that interoperability (between EHR and other clinical and non-clinical systems) is a prime driver of benefits. The benefits were found to be distributed unevenly, with health provider organizations benefiting most (an average of 61 per cent of the benefits); patients and medical staff each gained, on average, 17 per cent of the benefits. Important observations are that benefits to providers tend to be long term (with an average seven years before a net positive benefit occurs) and that solutions are context-specific.

F. Citizen participation, individuals and communities

68. ICTs can facilitate democratic processes and increase participation by citizens. Such impacts may occur as a result of greater communication and information dissemination offered by ICTs, through use of social networking sites, e-mail, e-government and mobile phones. They are also frequently enabled by electronic information and services offered by government (e-government), usually via the Internet or mobile phone. E-government can improve democratic processes and encourage citizen participation in decision-making.

69. Many of the impacts on individuals of using ICTs can be seen as “intermediate”; that is, they concern (a) how ICT is changing activities such as shopping, banking and dealing with government; (b) how they spend their income; (c) how they spend their time; and (d) how they communicate with family, friends and the broader community.

70. It is clear that there are potential negative and positive social impacts of ICT use for individuals and communities. On the negative side, there is increasing concern about the impact on children of Internet use, for example, (a) exposure to undesirable content and overuse of Internet applications such as online games (see ITU, 2010b); (b) use of the Internet to disseminate images of pornography and violence against women; (c) Internet-based crime; (d) copyright infringement; and (e) security and privacy concerns.

71. Positive impacts are potentially numerous and include the ease and immediacy of communicating, finding information and accessing services. For minority groups and those who are socially disadvantaged, such impacts may be particularly beneficial. The World Bank (2009) discussed the potential empowerment of women when they are able to access public services electronically at home or locally and of minorities when they are able to gain electronic access to relevant public information on rights and benefits.

72. Using case study evidence, the United Nations Economic and Social Commission for Western Asia (ESCWA) (2009) summarized the positive social impacts of ICT in poor communities as improving communication, facilitating knowledge-sharing, networking within and between communities, and improving the delivery of awareness-raising activities.

73. Final-level impacts are generally harder to measure than intermediate impacts (OECD, 2007). However, some survey data on final impacts exist. Statistics Finland (cited by OECD, 2007) studied the links between ICTs and social capital and found significant

correlations between ICT use and the components of social capital, community involvement and size of the social network. ITU (2006) cited similar evidence from South Africa concerning use of mobile phones to improve relationships with friends and family.

74. In respect of perceived impacts, results from the international[10] 2003 Adult Literacy and Life Skills surveys included a comparison of respondents' perceived usefulness of computers with their literacy, numeracy and problem-solving skill levels. The study found a positive relationship, though there was no suggestion of causality (Statistics Canada and OECD, 2005).

75. A perceptions survey of 1,500 mobile phone users in Nigeria found that a high proportion reported savings in travel time and lower costs for travel or entertainment. Uses of mobile phones included education, health and entertainment purposes (Pyramid Research, 2010).

G. Environment

76. Measurement of the relationship between ICTs and the environment is a relatively new area. A number of positive and negative links exist between ICTs and the environment (OECD 2009b):

(a) Positive environmental impacts of ICTs: these include their potential to improve the efficiency of a range of energy-using processes and equipment, facilitation of dematerialization,[11] and ICTs' role in climate change monitoring and modeling, dissemination of information, and administration of carbon pollution reduction schemes; and

(b) Negative environmental impacts of ICTs: from energy needs and greenhouse gas (GHG) emissions arising from ICT use, manufacturing and transport of ICT products; and pollution from disposal of e-waste.

77. Some of the impacts of ICTs on environmental outcomes can be demonstrated using scientific knowledge and other available information. For example, the GHG emissions attributable to power-hungry data servers can be calculated if their power use and source of power is known.[12]

78. For some other aspects, impacts are less clear and therefore difficult to measure, for example, the impact of Internet purchasing on GHG emissions. Indirect impacts are even more difficult to measure, for example, the role of ICTs in facilitating a knowledge-based society with awareness of environmental issues. Some data relevant for measuring the potential impact of ICTs on the environment through dematerialization is already included in the Partnership's core set of individual use indicators, for example, the use of the Internet for various activities. However, as mentioned above, assumptions would be required to convert that information into measures of impact.

