Commission on Science and Technology for Development

CSTD 2010-2011 inter-sessional panel
15-17 December 2010
Geneva

Issues Paper on

MEASURING THE IMPACT OF ICT FOR DEVELOPMENT

NOT TO BE CITED

Prepared by the UNCTAD Secretariat

Abstract

This paper explores why measuring the impacts of ICT for development is important – and why it is statistically challenging. Measuring impacts in any field is difficult, but for ICT there are added complications because of its diversity and rapidly changing nature. A number of impact areas are identified in Section I and their relationships explored in the context of their place in the social, economic and environmental realms. The result is a complex web of relationships between individual impact areas (such as economic growth and poverty alleviation) and background factors such as a country's level of education and government regulation.

Existing measurement frameworks are described in Section I and relevant statistical standards examined. The latter includes internationally agreed standards for the ICT sector, ICT products and ICT demand. The contribution of the Partnership on Measuring ICT for Development (and its member organizations) to ICT measurement, and its goals for measuring ICT impacts, are outlined.

Methodologies used in the measurement of ICT are discussed and compared in Section II of the paper and empirical evidence reviewed in Section III. Most research conducted has found positive effects of ICT in the impact areas investigated. However, research has tended to focus on positive rather than negative impacts and so the latter tend to be indicated by anecdotal evidence. There is relatively little evidence from developing countries and indications that findings in respect of developed countries may not apply to developing countries. In respect of both developed and developing countries, there are few studies that provide internationally comparable evidence.

The difficulties of ICT impact measurement, major data gaps and lack of clear statistical standards suggest several issues for consideration by the CSTD. These are presented in the final section of the paper.

Acknowledgements

This paper was prepared by the CSTD Secretariat with the assistance of Sheridan Roberts, consultant to UNCTAD. Useful comments and material were provided by Mariana Balboni and Nestor Bercovich of UNECLAC, Seema Hafeez of UNDESA, Vincenzo Spiezia of OECD, Susan Teltscher of ITU and Rami Zaatari of UNESCWA.

TABLE OF CONTENTS

Section I. Introduction and conceptual framework

1. Information and communication technology (ICT) offers the promise of fundamentally changing the lives of much of the world's population. In its various forms, ICT affects 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 (paragraph 28) from the first phase (2003) 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." (ITU, 2005)

2. While much progress has been made in measuring ICT infrastructure and use, measurement of the impact of ICT presents a number of statistical challenges. Against this background, the United Nations Commission on Science and Technology for Development (CSTD) at its thirteenth annual meeting in May 2010, identified measuring the impact of ICT for development as a priority area of work and asked the CSTD Secretariat to prepare this background paper on the topic. The paper is divided into four sections. The first provides some background to why it is important to measure the impacts of ICT and the challenges involved in that measurement. It also presents frameworks for conceptualizing and measuring the impact of ICT. The second section discusses different methodological approaches to measuring ICT impact. The third section briefly reviews the empirical evidence in selected impact areas. The final section concludes and proposes a set of questions to consider.

The World Summit on the Information Society

3. The *Tunis Commitment* from the second phase of the World Summit on the Information Society (WSIS) expressed a strong belief in the development potential for ICT, stating that

> "The Tunis Summit represents a unique opportunity to raise awareness of the benefits that Information and Communication Technologies (ICTs) can bring to humanity and the manner in which they can transform people's activities, interaction and lives, and thus increase confidence in the future." (ITU, 2005).

4. The Geneva *Plan of Action* (paragraph 6) included ten targets to be achieved by 2015, of which six were to improve connectivity (for instance, between villages, educational institutions, libraries, hospitals and government organizations). There were three targets on ICT access (radio and television, other ICT

and Internet) by the world's population and a target on adapting education curricula to meet the challenges of the information society.[1] From the targets, some important impact areas can be inferred:

- Impacts of ICT access, especially on poor and rural communities;
- Impacts of ICT use on educational outcomes and the importance of school curricula in preparing students for the information society;
- Impacts of ICT networks on health institutions and health outcomes;
- Various impacts arising from the availability of e-government services; and
- Impacts of improving access to information and knowledge, by suitable access to electronic content.

5. The Geneva *Plan of Action* (paragraphs 14-22) also suggested a number of 'action lines', including promotion of ICT applications that can support sustainable development.[2] The *Tunis Commitment* (paragraph 2) included statements on the potential benefits of ICT to the world's population, linking them to achievement of the Millennium Development Goals (MDGs) (ITU, 2005).

The Partnership on Measuring ICT for Development

6. Much of the progress in measuring ICT 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* referred to the development of statistical indicators for "international performance evaluation and benchmarking" (paragraph 28). The *Partnership* was subsequently launched at UNCTAD XI in June 2004. The *Tunis Agenda* (paragraph 114) specifically mentioned the *Partnership* and its role in the measurement of ICT impact.

7. The work of the *Partnership* is directed towards achieving internationally comparable and reliable ICT statistics which, among other things, 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 the provision of technical assistance to developing countries. The *Partnership* has several task groups, including the *Task Group on Impacts,* which is led by the Organisation for

[1] ITU assessed progress against the targets in 2010 (ITU, 2010a).
[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), the United Nations Conference on Trade and Development (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 Organisation for Economic Co-operation and Development (OECD), Eurostat and four United Nations Regional Commissions (the UN Economic Commission for Africa, the UN Economic Commission for Latin America and the Caribbean, the UN Economic and Social Commission for Asia and the Pacific, and the UN Economic and Social Commission for Western Asia).

Economic Co-operation 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]

Challenges in measuring the impact of ICT

8. It may seem obvious that there are significant impacts of ICT. However, as stated succinctly by ITU (2006): "You want to know the difference information and communication technologies make? Try to live without them…" Nevertheless, illustrating impacts of ICT statistically is far from simple, for several reasons:

- There are a number of different ICTs, with different impacts in different contexts and countries. They include goods (such as mobile phone handsets) and services (such as mobile telecommunications services) which change rapidly over time;
- Many ICTs are general purpose technologies, which facilitate change and thereby have indirect impacts;
- It is difficult to determine what is meant by 'impact'. For example, a model proposed by the OECD for ICT impacts (Figure 1) highlights the diversity of impacts, in terms of intensity, directness, scope, stage, timeframe and characterization (economic/social/environmental, positive/negative, intended/unintended, subjective/objective); and
- 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.

