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Opportunities for Knowledge-based Development: Capabilities, Infrastructure, Investment and Policy

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1. Introduction

'Tectonic shifts, revolutionary changes, a new paradigm, a tsunami of transformation ...' (Tapscott, 1995, page 4); these are the ways in which the impact of advanced information and communication technologies is being described. Studies of the impact of the extension of computing, telecommunication and software-based systems into industry and into everyday life draw most of their lessons from recent experiences of industrialised countries. Yet the spread of the new technologies is not restricted to these countries. Developing countries are being besieged and challenged by the spread of these new technologies and their promise to intensify the role of information and knowledge in economic and social life.

Knowledge management is the centrepiece of recent business management and consultancy advice oriented towards 'creating the knowledge-based business' (Business Intelligence, 1997) and at augmenting the co-ordination of specialised expertise and problem-solving capabilities to deliver what has come to be known as 'knowledge-based development'. The recent emphasis especially in the industrialised countries on knowledge-based development and growth is partly a reflection of the increasing emphasis on services requiring the generation, distribution and use of knowledge within national economies, and partly a reflection of the rapid innovations in information and communication technologies that are contributing to the generation and circulation of enormous volumes of digital information and to the opening of new opportunities to communicate and access such information around the world. Taking its lessons from the observations that digital sources of information can be applied to create new knowledge in the industrialised and developing countries, the World Bank's World Development Report 1998/99 argues that:

> 'Knowledge is like light. Weightless and intangible, it can easily travel the world, enlightening the lives of people everywhere. ... Poor countries differ from rich not only because they have less capital but because they have less knowledge' (World Bank 1998, page 1).

Some observers have argued that 'technological progress will allow countries to leapfrog states of development in building their info-structures, thanks to technological discontinuities (e.g. the emergence of digital networks)' (Primo Braga, 1996); and that '..with information on our side, with knowledge a potential for all, the path to poverty can be reversed' (Annan, 1997). The unspoken assumptions are that digital information can be relatively easily converted into accessible and productive knowledge.[1]

These promises for the 'weightless' distribution of knowledge are predicated upon a belief that our understanding of interactions between technical innovation, diffusion and the appropriation of

technologies, and between the accumulation of new social infrastructures and capabilities and the social development and economic growth processes, is sufficiently robust to specify the actions required to fulfil the potential of the new technologies. Yet the results of systematic research, regardless of its disciplinary focus, frequently express uncertainty, if not major disquiet, about whether there is a proper instruction book for building 'info-structures' or using them to help accelerate the development process. Empirical evidence shows that, in many instances, the returns from the use of information and communication technologies in mediating the generation, distribution and use of new knowledge are insufficient to outweigh the accompanying risks of adopting the new technologies (Mansell and Wehn, 1998; Mansell and Silverstone, 1996; Roche and Blaine, 1996).

In the 1990s, knowledge-based development seems to provide a new pathway for developing countries to secure their economic and social development. Knowledge-based development is said to require 'intangible processes of re-engineering, managerial quality and leadership, flexible and multi-skilled labor, and institutional learning and experimentation' (Hanna *et al,* 1996, page 190) as well as the spread of global networks like the Internet to convey new information. How such information might be interpreted and transformed into knowledge that is relevant to the prevailing conditions in developing countries and how the necessary infrastructure should be constructed is not considered in any detail in most of the debates about the new opportunities created by the shift to a more intensive knowledge-based development process. Just as the progressive accumulation of economic strengths by some of the East-Asian countries in the 1970s and 1980s led to heightened expectations that other developing countries would benefit by emulating their technology policies and business strategies (World Bank, 1993), 'revolutionary' applications of information and communication technologies in scientific research, manufacturing and services now are expected to provide the foundation for a new development 'miracle'. This belief is widely held, notwithstanding the World Banks' own less than optimistic assessment as to whether the East Asian experience is replicable (Hanna *et al,* 1996, page 211).

