Development Centre Seminars

Technology and Poverty Reduction in Asia and the Pacific

INTERNATIONAL DEVELOPMENT

OECD

Preface by
Jorge Braga de Macedo and Tadao Chino

Development Centre Seminars

Technology and Poverty Reduction in Asia and the Pacific

Preface by

Jorge Braga de Macedo and Tadao Chino

OECD

ASIAN DEVELOPMENT BANK

DEVELOPMENT CENTRE OF THE ORGANISATION
FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), Korea (12th December 1996) and the Slovak Republic (14th December 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

The Development Centre of the Organisation for Economic Co-operation and Development was established by decision of the OECD Council on 23rd October 1962 and comprises twenty-two Member countries of the OECD: Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Korea, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Slovak Republic, Spain, Sweden, Switzerland, as well as Argentina and Brazil from March 1994, Chile since November 1998 and India since February 2001. The Commission of the European Communities also takes part in the Centre's Advisory Board.

The purpose of the Centre is to bring together the knowledge and experience available in Member countries of both economic development and the formulation and execution of general economic policies; to adapt such knowledge and experience to the actual needs of countries or regions in the process of development and to put the results at the disposal of the countries by appropriate means.

*
*   *

Publié en français sous le titre :
Technologie et lutte contre la pauvreté en Asie et dans le Pacifique

Asian Development Bank

Established in 1966, the Asian Development Bank (ADB) is a multilateral, development finance institution owned by 59 members, mostly from Asia and the Pacific.

ADB's fundamental goal is to reduce poverty in the Asian and Pacific region. To this end, it fosters economic growth, supports human development, improves the status of women, and protects the environment. ADB's principal assistance for developing member countries comprises loans and technical assistance. While a large portion of the assistance is used in public projects and programmes, ADB also pays special attention to private sector development.

ADB headquarters is in Manila, Philippines. The Bank has resident missions in 13 Asian countries, a regional mission for the Pacific, and three representative offices in Frankfurt, Tokyo, and Washington, D.C. ADB's staff numbers 2 000 employees from nearly 50 countries.

Headquarters
6 ADB Avenue, Mandaluyong City
0401 Metro Manila, Philippines

Mailing Address
P.O. Box 789
0980 Manila, Philippines

Tel: (63-2) 632-4444
Fax: (63-2) 636-2444

E-mail: information@adb.org
Website: http://www.adb.org

OECD Development Centre

The Development Centre of the Organisation for Economic Co–operation and Development was established by decision of the OECD Council on 23rd October 1962 and comprises twenty–two Member countries of the OECD: Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Spain, Sweden and Switzerland, as well as Argentina and Brazil from March 1994, and Chile since November 1998. The Commission of the European Communities also takes part in the Centre's Advisory Board.

The purpose of the Centre is to bring together the knowledge and experience available in Member countries of both economic development and the formulation and execution of general economic policies; to adapt such knowledge and experience to the actual needs of countries or regions in the process of development and to put the results at the disposal of the countries by appropriate means.

The Centre has a special and autonomous position within the OECD which enables it to enjoy scientific independence in the execution of its task. Nevertheless, the Centre can draw upon the experience and knowledge available in the OECD in the development field.

Foreword

This publication was undertaken in the context of the International Forum on Asian Perspectives, jointly organised by the Asian Development Bank and the OECD Development Centre. It forms part of the Centre's research programme on Globalising Technologies and Domestic Entrepreneurship in Developing Countries, and the Centre's External Co–operation activities. The Forum held its seventh meeting in Paris on 18 and 19 June 2001 on the theme "Technology and Poverty Reduction in Asia and the Pacific". Contributions to the meeting are included in this volume.

Table of Contents

Part Two
Policies to Make Technology Work for the Poor

Preface

The seventh International Forum on Asian Perspectives chose to focus on technology and its potential benefits for the poor at a time when technological progress seems to be occurring at a bewildering pace. The poor remain in vast numbers around the world, mostly in Asia. No enterprise can be more important than to explore ways to harness the technology for the alleviation of poverty.

Transforming stagnant economies into dynamic ones poses formidable challenges for many developing countries. Technology can contribute in two mutually reinforcing ways. First, sustained technological progress can generate a steady rise in output per person, hence in real incomes. Second, these rising incomes can stimulate higher educational attainment, which generally leads to smaller families and higher living standards, while also facilitating further technological and economic advancement.

Two key sets of technologies served as the principal focus of discussion during the two days of the Forum: agricultural technologies, beginning with the green revolution and moving on to modern biotechnology; and new information and communications technologies. Academics, policy makers and business executives were able to exchange views on how these two sets of technologies have impacted the lives of poor people in the developing world, and what constraints must be addressed if they are to become even more effective in alleviating poverty in the future. A particularly thorny issue is that of intellectual property rights. How does their protection contribute to ensuring developing countries' access to technology developed elsewhere and to realising their own technological achievements? How can they be designed and enforced so as not to exclude the poor from technology's benefits?