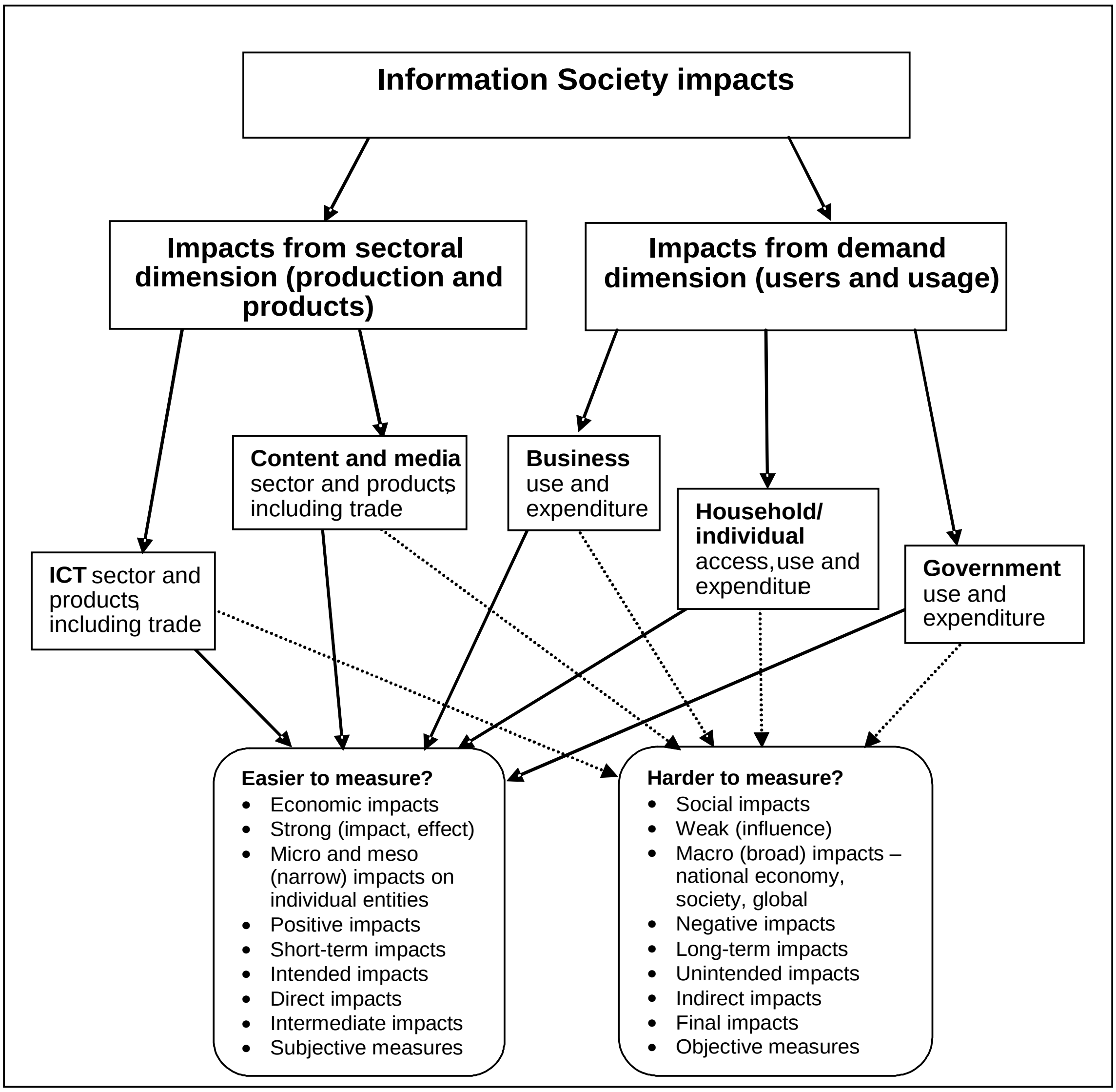
9. Many studies have categorized ICT impacts as economic, social or (less frequently) environmental. However, the picture is usually more complex than this. For example, while some direct impacts of ICT use can be described as economic, there may be indirect impacts that are social or environmental.[5] In addition, direct impacts may be both economic and social, related through human capital, which is defined by the OECD as "productive wealth embodied in labour, skills and knowledge." 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 will usually accrue to individuals who are gaining skills and knowledge by using ICT.

[4] For further information on the objectives and activities of the *Partnership*, see http://measuring-ict.unctad.org.
[5] The United Nations Economic and Social Commission for Western Asia (UNESCWA, 2009) discussed the overlap between economic and social impacts, for instance, where communicating and networking for social purposes result in new business opportunities.

10. There are other economic benefits of ICT resulting from its use by households and individuals, described by the OECD (2009a) as follows:

- 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 ICT, for example, media and entertainment;
- The diffusion of ICTs among households may create a 'critical mass' allowing firms to realize the full benefits of switching to ICT, for example, in the delivery of products; and
- 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.

Measurement frameworks

11. It is useful to consider where impacts lie in a broader information society conceptual model. The model used by the OECD to illustrate the information society (OECD, 2009a) identifies the following inter-related segments: *ICT demand* (use and users), *ICT supply* (the 'ICT sector'), *ICT infrastructure*, *ICT products*, *Information and electronic content* and *ICT in a wider socio-political context*.

12. OECD (2007) discussed the impacts components of the conceptual model as follows:[6]

- *Impacts of ICT access and use* on individuals, organizations, the economy, society and environment;
- *Impacts of ICT production and trade* on ICT producers, the economy, society and environment;
- *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
- *Influence of other factors* on ICT impacts, for example, skills, innovation, government policy and regulation, existing level of ICT infrastructure.

13. With specific reference to ICT4D projects, an *ICT for development* (ICT4D) *value chain* has been proposed as a basis for impact assessments (Heeks and Molla, 2009). It starts with precursors and proceeds to inputs, deliverables, outputs, outcomes and development impacts. The authors consider the last three to be impacts and distinguish them as follows:

- *Outputs* are the micro-level behavioural changes associated with the ICT4D project;
- *Outcomes* are the specific costs and benefits associated with the project; and
- *Development impacts* are the contribution of the project to broader development goals.

14. ICT4D project impact assessment frameworks often include (Heeks and Molla, 2009): cost-benefit analysis; assessment against project goals; assessment of the effectiveness of communications (on changing behaviour or attitudes); assessment of the impact of ICT on livelihoods; assessment of whether ICT is meeting information requirements; cultural-institutional impacts; and impacts on enterprise performance, relations and value chain.[7]

15. An important aspect of measurement frameworks are definitions and classifications applying to its separate elements. The following paragraphs provide a brief overview of key international standards that define ICT products and the ICT sector, as well as the concept of ICT demand applied in this paper.

---

[6] See also ITU (2006).

[7] Each assessment framework includes information on the nature of data and the requirements of data collection. A particular framework may accommodate different analytical techniques and data sources.

16. The term 'ICT' covers a diversity of ICT products (goods and services) which are primarily intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display (OECD, 2009a). ICT products have most recently been classified by the OECD in terms of the United Nations' Central Product Classification (CPC) Ver. 2 and can be broadly grouped into ICT equipment (computers and peripherals, communication equipment, consumer electronics, and components); manufacturing services for ICT equipment; business and productivity software and licensing services; information technology consultancy and services; telecommunications services; and other ICT services.[8] ICT components are also present in a variety of non-ICT products, such as scientific and medical equipment, motor vehicles and manufacturing equipment.[9] The manufacture and use of such products is not usually captured in ICT impact studies.

17. The ICT sector includes industries in ICT manufacturing and ICT services (including wholesaling of ICT products). The current version is based on the international standard for classifying industries, the United Nations ISIC[10] Rev. 4.[11]

18. The concept of ICT demand for the purposes of this paper is broad and follows OECD (2009a).[12] It includes:

- Use of various ICTs at different levels of intensity and for various purposes;
- Use of, and access to, ICT by individuals, households, businesses, government and other organizations;
- Financial aspects, such as ICT asset value of, and investment by, individuals, businesses, government and other organizations; and
- Use of ICT components as intermediate inputs to production by the ICT and non-ICT sectors (for instance, electronic components embodied in domestic appliances).