In fact, comprehensive assessments of the implications of information and communication technologies for social development and economic growth in developing countries are extremely rare. So too are empirical investigations of the feasibility of a more knowledge-intensive development process for developing countries. In 1995, the United Nations Commission on Science and Technology for Development (UNCSTD) undertook the first steps toward such an assessment.[2] This paper highlights some of the information and communication technology applications whose promise was examined as well as some of the generic factors likely to create new barriers and bottlenecks to development. Empirical techniques were identified for analysing

the relative strengths and weaknesses of countries in tapping the opportunities and avoiding the pitfalls of the new technologies. Countries build upon their existing experience of producing or using information and communication technologies, combining these capabilities of production and use to engage in more intensive knowledge-based development. Precisely because very little is known about how this process operates, there is no smooth route available to knowledge-based development. .

The UNCSTD's conclusion was that the costs of using information and communication technologies for building a new technical and social infrastructure for sustainable knowledge-based development in most developing countries are very high. The costs of not doing so, however, are even greater. The importance of accumulating specific kinds of experience and skills for *using* innovative network technologies and services is stressed in this paper as major priorities for information and communication technology policy in developing countries.

2. Applying Information and Communication Technologies for Development

There are many computer, telecommunication and audio-visual technologies that support new applications for business and civil society that could be deployed in developing countries and that could lead to potential benefits for social and economic development. These applications derive much of their value from their contribution to improved communication of information. They can enable the generation and distribution of local information (or access to distant sources of information) that can strengthen social organisation and enable new entrepreneurial activities to alleviate conditions of poverty in developing countries. They can also provide the basis for exchange and co-operation supporting new business and social or cultural initiatives.

Such applications build upon a very heterogeneous technical infrastructure which today includes the Internet. Despite the much heralded convergence of information and communication technologies, the products and services necessary for effective solutions remain specialised and their maturity differs dramatically across countries and regions. In many cases, new applications in developing countries are simple 'transfers' of the aims and methods of those employed in industrialised countries. In others, however, creative solutions to distinctive needs are resulting in the adaptation of these technologies in novel ways in the developing world.

For example, information and communication technology applications in development contexts are being deployed in the health, education, environment protection and agriculture sectors (Girvan, 1994: 1996; d'Orville, 1996; Valantin, 1995). In the healthcare field, Internet-supported

telemedicine is leading to ‘on-demand’ medical information and patient care (Holland, 1997). In some countries, environment protection services are being strengthened by real-time decision support systems and improved communication between local authorities, environmental protection agencies and citizens. In the agriculture sector, information about new farming practices, crops, weather forecasts, pest control and markets is playing a growing role in strategies aimed at alleviating hunger (Alemu, 1996).

New electronic services for citizens’ networks are enabling interest group formation in some countries and more intensive communication among members of these often widely dispersed groups (Levin, 1996; Institute on Governance, 1996). These new activities may embrace minority and disadvantaged groups and there are increasing numbers of women’s initiatives built around new electronic services in developing countries. In education, ‘tele-education’ is providing some students and teachers with access to new learning resources including remote tutorials and libraries and there is evidence that some of these resources are being tailored to local styles of learning and teaching (Barros, 1999; Byran and Gagliardi, 1997).

In both the commercial and public sectors new applications are having major, if uncertain, impacts on job creation and employment (Mitter and Efendioglu, 1998). The growing tradability of services means that there is a potential for creating new markets for products and services which, in turn, may lead to new jobs and revenues for developing countries. In areas such as software development and back-office services, including the processing of health insurance claims and the maintenance of customer databases, there is evidence that new patterns of trade can benefit developing countries.

Automated information processing systems and systems for data entry and storage are increasingly being used in the business context (Cassiolato, 1996) and distributed computerised systems are supporting computer-aided design in the manufacturing industries. Corporate networks (and Intranets) are providing the infrastructure for teamwork using computer-supported co-operative-working software and electronic commerce transactions, together with computerised systems for stock control, just-in-time manufacturing, computerised numerical controls and robotics, are becoming increasingly widespread (Wu, 1995). For developing countries, benefits for business can also flow from the extension of conventional telephone infrastructures as well as from the most advanced network applications.

Scientific and technical research and development is becoming more dependent on applications of information and communication technologies (Foray and Gibbons, 1996). For example,

computerised systems are being used to help with the assessment, selection, application, adaptation and development of innovative technologies and services. In addition, collaborative research within and between countries is increasingly built around networks for e-mail communication and Internet access to scientific and technical databases (Hicks and Katz, 1966).