The distribution of benefits from green revolution technologies has been widely debated since the 1970s. While those benefits were no doubt unevenly distributed among farmers, there can be little doubt that, without the agricultural productivity gains they made possible, many millions of poor people would have subsisted on far inferior diets, died earlier, and suffered even dimmer developmental prospects than they have over the past quarter century. The challenge for the future is to ensure that the green revolution continues to extend the benefits of affordable nutrition to the less fortunate segments of society.

If one were to prioritise, the new agricultural biotechnologies would rank high on the list of technologies of potential benefit to the poor in the developing world. Information and communications technologies would figure largely in a supportive role. In the longer run, they may prove very important to the development prospects of poor countries. This is because these technologies — notably the Internet — have only begun to diffuse in much of the developing world. Further progress in policy and institutional reform must precede a more rapid diffusion. Also, basic literacy must become near universal if the poor are to benefit fully from the use of the Internet.

The analytical parts of this book advance our knowledge of how technology flows operate and how they may impinge, for the better, on populations in poverty. The policy chapters go far to provide not only a setting but also guidelines for policies that can effectively use technology to pursue poverty reduction.

Jorge Braga de Macedo
President
OECD Development Centre
Paris

Tadao Chino
President
Asian Development Bank
Manila

May 2002

Introduction

David O'Connor and Yun–Hwan Kim

The 2001 joint ADB/OECD Development Centre Forum, "Technology and Poverty Reduction in Asia and the Pacific" was particularly timely.

The first day's Experts' Meeting brought together a diverse group of academics, policy analysts and practitioners to assess technology's role in poverty reduction. Among the participants were Michael Lipton of Sussex University (United Kingdom), Peter Ballantyne of the International Institute for Communication and Development (Netherlands), and Stéphane Ducable of Alcatel (France). The meeting was divided into four sub–sessions:

— A conceptual framework for mapping the connections between technology and poverty;

— The potential benefits of agricultural biotechnology and the impact of the intellectual property regime on technology diffusion from richer to poorer countries;

— ICT's role in productivity growth and poverty reduction in Asia; and

— Technology financing questions.

The second day assembled a panel of high–level decision–makers for a public conference hosted by the French Ministry of Finance and attended by some 150 participants from the public and private sectors. Panellists included Suwit Khunkitti (Deputy Prime Minister of Thailand), Desmond O'Malley (Personal Representative of the Deputy Prime Minister of Ireland, Mary Harney), Yoginder K. Alagh (former Power/Science and Technology Minister of India), François Huwart (French State Secretary for International Trade) and John Kay (invited columnist for the *Financial Times* of London). Debate focused on policies for domestic technology development and diffusion and the implications for developing countries of current international rules protecting "trade–related intellectual property".

Results

The key conclusion resulting from the Forum was that technological advances have been historically — and have the potential to continue to be — one of the crucial contributors to poverty reduction in both the developed and the developing world. Realising this potential, however, depends on ensuring that innovation does not neglect the food security, health and livelihood needs of the poor and that potentially beneficial technologies are made affordable to them.

Poor people confront and can benefit from a whole range of technologies, from the simple to the advanced, in their daily lives. Yet, of the many that may be valuable, only a few are likely to be important in the sense of having major quantifiable effects on productivity and poverty. The Green Revolution technologies (GRTs) pass the "importance" test. Nevertheless, as important as the Green Revolution was to food security and improved basic nutrition in some large, poor countries, not all poor people have shared in the benefits. In addition, yield improvements have been increasingly difficult to sustain. The unfolding Gene Revolution — in the form of agricultural biotechnology — has the potential to provide benefits to some of those left aside by GRTs, *viz.* farmers in marginal environments where water and heat stress are high and soil quality is low. It may also prove an effective means of reducing micronutrient deficiency among the poor. Whether this occurs depends in part on the continued funding of public R&D (and perhaps public–private partnerships) to develop crop varieties with the desired properties. Lately, such funding has declined and remains under threat.

The productivity effects of ICTs are just beginning to show up in the statistics of a few OECD countries, so it will be some time before they become measurable in poor countries. Moreover, the link between technology and poverty is inherently more difficult to measure for ICTs than for GRTs, where individual farmers' decisions on whether or not to plant hybrid seeds are a simple measure of technology adoption. In the case of ICTs, many of the adopters will be large organisations (government agencies, firms) rather than individuals, and any effects on poverty are likely to be far more diffuse and indirect. While many experts expressed guarded optimism about ICT's value to the poor, they were cautious about the time frame within which ICTs would make an important contribution to poverty reduction. The research into ICT's potential for the poor is still in the infancy stage and it will take some time before it can contribute substantially to shaping policy and resource allocation in developing countries.