19. It is useful to distinguish the incidence of use (for example, the proportion of individuals using the Internet) and the intensity of use. While investment in ICT is an indicator of intensity, there are a number of measurement issues that make international comparison problematic at both the micro and macro

[8] An earlier, and broader, version of ICT goods was based on the 1996 and 2002 Harmonized System used for classifying goods trade (OECD, 2005a).
[9] The 2003 definition of ICT goods included many such products, whereas the current version does not.
[10] International Standard Industrial Classification of All Economic Activities (ISIC).
[11] An earlier version, released in 2002 and based on ISIC Rev. 3.1, was somewhat broader, including also manufacturing of some goods that use ICT products. For more information, see OECD (2009a), *Partnership* (2010) and UNCTAD (2009).
[12] A note on terminology. Various terms are used in this area of measurement. 'ICT use' refers to use of ICT by entities (except households). 'ICT access' refers to availability of ICT and is generally used in the context of household access to ICT. A business or government organization may also have access to an ICT (for example, an extranet) though it is generally assumed that it will be used. 'ICT diffusion' is generally used in a broad sense, analogous to 'ICT demand'.

levels. The *Partnership*'s work on developing core ICT indicators has resulted in policy-relevant and comparable indicators of ICT use by businesses and individuals. While they are of the 'incidence' type, they range from simple indicators (e.g. use of computers) to more sophisticated applications (e.g. receiving orders via the Internet).

A note on the digital divide

20. An area that has received significant attention from policymakers is the question of a 'digital divide' between individuals, organizations and countries. A major focus of the WSIS was to narrow the digital divide. For instance, the Geneva *Declaration of Principles* referred to the goal of the Declaration as "… bridging the digital divide and ensuring harmonious, fair and equitable development for all…" Concern over digital divides is based on the assumption that ICT is, on balance, beneficial and that those without access to it are relatively disadvantaged. For individuals, negative impacts may range from inconvenience to more serious outcomes, such as employment disadvantage due to lack of familiarity with ICT. For economies, lack of ICT access may make existing country divides greater, as the global economy relies increasingly on ICT to function efficiently and effectively.

21. While this paper does not discuss studies of the digital divide, it recognizes its resolution as underlying much of the impetus for measuring the impacts of ICT.

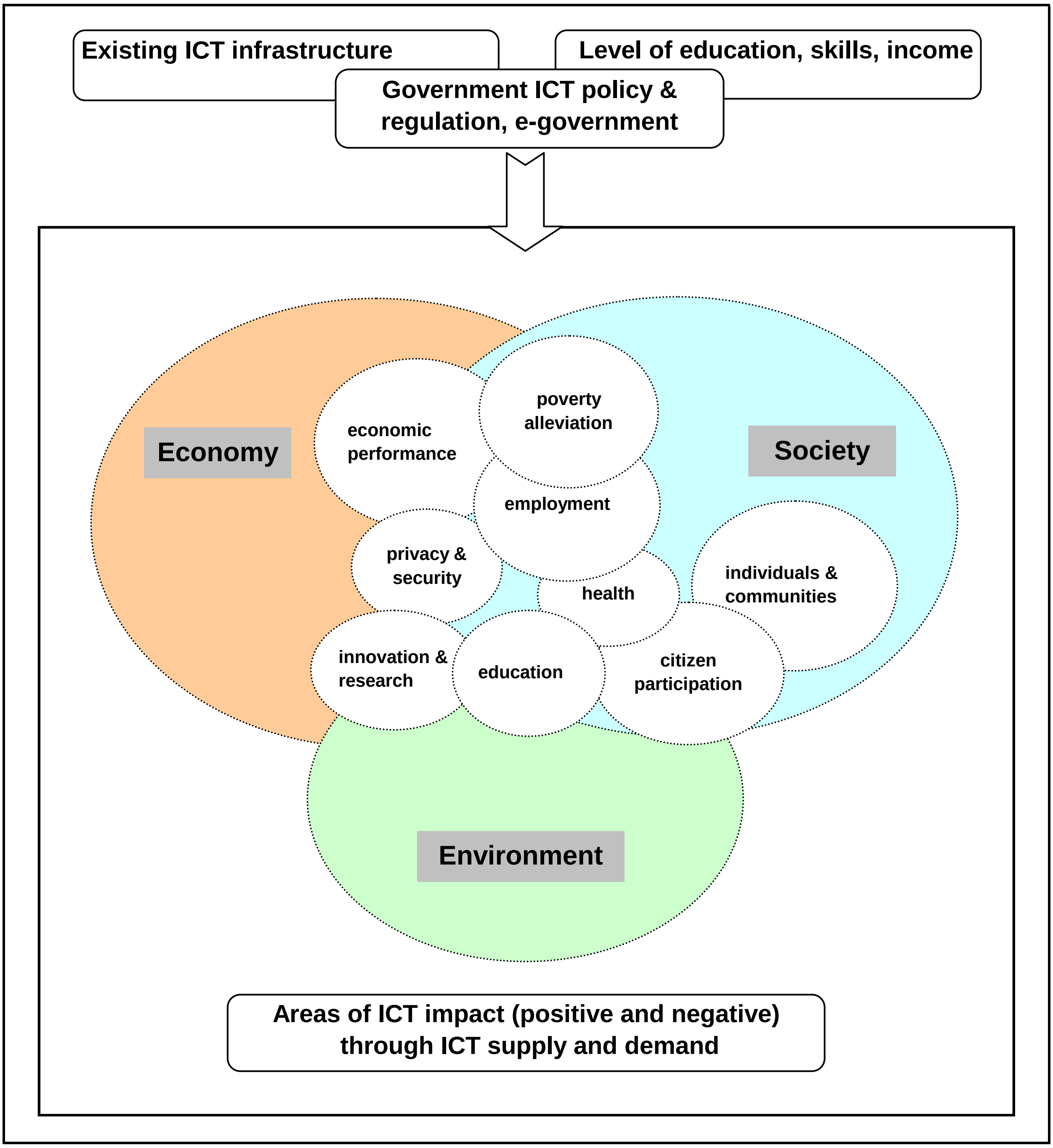
ICT impact areas and their relationships

22. The ICT impact areas discussed in this paper and their relationships are shown in the simplified model below (Figure 2). The model indicates the web of relationships between impact areas and with the broader economy, society and environment. Impacts of ICT arise through ICT supply and ICT demand and, at a country level, are likely to be influenced by:

- Existing ICT infrastructure (which enables an ICT 'critical mass' that can amplify impacts);
- Country level of education, skills and income; and
- Government ICT policy and regulation, and the level of e-government.[13]

[13] E-government is not treated as a separate impact area in this paper. In terms of ICT demand, e-government can have positive impacts on the efficiency of government operations. In terms of ICT supply, government as a provider of electronic services, can influence impacts in all areas, for example, by encouraging adoption of electronic processes and by providing information via the Web or mobile phone.

Figure 2. ICT impact relationships



Section II. How the impact of ICT is measured

23. This Section looks at the methodologies and data sources used in measurement of the impact of ICT. It concludes with some comments on strengths and weaknesses of the different approaches. The approaches considered 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.

Analytical techniques

24. 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. Econometric regression models have also been used in other areas of measurement, for example, to measure the impact of ICT use on educational outcomes (see Section III).

25. The usual objective of an ICT impact analysis is to examine the relationship[14] between *ICT* 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. *ICT* includes the ICT producing sector, often split into manufacturing and services, and ICT diffusion, measured by ICT investment and/or use. *Productivity* measures relate a measure of output (gross output or value added) to one or more inputs. *Economic growth* is usually defined in terms of change in gross domestic product (GDP) or value added. *Employment* refers to jobs generated through the direct and indirect impacts of ICT.