79. Despite the importance of the topic, empirical evidence on the impact of ICTs on environmental outcomes is lacking. Several analytical studies have attempted to estimate the impact. For example, The Climate Group and GeSI (2008) estimated that the ICT sector and ICT products are responsible for about 2 per cent of global GHG emissions and that

---

[10] The 2003 survey involved Bermuda, Canada, Italy, Mexico, Norway, Switzerland and the United States.

[11] Use of the Internet as a substitute for "material" activities, for instance, downloading online newspapers, Internet banking, downloading digital content.

[12] Assuming that GHG levels and climate change are causally linked.

this will grow unless mitigated. They also found that the greatest potential for a positive impact of ICTs is their use to increase the energy efficiency of industrial processes that are high GHG gas emitters (power transmission and distribution, buildings, manufacturing industry and transport). A 2004 report commissioned by the European Commission's Institute for Prospective Technological Studies (IPTS, 2004) found a greater potential for GHG reduction through dematerialization.

IV. Findings and suggestions

A. Findings

80. The following main findings were highlighted by the CSTD intersessional panel and put forth for consideration by the Commission at its fourteenth session, scheduled to take place in Geneva from 23-27 May 2011:

(a) Measurement of the impacts of ICTs is a very important issue for policymakers and business leaders. However, measuring the impact of ICTs presents some difficulties due to the diverse and changing nature of ICTs, the complexity of ICT impacts and the more general difficulties of illustrating a cause-and-effect relationship between dependent and independent variables;

(b) Reflecting the complexity of measuring ICT impacts, there is a variety of methodological approaches and these are not mutually exclusive. Particular approaches appear to be generally suited to measure a particular type of impact. For example, econometric regression models suit the analysis of firm level impacts of ICT and case studies are better suited to the evaluation of small scale ICT projects;

(c) Most of the empirical research examined had found positive impacts for economies, businesses, poor communities and individuals. Impacts are direct and indirect, and include impacts across the economic, social and environmental realms, and therefore potentially enable achieving several MDGs;

(d) In terms of poverty alleviation, there is case study and some evidence that ICTs may contribute. Mechanisms include "trickle-down" effects from overall economic growth, employment and self-employment opportunities, establishment of micro businesses that are in the ICT sector or related to it (such as retailing of mobile phone cards), and direct use of ICTs such as mobile phones by small businesses, including in rural areas;

(e) While there are clearly also negative impacts of ICTs, there has been less research in this area. Evidence of negative impacts is more likely to be anecdotal and includes adverse economic and social impacts on individuals and organizations, and negative impacts on the environment;

(f) Many data gaps remain in the area of ICT impacts, particularly with regard to developing countries. Evidence for developed countries has tended to focus on macro- and micro-level analyses, usually supported by extensive statistical datasets. Much developing country evidence is of a local "case study" nature. While this is useful, the extension to different situations or to a country level is challenging;

(g) It appears that evidence from developed countries may not apply to developing countries, although the methods of investigation may. In low-income countries, access to more advanced ICTs is problematic, leaving a much greater role for ICTs such as radio, television and mobile phones to have important economic and social impacts, at least in the short term;

(h) There are few studies or surveys that provide internationally comparable data on the impacts of ICTs. The main exceptions are macro-economic analyses carried out by OECD and the World Bank, firm-level analyses covering mainly European countries, OECD's PISA study and ICT impact perceptions data from some surveys that are harmonized internationally;

(i) There are internationally agreed standards for many aspects of ICT measurement. While these are necessary for measuring the impact of ICTs, they need to be complemented by standards specifically targeted at measuring the impact of ICT. These could include methodologies for econometric approaches and model questions for perceived impacts. The findings of the Partnership's Task Group on Impacts will be important in overcoming this deficit of measurement standards.