Part One

Technology's Contribution to Poverty Reduction?

Technology and Poverty: Mapping the Connections[1]

Maurizio Bussolo and David O'Connor

What Relationship between Technology and Poverty Reduction?

On a long historical view, technological advance has been instrumental to rising living standards and, by inference, to poverty reduction across the globe. The world would be far poorer, were it not for the successive waves of innovation since the beginning of the Industrial Revolution in Europe. Maddison (2001) calculates that the rate of growth of world per capita GDP increased by a factor of 24 with the Industrial Revolution — from a mere 0.05 per cent per annum in 1000–1820 to 1.21 per cent a year from 1820 to the present. It may seem self–evident that the more than one billion people who still live in poverty remain largely excluded from technology's benefits, but this begs the question of how it can help to alleviate their poverty.

While the absolute numbers of poor people in the world continue to rise, poverty incidence has fallen in many countries — including some very large ones like the People's Republic of China (PRC) and India — over the past several decades. What role has technology played in this story? What are the potential benefits of emerging technologies — e.g. agricultural and medical biotechnology, information and communication technology — to the many remaining poor of the developing world? What features of the policy, institutional and legal environment are instrumental in directing more innovative effort into solving the problems of the poor and encouraging widespread uptake of promising new technologies by the poor?

Although, as this paper shows, technology has made an important difference for poverty reduction, it is not the only contributory factor. Institutional change, responding sometimes to technological change and sometimes to government policy or social pressures, has also been important. For instance, while technology has played a role in the PRC's dramatic reductions in rural poverty, so have institutional reforms in agriculture since 1978. Also, technology seldom works its effects in a vacuum; it is embedded in social systems and, whether adopted by individuals or organisations, it usually involves adjustments in accustomed practices. Behavioural and/or organisational change is normally a *sine qua non* for realising the full potential of a new technology[2].

In mapping the connections from technology to poverty, we do well to bear in mind the reverse connections as well, from poverty alleviation to enhanced human capability to use technology. Insofar as poverty reduction associates closely with improvements in human health and education, i.e. in the quality of human capital, it will likely improve the conditions for technology adoption and innovation. Lipton (2001) points to a virtuous circle, whereby technological advances in agriculture lead to improvements in health and human productivity, declining mortality and fertility rates, increased investment in children's education and enhanced human capabilities to develop and use new techniques. While a large empirical literature maps links from nutrition and health to worker productivity (cf. Craig *et al.*, 1997, and Strauss and Thomas, 1998, for a literature review), the links from poverty reduction to technical progress are less direct and more difficult to establish empirically. Not explored extensively here, this reverse causality could offer a promising avenue for future research.

For the very poor, many common technologies may not be available. Yet a catalogue of the technologies that poor people in rural areas of the developing world often do encounter in their everyday lives might include modern seed varieties and other inputs used to grow food; motors to power pumps, farm machinery, and vehicles to transport produce to market (where animal traction or human leg–power are no longer the main means); electricity; vaccines, antibiotics and other medicines; and radio and perhaps TV. Not all are advanced, state–of–the–art innovations fresh from the R&D laboratories of multinational corporations, leading universities or publicly funded research institutes (like the various agricultural research institutes that form the CGIAR network). Some are rather mundane technologies present for many generations in the developed world and, very often, considered obsolete there. Others have been developed to address local technical problems in specific developing countries and might be classed as "intermediate technologies". Whether they represent economically *valuable* technical advance depends on whether they make possible, in production, greater output (or better quality) with the same or fewer inputs or, in consumption, greater human satisfaction within given budget constraints. They represent economically *important* technologies largely when, singly or in combination, they contribute to lifting large numbers of people out of poverty.

In what follows, it proves convenient to distinguish among three sorts of technology, although the lines dividing them are not always clear:

— *Process* technologies that result in increased productive efficiency and/or improved product quality;

— *Product* technologies, i.e. new products with direct welfare benefits to consumers (medicines, artificial contraceptives, micronutrient–enhanced grains, etc.); and

— *Transaction* technologies that facilitate co–ordination, information sharing and exchanges between buyers and sellers or other sets of economic agents, reducing transaction costs.

This paper is concerned principally with two broad sets of technologies: agricultural innovations (beginning with the green revolution technologies and continuing with agricultural biotechnology) and information and communications technologies (beginning with the computer and continuing with mobile telephony and the internet). The former fits more neatly into the category of process technologies, although modern agricultural biotechnology also has a strong product–technology dimension, while the latter are both process technologies and — especially in the case of the internet and other communications media — transaction technologies.