26. 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 ICT.[15]

[14] 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'.
[15] Katz (2009) cited a number of studies that used I/O techniques to calculate the multiplier effects on employment of broadband diffusion through indirect and induced effects. OECD (2008a) used I/O techniques to analyse the impact of the ICT sector on economic growth by three channels (final demand increases the output of the ICT sector, the ICT sector's intermediate demand from non-ICT industries and the supply of intermediate inputs by the ICT sector to non-ICT industries).

27. Many ICT impact studies examine labour productivity, that is, how productively labour is used to generate output (gross output or value added). While relatively easy to measure, it captures 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).

28. In recent years, a lot of 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 often come from different statistical sources and are linked at the firm level. They 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 other forms of innovation.[16] In some countries, these data are brought together in longitudinal databases, which provide data over different points in time. Economic impacts studied include labour productivity, MFP and value added.

Case studies

29. 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. At the same time, case study 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.

Statistical surveys

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

- Household surveys[17] that collect information about the household entity, including its characteristics, income, expenditure, and access to ICT;
- Household surveys that collect information from individuals, including their characteristics, income, expenditure, how they spend their time, how they use ICT and their perceptions of particular ICTs;

[16] The Oslo Manual (OECD and Eurostat, 2005) recognizes four types of firm-level innovation, including new organizational methods.
[17] Household surveys include population censuses, which can be a useful source of household ICT data.

- Surveys of businesses (including those in the ICT sector) that collect information including employment, economic performance, innovation, expenditure on ICT, use of ICT and perceptions of ICT impacts; and
- Surveys of other entities such as government organizations, collecting information such as employment details, economic performance, expenditure on ICT, use of ICT and electronic services offered.

31. Perception questions provide causal information on the impacts of ICT, but lack objectiveness (see Box 1). However, in respect of individuals' perceptions, it has been argued that without subjective indicators, measurement efforts are bound to be inadequate (UNESCWA, 2009).

Box 1. Use of surveys to measure perceived impact of ICT

Surveys can be used to directly measure impact by collecting self-reported 'perception' data on benefits and disadvantages of ICT. The 2005 OECD *Model survey of ICT use by businesses* includes a question on the benefits of selling over the Internet. Response categories include: reduced transaction time, increased quality of customer service and lower business costs (OECD, 2009a). Eurostat's 2008 model questionnaire for the *Community survey on ICT usage and e-commerce in enterprises* included a module on perceived benefits of new ICT projects (Eurostat, 2010).

Some official household surveys have asked individuals about their perceptions of the impact of ICT. An interesting example is a set of questions in the international Adult Literacy and Life Skills (ALLS) surveys of 2003 and 2006 that probed respondents' attitudes to computers.[18] ALLS surveys are run periodically by several countries in conjunction with Statistics Canada and the OECD (OECD, 2007).

The 2009 *Survey on the Internet Usage* conducted by the Korea Internet & Security Agency collected data on individual Internet users' perceptions of the Internet by asking whether they agreed or disagreed with several positive and negative propositions about the Internet, including 'Internet is important to daily life', 'Information on the Internet is reliable' and 'Groundless rumours are easily created and spread through the Internet' (KISA, 2009).

Panel studies

32. 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.

Controlled experiments

33. Controlled experiments are able to establish causality by having all the independent variables controlled. Therefore, the experimenter can alter a condition and observe the effect. In general, the types of studies of interest for this paper cannot be controlled to the degree necessary to determine a 'cause and effect' relationship. However, where the conditions are limited, a controlled experiment may be possible.

[18] Questions for 2006 were a set of agree/disagree statements about computers including: they allow the respondent to do more in less time; they have made it easier to get useful information; and they have helped the respondent to communicate with people (OECD, 2007a).

Administrative data

34. An important data source in the field of ICT statistics is administrative data collected primarily for non-statistical purposes but used to form statistical indicators. The main examples are telecommunications/ICT infrastructure data collected by ITU from member governments, goods trade data compiled by the United Nations Statistics Division (UNSD) and ICT-in-education data compiled by UNESCO's Institute for Statistics (UIS). All three sources are used for the *Partnership*'s core ICT indicators (ICT infrastructure and access, trade in ICT goods and ICT in education indicators respectively). Even though these administrative data are not usually collected for statistical purposes, through the efforts of organizations such as ITU, UNSD and UIS, classifications and definitions can be applied to administrative data collection to enable statistical output.[19]

Other methodologies and data sources

35. Other methodologies and data sources include the use of focus groups, direct observation and document examination (Heeks and Molla, 2009). Scenarios may be used to establish impacts in different situations, using different sets of assumptions. Forecasting may be used to estimate the future impacts of ICT and can involve a number of techniques, data sources and assumptions.

Strengths and weaknesses of the different approaches and data sources

36. It is clear that there are a number of different methodological approaches and data sources used in the measurement of the impacts of ICT. Each has strengths and weaknesses as described below.

37. The main analytical techniques used to measure the impact of ICT 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, they will be limited to the extent that models are imprecise or input data are inconsistent, inaccurate or lacking in availability. A number of data problems relating to use of analytical techniques for measuring ICT impacts should be noted (OECD, 2001, 2004):

- Measurement of hours worked for productivity measures, especially by industry;
- Data from input-output tables may be missing, dated or not integrated with national accounts;
- Lack of comparable data on ICT investment (especially software[20]), and deflators adjusted for quality change (hedonic price deflators[21]);

[19] *Partnership* (2010) discusses statistical standards applying to core ICT indicators. UIS (2009) provides guidelines for collection of data on ICT in education.
[20] Software was first recognized as investment in the 1993 revision of the System of National Accounts (SNA). Chapter 4 of OECD (2004) includes a useful discussion of software measurement issues.
[21] A hedonic deflator adjusts for price and quality e.g. for computers, the deflator takes changes in speed and memory into account.

- A number of assumptions are required to estimate the services from ICT capital;[22]
- 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;
- In respect of some ICT-using services sectors, productivity growth is difficult to show because of weaknesses in measures of output (for example, banking, insurance and health); and
- 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.

38. Case studies can be flexible and shed light on particular situations. They may be used to explore causation within their scope applying a variety of data sources, including perceptions surveys conducted as part of the study. While their results will not usually be generalizable outside their context, they may indicate other avenues of enquiry. The cost of case studies is highly variable; they may be expensive if additional data collection is required.

39. Statistical surveys that are well conducted are able to provide representative data about the population being measured. Their output can be cross-classified by a number of characteristics (e.g. age of individuals, or industry of a business). While surveys are generally expensive to conduct, their results are essential input to many of the analyses discussed in this section. Survey results are subject to a number of sources of sampling and non-sampling error, and a high degree of harmonization of statistical standards is required to enable international comparison of survey output. National statistical surveys of households and businesses are the basis for the *Partnership*'s core indicators on ICT use.[23]

40. Panel studies can be very useful in following change over time in individual units (for example, people or businesses). 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 can be expensive, especially if the panel is large, and suffer from attrition, that is loss of units over time (for example, individuals may wish to withdraw from the study, businesses may cease to exist).

41. Controlled experiments are problematic for this topic as the number of factors involved in an ICT impact can be very large (and some unknown). However, a couple of examples are presented in this paper

[22] ICT capital services are estimated from a number of data sources including ICT investment. 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.