Although information and communication technologies offer considerable potential, their diffusion raises problems that need to be addressed carefully in order to ensure their use is beneficial and that it does not deepen existing social and economic inequalities or engender new ones. Existing inequalities in the international distribution of important skills and competencies needed to use new applications effectively mean that many of the high skilled jobs associated with electronic services are being located in the industrialised countries (Ramesan, 1997). It appears that if developing countries invest substantially in a workforce with both specialised and generic skills there will be increasing opportunities to benefit from new job opportunities. Yet this entails high costs in terms of new forms of education and training and in terms of achieving greater computer literacy in the business community and throughout civil society. In many cases, new applications for education as well as for other applications areas are over-specified in terms of their technical sophistication, they are unsuited to the organisational and technical infrastructure within developing countries, or they are insufficiently tailored to the requirements in a given problem-solving environment. In addition, where the private sector and donor organisations become jointly involved in introducing information and communication technologies in education and other areas, in many cases, there are clashes between the profit-driven motives of reducing the cost of training materials and the need for materials that embody local social and cultural values (Laaser, 1998). Much greater attention needs to be given to the localisation and organisation of education and training materials when new technologies are introduced and to the infrastructure that will be most effective for co-ordinating the creation and delivery of such materials.

Inequalities also arise with regard to access to information and communication technologies and global networks. Although full Internet connectivity offers scientists and R&D professionals access to vast sources of information, in many developing countries, access remains limited to simple store-and-forward e-mail facilities, ‘real time’ network infrastructure simply does not exist, it is too costly to use, or it is accessible only by the most senior scientists or professionals (Ajayi, 1995; Alemu, 1996, Holderness, 1999; Lund, 1998). Access issues can also affect small and medium sized enterprises, for example, in the tourism industry if they are unable to adopt new applications. By increasing the welfare and improving education opportunities for only some parts of the business community and civil society, the new systems and services can have the effect of reinforcing inqualities in income and education leading to disempowerment for some communities

within developing countries (Cooper 1999; Hamelink 1996).

In addition, successful implementations rely not only on the availability of the necessary technology but also on the willingness and ability of individuals to adopt new applications. There is substantial evidence that if applications fail to reflect user needs or involve them in the process of development, the applications simply will not provide a basis for generating the expected benefits. Instead, they will create new problems that are costly to address. If the relevant social, cultural, and economic conditions, the expertise and commitment of users, and the various components of the infrastructure are not assembled in a co-ordinated way, innovative applications will fail to yield the expected benefits. Effective policies and initiatives to take advantage of the new applications must be embedded in the local environment and in the organisations which expect to benefit from them.

These issues are creating a new frontier for policy analysis and implementation. These include the regulatory issues of protecting the privacy of individuals as commercial and public sector databases proliferate. Growing accessibility and use of data communications raises questions about for whom the enforcement of existing copyright conventions is being pursued. Most recently, concerns about network security and encryption policy in the context of electronic commerce and electronic government is leading to new initiatives for international collaboration that impose new costs on developing countries through the need to divert skilled individuals to negotiate new policies and practices in new forums.

The accumulation of the necessary technical and social infrastructure for using information and communication technologies is a costly process. The outcomes of applications in developing countries depend on how well public policy actions and private sector management respond to the new opportunities and problems. Policy measures are required in key areas within each country's overall development strategy and it is a major challenge for decision makers to assess their performance and to allocate scarce financial resources in a way that will create the greatest opportunities for benefits from the use of new applications.

3. Catching-up, forging ahead or falling behind?

The use of the Internet and many other potentially beneficial applications of information and communication technologies requires considerable investment in the social infrastructure and the development of applications that are compatible with local circumstances, cultures, and capabilities (Enos, 1996). Ideally, the necessary capabilities include the skills and resources to design, develop

and maintain technical applications as well as the specialised (e.g. information technology related) and generic (e.g. numeracy or management) skills for creatively using applications to complement existing practices and routines in the workplace, in the community and in the home (Freeman and Soete, 1994). In practice, although it is widely recognised that countries present very different profiles and combinations of producer and user capabilities relating to the new applications, there is only the most rudimentary basis for systematic comparison.