One can approach the topic of technology and the poor from one of two perspectives, by asking "Where are the poor and how does technology affect their lives?" or, alternatively, "What are the most important technologies that have emerged in the last, say, half century and what impact have they had on the poor?" The first approach would probably lead to a primary focus on agriculture and the so–called "green revolution" technologies (GRTs), since most of the poor in the developing world still depend on the land[3]. By one estimate (Spillane, 2000), there are some 1.05 billion farmers in the developing world. In this case, there is little doubt that the technologies have contributed to reducing poverty, but the question often asked is "With the productivity gains these technologies have made possible, why are there still so many hungry, malnourished, poor people?" The second approach might lead one to focus first on information and communication technologies (ICTs), the latest "general purpose technology"[4], in which case the impact on the poor is less direct and less obviously positive. To the extent that ICT contributes to overall productivity growth and distribution does not worsen, the effect on the poor should be positive. To the degree, however, that ICT's effective use demands skilled labour, its benefits to the poor, as producers, may be limited or even negative in the event that widespread, skill–biased technical change should substantially depress aggregate demand for unskilled workers. There remain the possible benefits to the poor as consumers of goods and services that can be delivered more efficiently using ICTs (e.g. health care, government services) or as users of cheap information available through ICT to command higher prices, reduce or hedge risks and resolve technical problems (e.g. pest management, veterinary health).

By virtue of a technology's having been adopted, one can assume that expected benefits to the adopter exceed the costs. Thus, a technology observed as ignored by poor people does not pay at its current cost. In the case of GRTs, for example, a small–scale farmer on an arid piece of land may decide not to adopt high–yielding varieties, considering the modest expected yield improvement, while the investment might well be justified under more favourable rainfall conditions or on irrigated land. The policy question, in this case, is whether greater investment in public agricultural research on varieties better adapted to arid conditions is the best use of scarce resources, or whether the poor farmer on marginal land would be better served through other public investments.

For public policy, three sorts of technology choices need to be considered. The first follows from the preceding example. How much should the government (and the international donor community) support science and technology development in the interests of poverty reduction and, within the agreed budget envelope, how should that support be allocated? Second, what sort of legal and policy environment is needed to ensure adequate incentives to poverty–relevant research and development by commercial interests, while at the same time providing timely access to the fruits of R&D by poor people? The appropriate framework for protection and transfer of intellectual property rights is the key issue here. Finally, how does the broader economic policy environment affect the rate and the direction of technology development? Especially with respect to this last question, it is worth remembering that, while in some cases poor people themselves are the agents making technology adoption decisions (e.g. small farmers and modern seed varieties), in many others the poor are merely affected by the technology–adoption decisions of others (e.g. factory owners who introduce new methods of production that alter labour demand). Standard economics would prescribe that government policy not significantly bias choice of technique against “natural” factor endowments — e.g. by measures that favour capital–intensive technology in a labour–abundant economy. In a comparative–static framework, this prescription would be best for the poor, who are the ones hurt by policies biased against employing unskilled labour. There is a possible tension that needs to be recognised, however: in such an economy, the returns to education will likely be lower than in one where technology choice creates strong demand for skilled labour and thus also incentives to invest in human capital. This, in turn, may limit future growth prospects.

Even for the poor farmer who controls the decision of what to grow with what technique, his rewards depend on the constellation of demands, output levels, and production technology choices by a host of other agents. Similarly, what may appear profitable to the individual farmer at a given time may end up becoming unprofitable if enough others make similar choices, affecting appreciably total supply and market prices. Still, the early adopter has the prospect of earning technology rents during the transition, and this continues to serve as inducement to innovation. The embedding of individual technology choices in the larger economic and social structures, and the influence of other actors’ choices on the individual returns to technology adoption call for a general equilibrium (or at least economy–wide) analysis.

A Macro Perspective on Technology and Poverty

Economists normally discuss the macroeconomic impacts of technological change in terms of productivity growth. In the standard Solow growth model, in the long run, a country’s income can grow only through technical change. The macroeconomic treatment of technological progress is not especially concerned with specific technologies and their characteristics, or with the impacts of technological advance on income distribution. A partial explanation of the neglect of income distribution is that pioneer researchers in the field of development economics expected a “trickle–

down” effect. With time, growth would lift the whole population out of poverty — an idea that crystallised in the so–called Kuznets curve. The focus lies on aggregate productivity growth, with technological progress in Solow modelled as an exogenous parameter shift in an aggregate production function, and with much recent growth theory (beginning with Romer, 1986) intent on endogenising it. Steady improvements in average per capita income will, with unaltered income distribution, lift a progressively larger share of the population out of poverty. As Bruno *et al.* (1998) point out, however, the initial income distribution has a strong bearing on how far productivity growth benefits the poor. Also, the income distribution need not remain constant, and the benefits to the poor depend strongly on whether it improves or deteriorates with growth.