[23] Guidance on conducting household and business ICT surveys may be found in manuals produced by ITU (2009) and UNCTAD (2009), respectively. The ultimate aim of the manuals is to assist in the production of reliable and internationally compared ICT indicators.

and their results are interesting. Like case studies, results are likely to be limited in scope but may indicate areas that could be explored more broadly.

42. ICT administrative data form the basis of many of the *Partnership*'s core indicators. ITU's telecommunications/ICT indicators and UNSD's goods trade data are available for many countries, are readily accessible and have long time series of data. They are not indicators of impact but may be used as inputs in analyses or case studies. Their usefulness may be limited because their primary purpose is not statistical. For example, subscriber data from ITU's telecommunications/ICT indicators are often used to measure the penetration of ICT. However, subscribers are not equivalent to users[24] and impacts will arise from use of ICT, not through subscription to ICT services *per se*.

[24] The differences apply in both directions, for example, there may be more than one Internet subscriber in a household or several individuals may use the same Internet access subscription. In respect of mobile phones, many users have more than one SIM card, with each one counting as a subscription.

Section III. Empirical evidence

43. This section reviews empirical evidence on the impact of ICT, with particular emphasis on developing countries and the alleviation of poverty. The structure of the section follows Figure 2 and includes a number of impact areas, covering the economic, social and environmental realms. The areas covered are the impact of ICT on economic performance, employment, innovation (including R&D), privacy and security, education, health, citizen participation, individuals and communities, and the environment. It is important to note that the coverage does not aspire to be comprehensive. Moreover, the different impact areas are not mutually exclusive. For example, innovation is an important factor in firm performance, which is described in the first impact area, and education is an important element in economic growth.

Impacts of ICT on economic performance

44. This section discusses the impact of ICT on economic growth and productivity at the macro, sectoral and firm level. Effects on poverty alleviation are also considered, although the concept of poverty extends beyond the economic dimension. Following most studies on the economic impact of ICT, the paper distinguishes economic impacts arising from an ICT sector and from ICT diffusion throughout the economy.

45. Positive macro-economic impacts of ICT in terms of increases in productivity and growth can arise from the following sources OECD (2004, 2008a):

- Increase in the size and productivity of the ICT sector, and associated effects such as growth in industries that provide inputs to ICT production;
- ICT investment across the economy contributes to capital deepening and leads to an increase in labour productivity; and
- Multi-factor productivity (MFP) growth across the economy, arises from the role of ICT in helping firms innovate and increase their overall efficiency.

46. A growing ICT sector can contribute to aggregate increases in productivity, GDP and trade. 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. The relative figures for the Republic of Korea 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.

47. 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 tends to apply for developed countries) (UNCTAD, 2007).

48. 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). Opportunities exist, not least in ICT micro-enterprises, such as very small businesses providing mobile phone and Internet services, ICT repair and ICT training. While not in the ICT sector,[25] businesses retailing ICT goods, such as used mobile phones and recharge cards, will also be created as a consequence of increased ICT penetration in society. ICT-related banking services, such as mobile money, are also activities suited to small businesses in low-income countries. Much of this activity is in the informal sector and, while the activities are not well measured, anecdotally, they provide benefits for proprietors and customers and occupy niches that larger formal businesses are not interested in (UNCTAD, 2010).

49. Economic impacts of ICT diffusion have been assessed in a variety of studies at the macro-economic, sectoral and firm level. ICT diffusion includes use, access and financial aspects. It may be measured directly through surveys[26] or indicated by the levels of ICT penetration measured by administrative data.

50. In macro-economic terms, a direct link has been established for developed countries between aggregate labour productivity based on value added and income per capita, a measure of living standards (OECD, 2001). 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,[27] whereby impacts 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.

51. Macro-level research has generally shown a positive link between ICT investment and growth in GDP. Data for several developing countries on the contribution of ICT capital to GDP growth over the period 1990-2003 suggested that, in all cases, the impact was modest relative to the contribution from other capital and labour (UNCTAD, 2007). In part, that result may have been due to relatively low levels of ICT penetration in the countries investigated.

52. Firm-level studies have been used extensively, especially in developed countries, to examine the impact of ICT on firm performance. They typically involve a number of variables covering ICT, firm performance and non-ICT factors that might affect performance. In developed countries, there have been a

[25] Using the definition referred to in Section I, ICT retailing is excluded from the ICT sector.
[26] For example, surveys of ICT use by businesses, from which the *Partnership*’s core indicators of business ICT use are sourced.
[27] This arises because of the network nature of ICT – the more people and firms using the network, the more benefits are generated (OECD, 2004).

large number of firm-level studies on the impact of ICT. They have generally 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). A number of studies have found that ICT has most impact when accompanied by complementary investments and changes, for example, in human capital, organizational change and other forms of innovation (OECD, 2004). Box 2 describes a study of firm impacts in a number of European countries.

Box 2. Firm level impacts in European countries

The most ambitious firm-level study to date was conducted during 2006 to 2008 and was led by the UK Office for National Statistics. The project included data from 13 EU countries and variables on ICT use and relevant non-ICT factors. For each country, firm-level data were drawn from three basic data sources: ICT-usage (from the harmonized EU community survey on ICT use), economic characteristics and firm performance (from structural business surveys) and firm population information from business registers. The productivity measures were labour productivity and MFP. ICT use metrics were computer use, e-sales, e-purchases, fast Internet enabled and Internet-using employees. Data were compiled by each country using common methodologies and computer code to run regressions. Countries which had additional data collaborated in topic groups (for instance, the Nordic countries worked together on skills).

The results showed that ICT use (measured by computer use, e-sales, e-purchases, fast Internet enabled or Internet-using employees) had reasonably consistent and positive labour productivity effects for manufacturing firms. For services firms, ICT use had mixed productivity impacts. Finally, industry analysis by country indicated that high speed Internet use by employees was positively correlated with productivity in countries where ICT adoption is highest, but negatively related to labour productivity in three other countries (the authors suggest that returns depend on ‘critical mass’ network effects).

Source: Franklin *et al.*, 2009.

53. 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 3.

Box 3. 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 ICT (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.

54. Case study evidence indicates that small and micro-enterprises in low-income countries can benefit from mobile phone use for business purposes, including improving communication with customers and

obtaining information on inputs and markets (UNCTAD, 2010).[28] 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 email 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 programs to provide information and web platforms to sell produce (*ibid.*).

55. 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). These benefits may be transferred to the poor in various ways, for example, by intermediary services for small businesses. In China, UNCTAD (2010) reported that 20,000 small businesses work through China's main e-commerce platform (Taobao.com) to advertise and sell online.

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

57. Different ICTs will have different impacts, depending on a number of factors, including the development level of a country. Several studies have indicated that under the right conditions, more advanced ICTs, such as broadband, can have a greater economic impact than simpler technologies. At the same time, many low-income countries still have very limited access to the Internet, especially at broadband speed (ITU, 2010b). 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). The mobile phone can be seen as a 'leapfrogging' tool, with a particularly important impact in rural areas – where three-quarters of the world's poor lives (World Bank, 2009). In addition, in contrast with ICTs such as computers and the Internet, mobile phone use does not require basic literacy skills or a high income.

58. 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).[29] It estimated that impacts for developing

[28] A perceptions survey of 1,500 mobile phone users in Nigeria found that, in respect of economic impacts, 80 per cent of respondents reported experiencing financial gains from using mobile services. High proportions also reported gains from better ability to find jobs and improved communication with clients (Pyramid Research, 2010).