B. Suggestions

81. The CSTD intersessional panel has put forth the recommendations set out below for consideration by the Commission at its fourteenth session:

(a) Explore the possibility of organizing an international conference dedicated to the measurement of impacts of ICTs, arranged jointly by the CSTD and the Partnership on Measuring ICT for Development. This conference would set in train a process to check data availability and develop impact assessments. Member States are encouraged to express interest in hosting and supporting such an event;

(b) Call on the Partnership on Measuring ICT for Development, which is a key player in enhancing the availability and quality of internationally comparable ICT data worldwide, to further develop its work on measuring the impact of ICTs. This also includes the development of practical guidelines, methodologies and indicators;

(c) Encourage research on measuring the impact of ICTs in developing countries;

(d) Promote impact assessment in the following main areas: economic performance, employment, education, health and the environment;

(e) Promote impact assessment of ICTs on poverty and identify the kind of knowledge and skills that are needed to boost impacts;

(f) Call on governments to share information about country case studies and the use of micro-data. This could be done through online consultations among countries;

(g) Promote collaboration between countries through a capacity-building exchange programme in the area of ICT for development. The objective of the programme would be to promote the sharing of skills and knowledge between participating countries;

(h) Call on governments to collect relevant data at the national level on ICTs, in particular the core ICT indicators established by the Partnership on Measuring ICT for Development and endorsed by the United Nations Statistical Commission. Capacity-building and allocation of sufficient funds are also needed to undertake surveys;

(i) Call on development partners to provide financial support needed to facilitate more capacity-building and technical assistance from relevant international organizations to developing countries, and especially the least developed countries.

References

Abhijit VB, Cole S, Duflo E and Linden L (2007). Remedying Education: Evidence from Two Randomized Experiments in India. *The Quarterly Journal of Economics*. MIT Press, vol. 122(3), http://www.povertyactionlab.org/evaluation/computer-assisted-learning-project-pratham-india.

EC (European Commission) (2010). *Interoperable eHealth is Worth it: Securing Benefits from Electronic Health Records and ePrescribing*, http://ec.europa.eu/information_society/activities/health/docs/publications/201002ehrimpact_study-final.pdf.

ESCWA (2009). *Impact of ICT on Community Development in ESCWA Member Countries*. http://www.escwa.un.org/information/publications/edit/upload/ictd-09-15.pdf.

Eurostat (2010). *Model ICT use questionnaires, years 2002-2011*.

Heeks R and Molla A (2009). *Impact Assessment of ICT-for-Development Projects: A Compendium of Approaches*, Paper No. 36, Development Informatics Working Paper Series. http://www.sed.manchester.ac.uk/idpm/research/publications/wp/di/documents/di_wp36.pdf.

infoDev (2008). *Improving Business Competitiveness and Increasing Economic Growth in Uganda The Role of Information and Communication Technologies*. The World Bank, Washington, D.C., http://www.infodev.org/en/Publication.559.html.

IPTS (Institute for Prospective Technological Studies) (2004). *The Future Impact of ICTs on Environmental Sustainability*. Technical Report EUR 21384 EN. http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=1208.

ITU (International Telecommunication Union) (2005). *WSIS Outcome Documents: Geneva 2003 – Tunis 2005*, http://www.itu.int/wsis/outcome/booklet.pdf.

ITU (2006). *World Telecommunication/ICT Development Report (8th ed.): Measuring ICT for Social and Economic Development*. http://www.itu.int/ITU-D/ict/publications/wtdr_06/index.html.

ITU (2010a). *Measuring the Information Society 2010*.

ITU (2010b). *Child Online Protection: Statistical Framework and Indicators*. http://www.itu.int/ITU-D/ict/publications.

James T and Miller J (2005). Developing a Monitoring and Evaluation Plan for ICT in Education. In D.A. Wagner *et al.* (eds.), *Monitoring and Evaluation of ICT in Education Projects: A Handbook for Developing Countries*, *info*Dev, http://www.unescobkk.org/education/ict/online-resources/e-library/elibrary-themes/monitoring-and-measuring-change/monitoring-and-evaluation-of-ict-in-education-projects/.