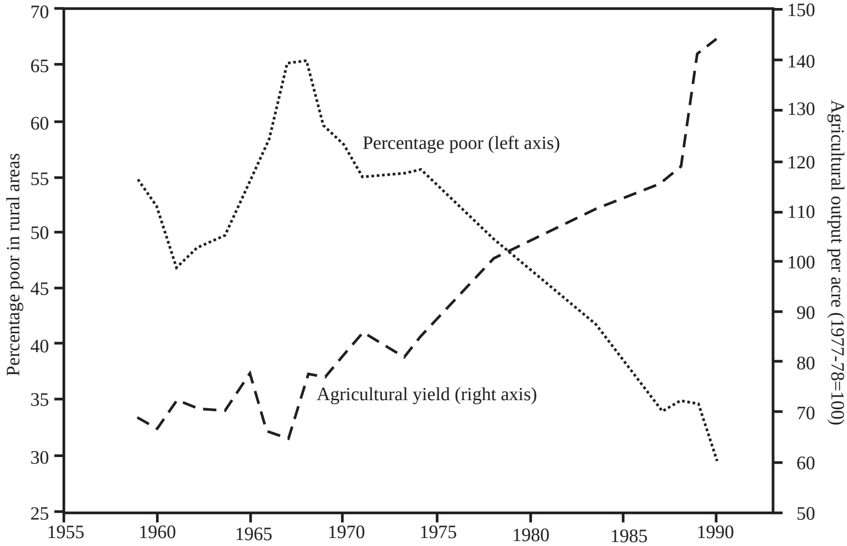
Evidence on the distributional changes accompanying growth is mixed, but historical evidence for a number of countries shows only gradual change over fairly long periods. In India, for example, the income Gini remained almost constant from 1951 through 1992, with a mean of 32.6 and standard deviation of 2.0 (Li *et al.* 1998). In those cases at least, stimulating growth should be a boon to poverty reduction[5]. Dollar and Kraay (2000) confirm this. Using panel data for a sample of 80 countries over several decades, they find that the income of the poorest quintile of the population rises roughly in line with average per capita income. In that respect, as the title of their paper suggests, growth *is* good for the poor.

As Ravallion and Datt (1999) point out, however, even if cross–country regressions show a strong link between average growth rates and poverty reduction, the poverty–reducing impact of a given growth rate shows considerable variance. The initial distribution matters, and that distribution (as measured again by the Gini) varies widely across countries, from 61.9 in Honduras in 1968 to 17.8 in Bulgaria in 1976. For instance, Ravallion (2000) estimates from a sample of 117 periods between household surveys in about 50 developing countries that the elasticity of poverty with respect to growth is about twice as high (in absolute value) for the distribution–corrected rate of growth as it is for the ordinary growth rate. What may matter more than the initial income distribution is the asset distribution, including physical assets, access to financial capital, and human capital.

The direction of change in distribution accompanying growth also matters. In countries where income inequality rose with growth, the median rate of decline in dollar poverty was 1.3 per cent per year, but in those where reduced inequality accompanied growth, the median rate of poverty reduction was seven times higher, or around ten per cent per year (Ravallion 2000). Whether growth is accompanied by widening or narrowing inequality depends, in turn, on a range of factors, including initial conditions like human capital endowments, access to credit by low–income households, and policies that may influence the distribution of benefits from growth.

The sectoral composition of growth also makes a difference to poverty reduction. Ravallion and Datt (1996) provide evidence for India that faster agricultural growth is strongly and unconditionally associated with both rural and urban poverty reduction (see Figure 1). The same is not true of faster growth in the manufacturing sector, whose benefits to the poor depend on a variety of initial conditions like educational attainment, infrastructure, urbanisation, and agricultural productivity.

Figure 1. **Agricultural Yields and Rural Poverty Rates in India**



Source: Ravallion and Datt (1995)

Insofar as technological progress raises farm and non–farm productivity growth, and assuming in the latter case that favourable initial conditions are in place, technology should benefit the poor. The question, though, is one of degree. How important is technology relative to other causes in explaining poverty alleviation? In developing economies — few of which are on a steady–state growth path — other important factors can affect growth prospects. Widespread distortions, market imperfections, and institutional deficiencies leave much scope for reform–induced growth acceleration, at least over some transition period.

Agricultural Technology Innovation and Diffusion

The Green Revolution

The GRTs have had probably the most dramatic effect on poverty in the developing world of any technologies developed over the past half century. The effects were not immediate, and much early literature suggested that the benefits would accrue primarily to better–off farmers. As Lipton (2001) points out, a dramatic reduction in malnutrition has occurred in much of Asia and Latin America as well as parts of Africa, despite a trebling of population. In India, between 1977 and 1993 alone, the percentage of children under five who were malnourished (measured by weight) fell from 71 to 53 (WDI, 2000).