A systematic basis for international comparison is hindered by the enormous variety of innovative applications and the need to assemble indicators. Existing data for industrialised countries provide an incomplete picture of the full size and nature of the production and use of information and communication technologies (and related services). The data for developing countries provide an even less complete picture and for many of the least developed countries, useful data are virtually non-existent. Nevertheless, the differences between developing countries are important in understanding the range of options for policies aimed at strengthening the contribution of new applications as 'tools' for a more knowledge-intensive development process.

One approach is to construct a framework that illustrates how some of the key features of information and communication technology production and use, and the requisite human skills, are combined to provide a foundation for co-ordinated policies aimed at using the technologies to support social and economic development. An INEXSK (INfrastructure, EXperience, Skills, Knowledge) approach can be used to illustrate how different combinations of infrastructure, experience, and skills may be contributing to knowledge-based development.[3]. Figure 1 displays the main features of the INEXSK approach.

Insert Figure 1 about here

As there is no 'ideal' indicator or composite indicator for the development of improved knowledge (see top of Figure 1), the INEXSK approach uses the indicators shown in Table 1.

Insert Table 1 about here

For infrastructure development (main telephone lines per capita and personal computers per capita) offer a means of assessing the breadth of the technical foundation for the development of experience and skills. A very undeveloped infrastructure will provide a narrow basis for the development of either information and communication technology (or content) production or consumption skills and capabilities. Electronics production (the share of electronics and data processing equipment revenue in GDP) and consumption (per capita 'consumption' of electronics

and data processing equipment as a share of GDP per capita) indicators are used to suggest the potential for accumulating knowledge about either information and communication technology production or consumption . Indicators of production skills (using scientific and technical graduates per 1,000 population and Internet hosts per 1,000 population) and consumption skills (number of televisions sets per 100 population and share of population reported as literate) are also included.

The construction of the indices shown in Table 1 was informed by three factors. First, it is desirable to adjust for population in measures of infrastructure and skills. A larger sized country will often have a larger infrastructure or a larger number of skilled individuals, but not necessarily higher levels per inhabitant. All the measures of infrastructure and skills as well as the two measures of 'outcome', Internet hosts and television sets, are adjusted for population. Second, in developing an indicator for information and communication technology production and consumption experience, the relative specialisation of a country's economy in electronics and data processing is important. For these measures, the share of electronics in GDP is used to 'scale' the size of electronics experience in the total economy. Third, each country needs to be graphed on a common scale. Therefore, one country must be chosen as the benchmark against which other countries may be compared. It is not very useful to benchmark against countries far in the lead but to ones whose experience, while toward the leading edge, is close to the experience of many other countries. . This approach was used to select the country 'taken to be 100' shown in the right hand column of Table 1.

The relationship between the various indices is dynamic. As suggested in Figure 2, a country's experience with either the production or consumption of information and communication technologies may be expected to provide a 'push' factor that encourages the deployment of the new technologies in roles that are ultimately related to the creation and application of knowledge (as shown by the direction of the arrows in Figure 2). The production or consumption of electronics products and data processing services, however, cannot ensure that the technological infrastructure will be put to productive use in the creation of knowledge. This requires a 'pull' from the availability in a country of a skills base for producing advanced technologies and services and/or a consumption skills base for assimilating digital information resources and transforming them into useful knowledge.. There are major difficulties in co-ordinating the 'push' of production or consumption experience and the 'pull' of production or consumption skills to achieve effective applications of innovative technologies and the expected outcomes in terms of benefits for economic growth or social development.

Insert Figure 2 about here

Our analysis of data for selected developing and industrialised countries using the INEXSK approach has suggested that there is no strong causal relationship between the development of the different features of information and communication technology production and consumption experience or skills (see Mansell and Wehn, 1998). Countries with both relatively weak and relatively strong technical infrastructures have been successful in developing a specialisation in electronics production. The extent of electronics production specialisation of a country appeared to have a relatively weak influence on the extent of production or consumption skills indicators (i.e. the availability of technical education, literacy rates, or consumption of electronic sources of information via television).