[29] The study used ITU data on the penetration of different ICTs and controlled for other factors that could contribute

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 ICT rises with wealth, which leads to increased penetration, which then increases wealth).

59. Broadband is essential to enable enterprises to make full use of Internet-based services and applications. In the United States, broadband users were 20 per cent more likely to make online purchases than narrowband users in 2004 (OECD, 2008b). In Sweden, enterprises with a high speed Internet connection made more use of the Internet, which in turn helped raise productivity (Statistics Sweden, 2008). Case study evidence confirms that broadband use in developing countries has had positive economic impacts (World Bank, 2009). For instance, a 2005 study on broadband use by 1,200 companies in six Latin American countries showed an association with considerable improvements in e-business processes, such as process automation through network integration, better data processing and information diffusion.

60. Broadband is also associated with ICT convergence and this has implications for ICT use. An example is the convergence of telephone networks and Internet to enable VOIP telephone calls, significantly reducing the cost of telephone-based services.[30]

61. Negative economic impacts associated with ICT diffusion have received relatively little attention from statisticians. They include a range of privacy and security impacts (these are discussed below) as well as systems failures, data loss or corruption, inadvertent disclosure of data, and loss of productivity because of employees’ use of ICT (particularly the Internet) during work time.

Impacts of ICT on employment

62. ICT has roles in the creation of employment and self-employment opportunities. Impacts can be direct, through growth of the ICT sector[31] and ICT-using industries,[32] and indirect through multiplier effects. In economies increasingly dependent on ICT, individuals will benefit by having requisite ICT skills, thereby enhancing their opportunities for employment. Arguably, ICT can also lead to loss of employment as tasks are automated.

---

to GDP growth.

[30] The World Bank (2009) suggests that convergence could have an enormous impact on economic and social development, for instance, by increasing productivity, lowering transaction costs and facilitating trade.

[31] For example, in some developing countries, such as Egypt, Malaysia and Mauritius, the ICT sector accounts for more than five per cent of the total business sector workforce (UNCTAD, 2010).

[32] Some of which may be new industries based on ICT-enabled business models, for example, web-based businesses.

63. 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 about 26 million internal migrant workers, with evidence that a large portion of their earnings is remitted to poor rural and remote areas. Mobile telephony penetration is increasing dramatically in developing countries (for example, see ITU, 2010b). In Nigeria, the positive economic impacts of a growing mobile telephony industry include growth in the mobile telephony industry itself and associated industries, creation of direct and indirect employment, and development of labour force skills (Pyramid Research, 2010).

64. 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. The second two ways can be expressed, through an input-output model, as multiplier effects. The relationship between broadband diffusion and employment through these mechanisms is a causal one (although the estimate of employment growth relies on a number of assumptions). Data are presented for Argentina and Chile comparing regional broadband penetration and employment growth and showing a moderately positive linear relationship.

65. The United Nations Economic and Social Commission for Western Asia examined the impact of telecentres on the economic development of poor communities (UNESCWA, 2009). Many of the impacts were on employment opportunities. In Egypt, survey data from 2009 indicated positive impacts accruing to IT Club members, for example, improving ICT skills and having better job opportunities. In Jordan, a 2007 survey-based evaluation of the impact of the Knowledge Stations Initiative on community development showed positive impacts, affecting males and females almost equally, and indirect employment opportunities through better access to micro-loans. In the Syrian Arab Republic, cultural community centres have trained a large number of people and appear to have enhanced indirect employment opportunities.

66. The potential impacts of IT services and IT-enabled services (ITES) on poverty reduction include employment and its multiplier effects. Because workers in IT services and ITES industries tend to be relatively well educated, indirect employment may be the major employment benefit for the poor (UNCTAD, 2010). According to the World Bank (2009), women in India and the Philippines benefit disproportionately from employment opportunities in IT services and ITES, with women accounting for about 65 per cent of professional and technical workers in the Philippines (and 30 per cent in India). Both are higher participation rates than in other service industries.

67. Evidence from six Latin American countries suggests that Internet use by individuals is associated with increased earnings (Navarro, 2009). Controlling for factors, such as education, that relate to wealth before Internet adoption, 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.

The relationships between ICT and innovation

68. Innovation is a broad concept, defined by the *Oslo Manual* (OECD and Eurostat, 2005) as "… the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations." Innovation can occur in all sectors of the economy, including government and higher education, and includes all forms of research and experimental development (R&D) as defined by the *Frascati Manual* (OECD, 2002).[33]

69. There are several relationships between innovation and ICT. We saw above that a key determinant of business and macro-level productivity is innovation, especially organizational change. More broadly, there is clearly a strong impact of innovation, especially R&D, on the development of ICT goods and services. OECD (2010a) explored the effects of ICT use as an enabler of innovation across nine member countries using a common methodology. Data from business use of ICT surveys and innovation surveys were linked at the firm-level and analysed using an econometric model provided by the OECD. Results indicated that higher ICT use (measured as the number of web facilities) generally increases the probability of innovation, with variations on the strength of the relationship by country, industry (manufacturing or services) and the type of innovation.

70. The importance of ICT in research is reflected in WSIS target 3 which aims "… to connect scientific and research centres with ICTs." ICT can be expected to have a strong impact on R&D activities in all sectors, as a general purpose technology, although there seem to be few studies in this area.

[33] Defined as "…creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."

Impacts of ICT on privacy and security

71. There are a number of adverse impacts of ICT on the privacy and security of individuals and organizations. They include commercial losses from denial of service attacks, data loss through theft or corruption, and disclosure of confidential data. 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 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 ICT and the serious consequences of failure. Such impacts can affect societies and economies, as well as individual businesses (OECD, 2008c).

Impacts of ICT on education

72. There is considerable policy interest in the benefits that ICT can bring to education, which is a particular focus of the MDGs and the WSIS outcomes. The impact of ICT in education has been assessed in various studies, with mixed results (for instance, see the discussion in UIS, 2009).

73. ICT may deliver significant educational benefits by providing tools for the teaching and learning process and by providing the skills needed in a society that is increasingly reliant on ICT. Conversely, students who enter such a world without those skills may be unable to fully participate and suffer from a 'digital divide' effect. The last is likely to be a greater problem for developing countries, where access to ICT is generally lower than for OECD countries. Other possible benefits of ICT in education are improved attitudes to learning, development of teachers' technology skills and increased access of the community to adult education and literacy (OECD, 2010b; Kozma, 2005).

74. Empirical experiments that are highly controlled can help establish causal relationships between ICT use and educational outcomes (Kozma, 2005). In Vadodara, India, students in 100 primary schools were provided with computers. In schools with trained teachers and educational software, students played computer games for two hours a week and scored significantly higher on mathematics tests. The bottom group of students benefitted most, with girls and boys benefitting equally. (Linden *et al.,* 2003, cited by Kozma, 2005). 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* program 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 programs were significantly better than for other students.

75. OECD (2010b) reviewed empirical experiments and correlation studies. They concluded that results of the former indicate that ICT in the classroom improves performance “if certain pedagogical conditions are met” and the latter that there is no demonstrated consistent relationship between ICT availability and use at school and educational attainment. It is clear from OECD’s discussion that the impact of ICT on school performance is a very complex topic and not easily measured.