The GRT package as originally introduced in Asia in the mid–1960s included high–yielding crop varieties (HYVs, traditional as well as hybrid), irrigation and nutrient and pest management (largely through application of chemical fertilisers and pesticides). HYVs, with shorter growing seasons, also offered greater opportunity for multiple cropping. Given the working capital requirements, the dependence on irrigation and the uncertainties associated with early adoption, it seems logical that wealthier farmers pioneered the use of GRTs. The early benefits to the poor went more to agricultural labourers and those engaged in off–farm employment, as well as to the urban poor in terms of lower food prices. For non–adopting smallholders, the effect of such price declines was mostly negative, although traditional varieties generally continued to command a quality premium.

A second phase of GRT development — dated roughly from the mid–1970s — aimed at extending benefits to poorer farmers through, for example, development of pest–resistant varieties and those capable of withstanding soil stress (e.g. acidic soils). India in the 1980s adopted modern cereal varieties on an additional 20 million hectares, a figure comparable to that at the 1967–75 height of the green revolution; land area planted to HYVs now greatly exceeds irrigated land area (Byerlee, 1996). While only two modern wheat varieties spearheaded the green revolution in India, by the mid–1990s the national research service was releasing eight new varieties a year for 20 different types of agro–climatic environment. With the extension to less favourable environments, however, has come a slowdown in yield growth.

Lipton and Longhurst (1989) cite the example of the Indian Punjab to illustrate the dramatic transformations that have occurred with the widespread adoption of GRTs. Between crop years 1965–6 and 1980–81, the area planted to wheat and rice increased from 38 per cent to 59 per cent of gross cropped area; wheat yields rose by 120 per cent and rice yields by 174 per cent; and grain output grew twice as fast as population, with less year–to–year variation, somewhat lower prices and more employment per hectare. In short, modern varieties “do tend to reach ‘small farmers’, reduce risk, raise employment, and restrain food prices”, all of which should redound to the benefit of the poor. Yet, at the time, the benefits in terms of poverty reduction appeared modest. The authors seek to resolve this paradox. They observe that the poor are increasingly land–poor and dependent on wage labour. They argue that the benefits to the poor as consumers (lower food prices) are captured largely by their employers, who can pay lower wages. The benefits to the poor as labourers are mitigated by farm mechanisation, increased use of herbicides and weak linkages between the modern varieties and the non–farm sector.

Some more recent studies of GRTs in the PRC paint a less bleak picture of their effects on poverty and income distribution. There are two broad approaches to analysing these effects. One looks narrowly at crop income, considering the differential rates of income growth of adopters and non–adopters of modern varieties. The other takes a broader view of impacts on total household income, across adopter and non–adopter households. Huang and Rozelle (1996) focus on Chinese rice productivity, seeking to estimate how much of its growth can be attributed to post–liberalisation institutional innovation (the decollectivisation of agriculture), how much to technology, and how the latter interacted with the former. They find that technology contributed 60 per cent of the growth in yields over 1975–90, while institutional change contributed 22.3 per cent. Moreover, after 1984, practically all of the positive contribution to rice yields came from technology, notably adoption of hybrids, more than offsetting negative effects of environmental stress and rising input prices.

Lin (1999) takes the broader view of technology adoption, focusing on how it affects total household income in both adopter and non–adopter households. He hypothesises that those who choose not to adopt the modern varieties (e.g. of rice) rationally prefer to devote more resources to other income–generating activities, whether in or outside of agriculture, where they enjoy a comparative advantage. The study draws on household survey data for five counties of Hunan province in the PRC, which has long had one of the highest adoption rates of hybrid rice varieties in the world. In all but one county the Gini coefficient on total household income is smaller than that on rice income alone, which is consistent with the view that households not able to profit from rice production (for reasons of technology, land endowment, or other factors) specialise in other areas where they can earn higher returns. The main trade–off in the technology adoption decision seems to be between rice and non–farm income — i.e. planting hybrids has a significantly positive effect on rice income and a significantly negative effect on non–farm income. At the same time, modern variety adoption apparently has no significant effect on total household income, while such variables as size of landholding, number of actively employed household members, and average years of schooling do.

The schooling–income link in Lin comes from schooling's effect on non–farm income, while the effect on farm income appears to be negligible, controlling for hybrid adoption. It is possible, of course, that schooling significantly affects the choice whether or not to adopt (or the timing of when to adopt)[6], but Lin cannot test for this. Still, the finding seems at least consistent with other studies, which find that the main effect of schooling in farm households is not on crop productivity *per se* but on allocation decisions — e.g. choice of cropping mix and mix of farm and non–farm activities. (See Feder *et al.*, 1985, for a review; and Taylor and Yúnez–Naude, 1999, for microeconometric evidence from Mexico.) These are essentially entrepreneurial decisions. Pomp and Burger (1995) offer another piece of supporting evidence. They find in Indonesia that education levels significantly affect decisions by farmers to grow cocoa (essentially diversification decisions), and that other farmers are more likely to follow the lead of educated early adopters than of uneducated ones, suggesting greater trust in their entrepreneurial judgement.