Figure 3 illustrates the application of the INEXSK framework to two countries, China and India.[4] In this comparison, virtually the only strength that India brings to information and communication technology-based development is its relatively literate population. China, in contrast, has a relatively higher experience of the consumption of electronics products and services, a higher literacy rate and greater access via television to digital content. These indicators suggest strengths in enabling the 'push' and 'pull' factors to work together to generate new knowledge despite the fact that China's performance on the technical infrastructure indicator is insufficient to bring it much above that of India. Despite the weakness of its infrastructure, Figure 3 shows the relative extent to which China is developing the electronics sectors of the economy and generating a technically educated work force.

Insert Figure 3 about here

Comparisons such as the one shown in Figure 3 for different countries suggest that there are numerous possible combinations of infrastructure, production and consumption experience, and the build up of production and/or consumption skills that may provide a foundation for knowledge-based development. The application of this INEXSK mapping technique reveals only part of the challenge facing developing countries. Strengthening and sustaining knowledge-based development using information and communication technologies involves many issues in addition to investment in the infrastructure, in production or consumption experience, and in skills development.

Sustained progress toward the emergence of many different knowledge societies depends upon how opportunities are developed through the interaction between the cultural context and different

types of social organisation. Creation of social and economic organisations that are consistent with the cultural context is as important as the rates of investment or the penetration of the new technologies within developing economies. Developing countries share with the industrialised countries the problems of increasing the flexibility of their institutional infrastructures to cope with governance issues associated with the spread of information and communication technologies. In addition, many developing countries also face challenges in matching export-oriented goals for information and communication technology products and services with the development of opportunities for broader domestic use of the applications.

The least developed countries do not have a realistic prospect for creating a *comprehensive* information and communication technology-related strategy for knowledge-based development. Their limitations in resources, previous experience, and existing infrastructure, combine to severely constrain their options. Instead, there is a need for investment strategies that lead to more intensive use of the technical and human resources that *are* available. For example, infrastructure systems may be designed to play a role in the distribution of medical knowledge, disaster assistance, environmental protection, or the supply of resources for education. These applications may justify the costs of some types of infrastructure investment even in the very low income countries.

The INEXSK approach is not intended to explain how varying combinations of information and communication technology related experience and skills support knowledge-based development because the results do not reflect the nuances of the distribution of skills and experience within each country. The approach does highlight the distinctive pathways that are being pursued by different countries and provides an avenue to stimulate discussion about policy action and the allocation of investment in the future.

4. Accumulating Social Capabilities for Knowledge-based Development

While there is no recipe for the best mix of investment in technical infrastructure and social (human and organisational) capabilities, a range of new skills will be needed to support knowledge-based development. Specialised skills, and generalised learning skills and information and communication skills are essential and the latter two are especially important because they have ‘a more enduring value, enabling individuals to adapt to changing patterns of demand.’ (Freeman and Soete, 1994, page 156). In the absence of new skills, investments in equipment, market and organisational restructuring, will make it very difficult for the potential of information and communication technology applications to be realised in the developing countries.

Knowledge-based development is likely to occur when investment in the technical infrastructure occurs in parallel with investment in skills and other social capabilities.[5] Learning how to reconfigure existing technological experience with available skills and to restructure institutional arrangements to create incentives for continuous learning is crucial to the success of knowledge-based development strategies (Gu and Steinmueller, 1999).[6] Many of the foundations for technological innovation and development already exist in the experience and unsolved technical and organisational problems of industrialising countries. Recombining this knowledge by promoting avenues for exchange and evaluation can provide a basis for new investment strategies and the accumulation of skills needed to support specific development goals. Little can be accomplished when this capability-building process is not undertaken within a country and there are formidable co-ordination problems in initiating and sustaining it. New public policies for knowledge-based development must be institutionalised and perpetuated through the efforts of both the public and private sectors. Inevitably there will be many temporary reverses and disappointments in creating and implementing these initiatives as they will be influenced by changes in the international environment, e.g. in trade practices or in relative international prices, as well as in the domestic environment, e.g. in the prices for accessing logistical and communication networks or the experience of users in taking advantage of these networks.