76. The Programme for International Student Assessment (PISA) is a triennial study of the knowledge and skills of 15-year old children in mathematics, reading, science and general problem-solving.[34] PISA is possibly the best available vehicle for studying the impact of ICT on learning outcomes. Results from the 2003 PISA surveys showed that the mathematics performance of students without home access to computers was significantly below that of those with home access. The gap was significant for all countries in the study and, in 23 out of 31 countries, a performance advantage persisted even after accounting for different socio-economic backgrounds of students (OECD, 2005b). The performance difference associated with school access to computers was generally less marked, with a positive association seen in only about half the participating countries.

77. The intensity and type of computer use has also been found to be related to PISA scores. In the 2003 survey, the highest performances in both mathematics and reading tended to be from students with a medium level of computer use, indicating that excessive computer use could have a negative impact on school performance. The 2003 survey also measured students’ confidence in using computers and the Internet. For most countries, it found a strong positive relationship between performance on the mathematics test and confidence in Internet and routine ICT tasks (such as opening and saving files). This could suggest that the quality rather than the quantity of ICT usage is a more important determinant of the contribution of ICT to student performance (OECD, 2005b).

78. Findings from the 2006 survey were similar and showed positive relationships between science scores and length of time using computers, frequency of computer use at different places (with a stronger relationship associated with home use), a moderate level of usage and higher levels of ICT confidence. A more detailed analysis of 2006 data found that for most countries, the groups of variables that affected the science score were: students’ characteristics (including science interest and motivation), parents’ characteristics, household characteristics, school characteristics (excluding access to ICT) and frequency of computer use (at home and school). For all countries, average science scores increased with increased frequency of computer use (OECD, 2010b).

[34] PISA is commissioned by the OECD and was conducted in 2000, 2003 and 2006. The 2006 surveys are the latest for which data are available and covered 400,000 students in 57 countries.

Impacts of ICT on health

79. Health is mentioned in WSIS documents as an area where ICT is expected to bring major benefits. According to ITU (2010a), e-health ICT applications include electronic health records, telemedicine, m-health (the use of mobile devices such as mobile phones for health purposes), decision support systems, e-learning and e-journals. OECD (2007) also cited the use of ICT as enabling complex and networked medical equipment and mentions that from an individual's point of view, the Internet can be a useful source of information about health. There is no doubt that ICT can also have negative effects on health, for instance, occupational overuse injuries associated with computer use. Recycling of e-waste is a particular problem for some developing countries, with adverse health impacts.

80. The World Health Organization (WHO, 2009) has a broad scope for *eHealth*, defining it as "… the use of information and communications technologies (ICT) for health." and stating that "eHealth works to improve health by enhancing patient services and health systems." The WHO, 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).

81. 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 programs, using the mobile phone as an interface. According to the World Bank, 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 that are able to 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.

82. 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 (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 benefitting 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.

Impacts of ICT on citizen participation, individuals and communities

83. ICT 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, email 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. A particular interest is how e-government can improve democratic processes and encourage citizen participation in decision-making.[35]

84. According to the United Nations Department of Economic and Social Affairs (UNDESA), e-participation can change the dynamics between government and citizens. It undertakes an international survey of e-government every one to three years and collects information on channels offered for online participation of citizens in public affairs. Results from the 2010 survey show that developed countries are leading the way in e-participation, although there are a small number of developing countries in the top 20 countries. Examples of greater electronic participation are provided for Singapore and China. In the latter case, senior government officials appear to be soliciting, and responding to, online suggestions posted by citizens (UNDESA, 2010).

85. Many of the impacts on individuals of using ICT can be seen as ‘intermediate’, that is, they concern how ICT is changing activities such as shopping, banking and dealing with government; how they spend their income; how they spend their time; and how they communicate with family, friends and the broader community.

86. It is clear that there are both 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, exposure to undesirable content and overuse of Internet applications such as online games (see ITU, 2010c[36]); use of the Internet to disseminate images of pornography and violence against women; Internet-based crime; copyright infringement; and security and privacy concerns.

87. 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.

---

[35] WSIS target 6 refers to the role of e-government in contributing to development, by enhancing transparency and accountability and promoting good governance in the public sector.

[36] The proposed statistical framework has few impacts indicators and those are of an ‘intermediate’ nature, for example, the proportion of children who have ever “… ended up on a porn site accidentally when looking for something else”.

88. Using case study evidence, UNESCWA (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.

89. 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 ICT 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.

90. In respect of perceived impacts, results from the international[37] 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).

91. The 2009 *Survey on the Internet Usage* conducted by the Korea Internet & Security Agency collected information from Internet users about their perceptions of the Internet. Results showed high levels of agreement with both positive and negative propositions, for example, 72 per cent of respondents agreed ('somewhat agree' or 'agree') that the Internet is important to their daily lives. The survey also asked about complaints about using the Internet and included response categories such as 'Leakage of personal information' (31 per cent of respondents) and 'Exposure to obscene contents (26 per cent of respondents) (KISA, 2009).

92. 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).

Impacts of ICT on the environment

93. Measurement of the relationship between ICT and the environment is a relatively new topic. OECD (2009b) discussed a number of positive and negative links between ICT and the environment. The scope of 'environment' was limited to aspects where ICT is likely to be a strong positive or negative factor, that is, climate change, energy use and waste. The proposed conceptual model recognised:

- *Positive environmental impacts of ICT*, such as its potential to improve the efficiency of a range of energy-using processes and equipment, facilitation of dematerialization,[38] and ICT's role in

[37] The 2003 survey involved Bermuda, Canada, Italy, Mexico, Norway, Switzerland and United States.
[38] Use of the Internet as a substitute for 'material' activities, for instance, downloading online newspapers, Internet

climate change monitoring and modelling, dissemination of information, and administration of carbon pollution reduction schemes, and

- *Negative environmental impacts of ICT* 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.

94. Some of the impacts of ICT 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.[39]

95. 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 positive role of ICT in facilitating a knowledge-based society with awareness of environmental issues. Some data relevant for measuring the potential impact of ICT 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.

96. Despite the importance of the topic, empirical evidence on the impact of ICT 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 this will grow unless mitigated. They also found that the greatest potential for a positive impact of ICT is its 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.

---

banking, downloading digital content.

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

Section IV. Summary and issues for consideration

97. This concluding section summarizes the findings presented above and proposes a set of key issues for consideration by the Commission on Science and Technology for Development.

98. Section I describes why measurement of the impacts of ICT is important for policy makers and why it is difficult. Reasons for the latter include the diverse and changing nature of ICT, the complexity of ICT impacts and the more general difficulties of illustrating a cause-and-effect relationship between dependent and independent variables.

99. ICT impacts are also contextual. At a country level, determining factors include human capital, the level and availability of ICT infrastructure and government intervention. At a business level, there is significant empirical evidence that complementary factors, such as skills and innovation, are important in determining the degree (and even the direction) of the impact of ICT access and use.

100. Reflecting the complexity of measuring ICT impacts, there is a variety of methodological approaches (described in Section II), which are not mutually exclusive. Particular approaches appear to be generally suited to measurement of a particular type of impact. For example, econometric regression models suit the analysis of firm level impacts of ICT and case studies are suited to the evaluation of small scale ICT projects.

101. Most of the empirical research examined in Section III 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. In terms of poverty alleviation, there is case study and some macro-level evidence that ICT 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 use of ICTs such as mobile phones by small businesses.

102. While there are clearly also negative impacts of ICT, 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.

103. 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. While the modelling required for such studies is not necessary difficult, data requirements are significant and pose barriers to such approaches for most developing

countries. 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.