If the poor are also the less educated, then they will presumably have less capacity to make optimal allocation decisions. A possible policy implication of this is that, given the choice between investing in new crop varieties tailored to the growing conditions of the poor and investing in their education, preference should be given to the latter. In this way, not only are the poor given more options but they also are afforded a stronger basis for choosing among them.

There is good reason to suppose that agricultural productivity gains matter more to poverty reduction than do productivity gains in other sectors of the economy. First and foremost, this derives from the heavy weight of food items in the consumption baskets of the poor. Food in general and staples in particular represent over 70 per cent and 50 per cent, respectively, of the consumption expenditures of the dollar poor. Second, the poor are much more likely than the non–poor to make a living from agriculture and/or other rural employment. About two–thirds of the world's 1.3 billion poor people live in rural areas, and most are employed in agriculture. Third, the poor depend heavily on labour income, and for a given growth in output the agricultural sector tends to employ more labour than other sectors, both directly and indirectly (in the form of labour–intensive rural non–farm services) (Lipton, 2001).

Using a computable general equilibrium model, with stylised rural economies and poverty characteristics for Africa, Asia, and Latin America, de Janvry *et al.* (2000) simulate the effects on poverty of an agricultural technology improvement, defined as a ten per cent gain in agricultural total factor productivity (TFP). In Africa, the benefits to the poor accrue directly to smallholders in terms of improved own consumption and income; in Asia they accrue mostly to agricultural labourers in terms of higher real wages and greater off–farm employment opportunities; in Latin America they accrue mostly in the form of cheaper food prices for the rural and urban poor.

The Gene Revolution

The biochemical green revolution has stalled, with depressed crop prices dampening incentives to farmers and increased input demand raising fertiliser and agrochemical prices while contributing to water scarcities. Yield improvements in developing countries have slowed significantly, from an average of 2.9 per cent per year for cereals in 1967–82 to 1.8 per cent per year in 1982–94 (de Janvry *et al.*, 2000). The latter yield growth, if sustained over the next 25 years, would just about satisfy the projected 59 per cent growth in demand. With existing technologies, however, the likelihood of sustaining such growth would appear to be low.

The so–called Gene Revolution of biotechnology does not offer any quick fix to this secular yield slowdown. The potential applications of biotechnology are of two major sorts: to reduce costs of varietal improvement by employing molecular markers and improved diagnostics for more precise selection of plants that carry desirable traits, and to allow transfer of genes from unrelated species to provide traits that would not be available through conventional breeding (Byerlee, 1996). In cereals research, transgenics is most advanced in rice so far, where eight new genes for pest resistance have been inserted and varieties carrying some of these genes are likely to be released by decade's end in Asia. Both sorts of application offer greater genetic variety, yield stabilisation and reduced pesticide use, but they are not likely to have a major impact on yield growth.

Rice breeding in West Africa provides a promising example of the potential biotechnology may hold for poor farmers. The West Africa Rice Development Association was established in 1971 as an autonomous intergovernmental research association with a mission to strengthen Sub–Saharan Africa's capability for technology generation, technology transfer and policy formulation, in order to increase the sustainable productivity of rice–based cropping systems while conserving the natural resource base and contributing to the food security of poor rural and urban households. It has adapted Asian HYVs to African circumstances, making them resistant to local pests and diseases and tolerant of poor nutrient conditions and mineral toxicity. Farmers play an important role in disseminating the seeds through traditional village systems of barter and sale. As a result, the hybrid varieties have diffused rapidly.

De Janvry *et al.* (2000) note a number of potential benefits of plant biotechnology to the poor. They include reduced risk (e.g. of pest infestation or drought–induced losses); improved storability (hence reduced wastage) due to pest resistance and delayed maturation; nutritional improvements (e.g. through genetic introduction of micronutrients); and health benefits due to reduced exposure to agrochemicals and development of new vaccines. Apart from biosafety risks, biotechnology may pose some risks to the livelihoods of poor people, for example by reducing labour demand for weeding with herbicide–resistant varieties. Perhaps the greatest risk is that the crops of poor subsistence farmers will be bypassed by biotechnology innovations. There is also a risk that, if terminator genes are used to enforce intellectual property rights, costs to farmers of seeds could increase markedly.

One of the most promising avenues of agricultural biotechnology research is the self–enrichment of staple food varieties with micronutrients (e.g. vitamin A, iron, zinc), whose deficiency in many poor people's diets is known to cause serious health problems (Bouis, 2001). Annually an estimated 250 000–500 000 pre–school children go blind from vitamin A deficiency, and about two–thirds of them die within months of going blind. As Bouis points out, good nutritional balance is as important for disease resistance in plants as it is in humans, and the efficient uptake of micronutrients from the soil contributes to such resistance. So, such varieties could reduce dependence on fungicides to maintain yields at the same time that they improve human nutrition. Once again, research is most advanced on rice. Bio–availability tests began in 2000 on an aromatic variety (IR68–144) with twice the iron (after milling) of standard IRRI[7] varieties; it is also early maturing, high–yielding and disease–resistant.