Policy measures at the national and regional level designed to stimulate knowledge-based development are needed to initiate the necessary capability-building processes especially for using information and communication technologies for knowledge-based development. They are also needed to co-ordinate the actions of a large number of interested stakeholders. Some models of development emphasise market-led investment initiatives (World Bank, 1993). In these models, the market provides the means of co-ordination and there is a relatively limited role for governments. In these models, entrepreneurial activity is expected to mobilise the resources for growth, and growth is expected to improve economic and social conditions. However, the co-ordinating capabilities of markets are limited in guiding and motivating processes of educational, social and cultural change. In addition, in the highly uncertain environment of rapid technological change, markets may deliver co-ordination solutions that do not address important social objectives. Market-led development cannot always be relied upon to deliver the financial, technological, and social resources for knowledge-based development. Governments have a role in promoting discussion and assessment of capabilities and needs. Governments also have a responsibility to discover and implement solutions for developing of capabilities and fulfilling needs that markets cannot or do not address.

A new development model is beginning to be coupled with discussions about the benefits of

knowledge-based development. It is focusing on the nature of partnerships among stakeholders within and outside developing countries (Talero and Gaudette, 1995; Michel, 1997; World Bank, 1998). Ideally, new partnerships between public sector organisations and the business sector are expected to create greater awareness of the possible contributions of information and communication technologies to social development and to stimulate the necessary investment. In this model, governments play a vital role, not only in facilitating market-led initiatives, but also in initiating the process of capability-building and co-ordination. Such policy measures are needed to assemble the best combination of the skills, capabilities and technologies to take advantage of the potential benefits of information and communication technologies. As David and Foray (1995) have argued, 'what is created is a network society, where the opportunity and capability to get access to and join knowledge- and learning-intensive relations determines the socio-economic position of individuals and firms' (OECD, 1996, page 14). Governments have a role in assessing and promoting these developments and in establishing institutional frameworks for their implementation.

New partnerships between governments and the private sector in some developing countries are likely to yield new mechanisms for financing the necessary accumulation of capabilities for knowledge-based development in the wealthier developing countries. Their feasibility for the poorest countries, however, will depend upon whether initiatives are taken to develop new business models. Such models must justify investment based upon the potentially enduring catalytic effects of that investment. This is likely to involve specific commitments to technical training and to the acquisition of skills for managing institutional, regulatory, and technical issues and for selecting specific information and communication technology applications. Realisation of positive 'spill-overs' from such investment strategies, will require the widest possible distribution of the benefits throughout the populations of developing countries which is unlikely to occur as a result of market-led forces alone.

5. Conclusion

Developing countries must find innovative ways of combining their existing experience and skills with the production and consumption of information and communication technology related products and services in order to benefit from the potential advantages for social and economic development. The new applications can be employed as 'tools' for development, but that their effective use requires substantial investment in both the technical and social infrastructure. Domestic production of these technologies can contribute to development goals, but most developing countries will obtain greater returns from investment in the capabilities for *using* them

than they will from producing them.

Targeted investment is needed for new partnerships to yield positive social and economic outcomes. When investments in the technical and social infrastructure cannot be undertaken simultaneously because of limited financial resources, the evidence so far indicates that investment in the social and organisational infrastructure and capabilities should receive the higher priority.

Some developing countries will be advantaged in realising gains from new investment strategies for using information and communication technologies for development, but other countries are in danger of being bypassed. If this continues to occur, efforts focused on stimulating knowledge-based development may simply replicate today's inequalities in the positions of individuals and firms. The application of information and communication technologies cannot eradicate poverty, but some applications can create a new distribution of opportunities for people in developing countries to join together with others to forge knowledge and learning-intensive relationships. Such applications can provide a foundation for strengthening opportunities for social development and economic growth. The potential of information and communication technologies to create opportunities for 'catching up' or 'forging ahead' exists. However, applications must be consistent with the distinctive information and knowledge systems within each developing country and their development priorities. A major empirical research task is needed to determine how new investment strategies and policies can produce the innovative applications that are needed to help to alleviate poverty through more intensive applications of knowledge for development.