104. 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 earlier ICTs such as radio, TV and mobile phones to have important economic and social impacts, at least in the short term. It should be noted that there are still significant data gaps in developing countries on the core ICT indicators, especially, measures of the ICT sector and household and business data on the use of ICT. While these data do not directly measure the impact of ICT, they may be used in the analysis of ICT impacts.

105. At this stage, there are few studies or surveys that provide internationally comparable data on the impacts of ICT. The main exceptions are macro-economic analyses carried out by the OECD and the World Bank; firm-level analyses covering mainly European countries; the OECD's PISA study (which in 2006 covered 57 countries); and ICT impact perceptions data from some surveys that are harmonized internationally (e.g. Eurostat's 2008 *Community survey on ICT usage and e-commerce in enterprises* and the Adult Literacy and Life Skills survey).

106. There are internationally agreed standards for many aspects of ICT measurement. While these are necessary for measuring the impact of ICT, 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.

Key issues for consideration

107. This paper has examined a number of impact areas indicated by the WSIS targets. As a basis for the discussion during the Inter-sessional Panel of the CSTD, a set of questions to the experts are presented below.

- Given the range of ICT impacts and the fairly low availability of evidence on impacts, should the measurement of impact in certain areas be given higher priority than others in the years leading up to 2015? This question is to be seen also in conjunction with considerations of feasible and affordable data collection work.
- This paper has emphasized the importance of producing relevant and internationally comparable data needed to undertake impact studies. What can governments, development partners and international organizations – especially those that are members of the *Partnership* – do to extend ICT impact indicators? Examples may include setting statistical standards, accelerating the

building of capacity for the production of relevant statistics and allocating sufficient funds to undertake surveys.

- From a policy perspective, what types of impact studies are the most useful? Possibilities include:
    - Extend macro-economic analysis to developing countries using methodologies applied by the OECD.
    - Extend the measurement of firm level impacts to more developing countries.
    - Consider the use of perceptions questions on surveys of business and household use of ICT. Several survey models exist and further investigation could be useful in checking the validity and comparability of results.[40]
    - Extending the PISA programme to more developing countries to shed light on the impact of ICT on learning outcomes of 15-year olds.
- What can be done to raise awareness among different stakeholders about the need for the measurement of impact of ICT? How can the CSTD contribute in this context?

[40] In order to shed light on impacts of the digital divide, it may be appropriate that non-users of ICT are asked about the impacts of lack of access. Both positive and negative impacts should be canvassed.

Bibliography

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/.

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.

Eurostat (2010), *Model ICT use questionnaires, years 2002-2011* web page http://circa.europa.eu/Public/irc/dsis/emisannexes/library?l=/data_-_database/theme_3_-_popul/isoc/householdsindiv&vm=detailed&sb=Title.

Franklin M., P. Stam and T. Clayton (2009), *ICT impact assessment by linking data*, Economic and Labour Market Review, 2009, vol. 3, issue 10, http://www.palgrave-journals.com/elmr/journal/v3/n10/pdf/elmr2009172a.pdf.

Heeks R. and A. Molla (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.

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 (2009), *Manual for Measuring ICT Access and Use by Households and Individuals*, http://www.itu.int/ITU-D/ict/publications/hhmanual/2009/index.html.

ITU (2010a), *World Telecommunication/ICT Development Report 2010, Monitoring the WSIS Targets, A mid-term review*, http://www.itu.int/dms_pub/itu-d/opb/ind/D-IND-WTDR-2010-PDF-E.pdf.

ITU (2010b), *Measuring the Information Society 2010*, http://www.itu.int/ITU-D/ict/publications/idi/2010/Material/MIS_2010_without%20annex%204-e.pdf.

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

James, T. and J. Miller (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, R. L. (2009), *Estimating broadband demand and its economic impact in Latin America*, http://unpan1.un.org/intradoc/groups/public/documents/gaid/unpan036761.pdf.

KISA (Korea Internet & Security Agency) (2009), *Survey on the Internet Usage 2009.11*, http://isis.kisa.or.kr/eng/board/?pageId=040100&bbsId=10&itemId=310.

Kozma R.B. (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, http://www.unescobkk.org/education/ict/online-resources/e-library/elibrary-themes/monitoring-and-measuring-change/monitoring-and-evaluation-of-ict-in-education-projects/.

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 (Organisation for Economic Co-operation and Development) (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 (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, http://browse.oecdbookshop.org/oecd/pdfs/browseit/9202081E.PDF.

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

OECD (2005a), *Guide to Measuring the Information Society, 2005*, www.oecd.org/sti/measuring-infoeconomy/guide.

OECD (2005b), *Are Students Ready for a Technology-Rich World?: What PISA Studies Tell Us*, http://www.oecd.org/dataoecd/28/4/35995145.pdf.

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

OECD (2008b), *Broadband Growth and Policies in OECD Countries*, http://www.oecd.org/dataoecd/32/57/40629067.pdf.

OECD (2008c), *Shaping Policies for the Future of the Internet Economy*, OECD Ministerial Meeting on the Future of the Internet Economy, Seoul, 2008, http://www.oecd.org/dataoecd/1/29/40821707.pdf.

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*, http://browse.oecdbookshop.org/oecd/pdfs/browseit/9609101E.PDF.

OECD and Eurostat (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, Third Edition*, http://browse.oecdbookshop.org/oecd/pdfs/browseit/9205111E.PDF.

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*, http://www.ncc.gov.ng/industrystatistics/studies/Pyramid+Impact_Mobile_Services_Nigeria.pdf.

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.

Statistics Sweden (2008), *Yearbook on Productivity 2008*, papers presented at the Saltsjöbaden Conference, October 2008, http://www.scb.se/statistik/_publikationer/OV9999_2008A01_BR_X76BR0802.pdf.

UNCTAD (United Nations Conference on Trade and Development) (2007), *Information Economy Report 2007-2008: Science and technology for development, the new paradigm of ICT*. New York and Geneva: United Nations, http://unctad.org/en/docs/ier2009_en.pdf.

UNCTAD (2008), *Measuring the impact of ICT use in business: The case of manufacturing in Thailand*, http://www.unctad.org/en/docs/sdteecb20073_en.pdf.

UNCTAD (2009), *Manual for the Production of Statistics on the Information Economy*, Revised Edition, http://new.unctad.org/templates/Page____885.aspx.

UNCTAD (2010), *Information Economy Report 2010: ICTs, Enterprises and Poverty Alleviation*. New York and Geneva: United Nations, http://www.unctad.org/ier2010.

UNDESA (United Nations Department of Economic and Social Affairs) (2010), *E-Government Survey 2010: Leveraging e-government at a time of financial and economic crisis*, http://unpan1.un.org/intradoc/groups/public/documents/un/unpan038851.pdf.

UNESCWA (United Nations Economic and Social Commission for Western Asia) (2009), *Impact of ICT on Community Development in ESCWA Member Countries*, http://www.escwa.un.org/information/publications/edit/upload/ictd-09-15.pdf.

UIS (UNESCO Institute for Statistics) (2009), *Guide to Measuring Information and Communication Technologies (ICT) in Education*, http://www.uis.unesco.org/template/pdf/cscl/ICT/ICT_Guide_EN.pdf.

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

WHO (World Health Organization) (2009), *Global Observatory for eHealth 2009 survey* http://www.who.int/goe/data/global_e-health_survey_2009_en.pdf.

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