Katz RL (2009). *Estimating broadband demand and its economic impact in Latin America*. http://unpan1.un.org/intradoc/groups/public/documents/gaid/unpan036761.pdf.

Kozma RB (2005). Monitoring and Evaluation of ICT for Education Impact: A Review. In D.A. Wagner *et al.* (eds.), *Monitoring and Evaluation of ICT in Education Projects: A Handbook for Developing Countries*, *info*Dev.

Navarro L (2009). The Impact of Internet Use on Individual Earnings in Latin America. United Nations Economic Commission for Latin America and the Caribbean, unpublished.

OECD (2001). *OECD Productivity Manual: A Guide to the Measurement of Industry-Level and Aggregate Productivity Growth*. http://www.oecd.org/dataoecd/59/29/2352458.pdf.

OECD (2004). *The Economic Impact of ICT, Measurement, Evidence and Implications.* http://www.oecd.org/bookshop?pub=922004051P1.

OECD (2007). Measuring the Impacts of ICT Using Official Statistics. Working Party on Indicators for the Information Society. DSTI/ICCP/IIS(2007)1/FINAL. http://www.oecd.org/dataoecd/43/25/39869939.pdf.

OECD (2008). The Contribution of the ICT Sectors to Economic Growth in OECD Countries: Backward and Forward Linkages. DSTI/ICCP/IIS(2008)2.

OECD (2009a). *Guide to Measuring the Information Society, 2009*. www.oecd.org/sti/measuring-infoeconomy/guide.

OECD (2009b). *Measuring the Relationship between ICT and the Environment*. http://www.oecd.org/dataoecd/32/50/43539507.pdf.

OECD (2010a). Are ICT Users More Innovative? An Analysis of ICT-enabled Innovation in OECD Firms. DSTI/ICCP/IIS(2010)8/REV1.

OECD (2010b). *Are the New Millennium Learners Making the Grade?: Technology Use and Educational Performance in PISA 2006*. Educational Research and Innovation, OECD Publishing, 10.1787/9789264076044-en.

Partnership on Measuring ICT for Development (2008a). Task Group on Impacts: Terms of Reference. Unpublished.

Partnership on Measuring ICT for Development (2008b). *The Global Information Society: a Statistical View, 2008.* http://www.unctad.org/en/docs//LCW190_en.pdf.

Partnership on Measuring ICT for Development (2010). *Core ICT Indicators*, http://www.itu.int/ITU-D/ict/partnership/material/Core%20ICT%20Indicators%202010.pdf.

Pyramid Research (2010). *The Impact of Mobile Services in Nigeria: How Mobile Technologies Are Transforming Economic and Social Activities*.

Statistics Canada and OECD (2005). *Learning a Living: First Results of the Adult Literacy and Life Skills Survey*. http://www.oecd.org/dataoecd/44/7/34867438.pdf.

The Climate Group and GeSI (Global e-Sustainability Initiative) (2008). *SMART 2020 – Enabling the low carbon economy in the information age.* http://www.smart2020.org/.

UNCTAD (2007). *Information Economy Report 2007–2008: Science and technology for development, the new paradigm of ICT*. United Nations publication. Sales No. E.07.II.D.13. New York and Geneva.
http://www.unctad.org/Templates/webflyer.asp?docid=9479&intItemID=3594&lang=1.

UNCTAD (2008). *Measuring the impact of ICT use in business: The case of manufacturing in Thailand*. United Nations publication. Sales No. E.08.II.D.13. New York and Geneva. http://www.unctad.org/en/docs/sdteecb20073_en.pdf.

UNCTAD (2010), *Information Economy Report 2010: ICTs, Enterprises and Poverty Alleviation*. United Nations publication. Sales No. E.10.II.D.17. New York and Geneva. http://www.unctad.org/ier2010.

World Bank (2009). *Information and Communication Technologies for Development: Extending Reach and Increasing Impact*. http://go.worldbank.org/NATLOH7HV0.

WHO (World Health Organization) (2010). *Global Observatory for eHealth Featured Projects* web page. http://www.who.int/goe/en/.