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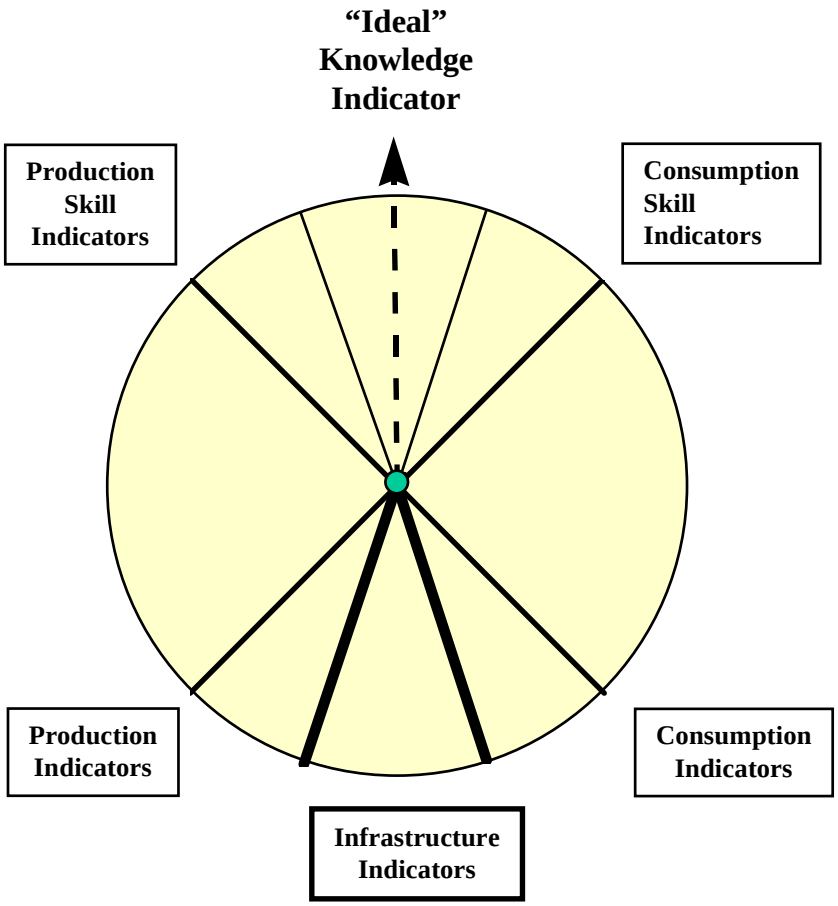
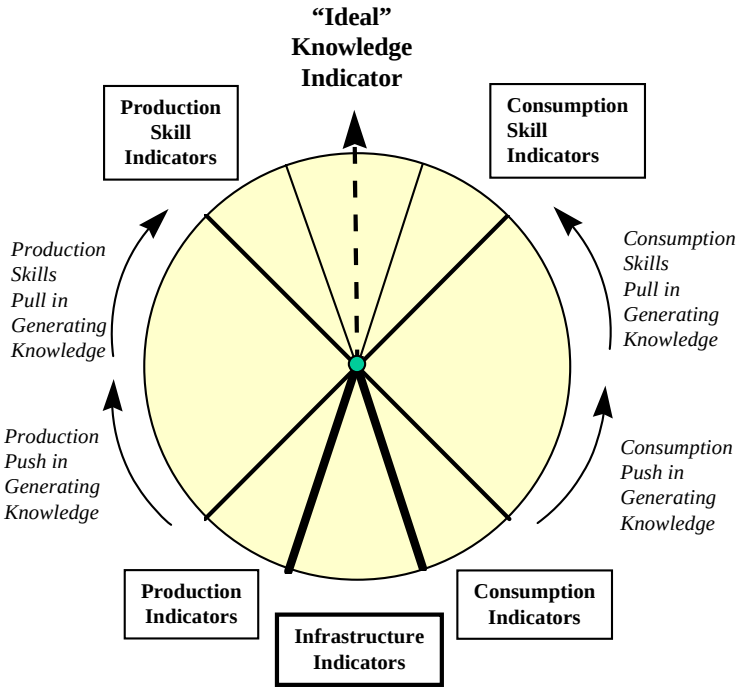
Figure 1 - The INEXSK framework



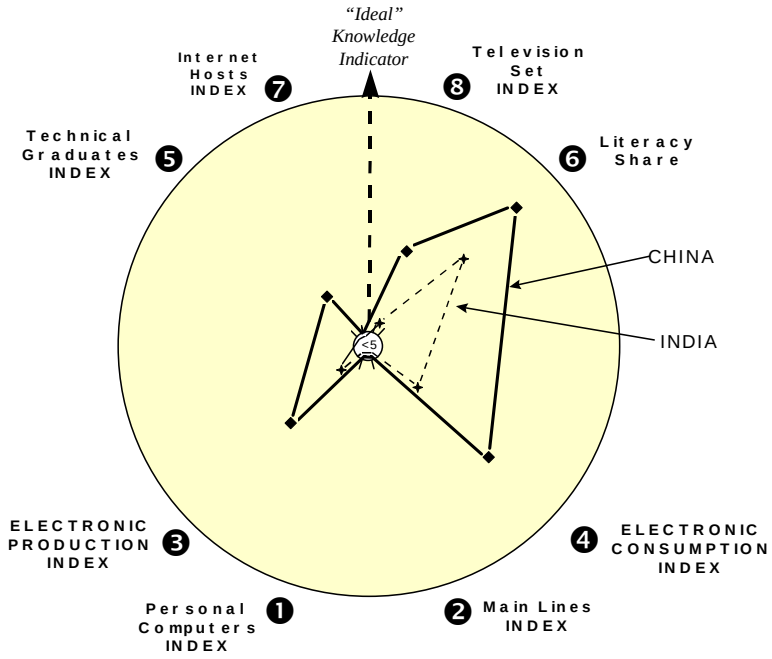
Source: Mansell and Wehn (1998)

Figure 2 - Dynamic Processes in the INEXSK Framework



Source: Mansell and Wehn (1998)

Figure 3: China and India footprints



Source: See Mansell and Wehn (1998) for a detailed discussion of data sources, the INEXSK method, data are from ITU, UNESCO and Elsevier sources for 1995.

Table 1 - Construction of INEXSK indicators

Indicator	Variables used to construct indicator	Computation used	Country taken as 100
❶ Personal Computer Index [Infrastructure]	Personal computers Population	Personal computers per capita	New Zealand
❷ Main Lines Index [Infrastructure]	Main telephone lines Population	Main telephone lines per capita	Sweden
❸ Electronics Production Index	Revenue from electronics production Gross Domestic Product (GDP)	Share of electronics revenue in GDP	Ireland
❹ Electronics Consumption Index	Market for electronic products Gross Domestic Product (GDP)	Per capita 'consumption' of electronics as a share of GDP per capita	Ireland
❺ Technical Graduates Index [Production Skill Indicator]	Graduates in Computer Science and Maths plus all levels of Engineering Population	Total graduates per 1,000 population	Netherlands
❻ Literacy Share {Consumption Skill Indicator]	Percentage of population that is literate	Simple percentage	None (100% taken as 100)
❼ Internet Hosts Index {Production Skills Indicator]	Number of Internet hosts Population	Internet hosts per 1,000 population	Denmark
❽ Television Set Index [Consumption Skill Indicator]	Number of television sets Population	Number of television sets per 100 population	United Kingdom

Note: the numbers refer to those shown in Figure 3.
Source: Mansell and Wehn (1998), p. 37.

Notes

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1 See Neef (1998) for a useful edited collection on the 'knowledge economy'.

2 A working group included representatives from: Austria, Belarus, Belgium, Brazil, Chile, China, Colombia, Costa Rica, Ethiopia, Germany, India, Jamaica, Malawi, Malta, Marshall Islands, Niger, Nigeria, Pakistan, Romania, Togo, United Kingdom, United Republic of Tanzania. The UNCSTD's Working Group analysis was complemented by a source book on the social and economic implications of information and communication technologies for developing countries (Mansell and Wehn, 1998).

3 For a full explanation of the INEXSK approach see Mansell and Wehn (1998), Chapter 2 prepared by Professor W. Edward Steinmueller, SPRU.

4 At the centre of the diagram, the value of each of the indices is zero and at the boundary of the circle the value is 100. The values for literacy are noted and correspond to the other indices. In the centre of the diagram is a small circle which is used as a means of graphing very low values (that is, less than five out of 100).

5 The importance of these capabilities in the development process has been recognised for some time in the literature on the economics of growth and development (Abramovitz, 1986).

6 See also (Bessant and Caffyn, 1997; Freeman and Soete, 1997; Lundvall, 1996; Perez, 1983; Senker, 1995).