The Heretofore Excluded

Some agricultural areas have been largely bypassed by both phases of the green revolution. These include areas generally classified as marginal for crop production — e.g. areas prone to frequent drought and, in the case of rice, with little water control; areas with poor infrastructure and no access to markets (most often affecting maize in Africa and parts of Latin America); areas where quality trades of traditional varieties outweigh the yield advantages of HYVs (as for rice in Thailand); and areas where the research system has been unable to develop varieties with yield advantages. Several of these area types happen, not by coincidence, to have an especially high incidence of poverty.

Lin (1999) questions the validity of suggestions (citing Lipton and Longhurst, 1989) that future agricultural research needs to give more consideration to the distributional implications of modern varieties. In his view, household resource reallocation decisions in the face of changing relative rewards will mitigate most if not all adverse distributional impacts of differential adoption of food–crop innovations. For those who find cereals production less profitable, investment in rural roads and other infrastructure may yield greater benefits (by providing better links to markets and encouraging development of off–farm employment) than investment in raising cereals profitability.

Lin himself is quick to caution against sweeping generalisations of the rather sanguine conclusions drawn from limited evidence on one province of the PRC. What is clear is that, if widespread adoption of GRTs were sufficient to alleviate hunger, malnutrition, and poverty, the rate of poverty would have declined far more rapidly than it has in major adopting countries. As Lipton and A. Sen have long emphasised, the issue is not simply one of increased food production but of entitlements of the poor to food, as manifested among other ways in the paid employment opportunities of the growing ranks of the landless and land poor (including the urban poor).

Arguably, within agriculture, certain types of research and investment relatively neglected in the past — like improved systems of water management — will assume greater importance in the future (Lipton, 1999). Worsening water scarcities in many countries will likely become a more severe constraint on continued yield growth, and they may even render current production practices unsustainable. While investing in development of drought–resistant crop varieties offers one route to addressing the water problem, the payoff could be far greater to investment in developing and putting in place better water–control and conservation techniques.

One cautionary note is appropriate. New biotechnology may play a role in addressing the food security, nutritional and health problems of the poor in the coming decades, but other factors may be more important. As a recent *Financial Times* article notes in summarising discussion at an international agricultural forum: “While US and European companies hawked technology as the solution to under–nourishment in developing countries, international agencies and national representatives saw a host of more immediate and mundane problems…inadequate farm size, lack of investment, trade distortions and subsidies in the industrialised countries” (Nikki Tait, *Financial Times*, 30 May 2001).

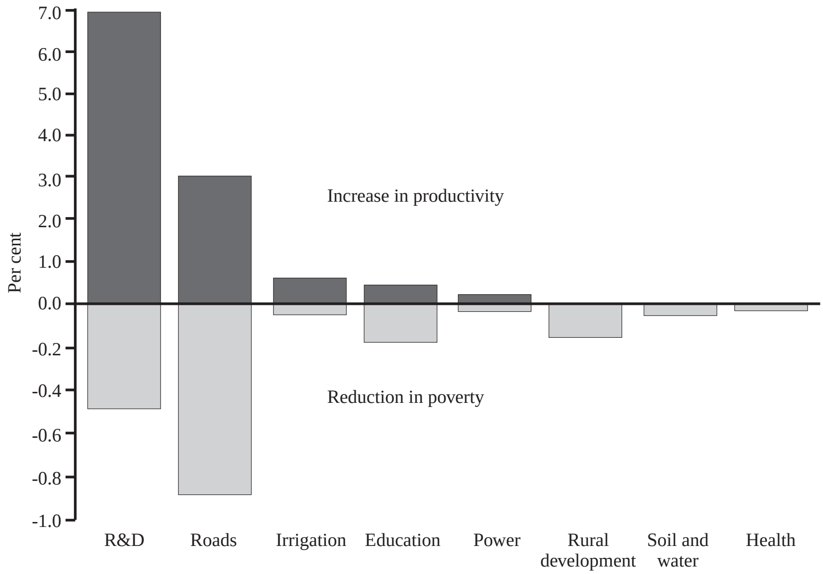
Non–Farm Productivity Growth and the Poor

The impact on poverty of productivity growth in non–farm activities is more ambiguous than that of agricultural productivity growth. Ravallion and Datt (1996) find that the sectoral composition of growth matters to poverty outcomes — e.g. whether the growth dynamic encompasses agricultural and rural non–farm activities or is confined primarily to the urban industrial sector, in which case the poverty impact is limited. Ravallion and Datt (1997) find that agricultural growth unconditionally reduces poverty across Indian states, but the effect of non–farm output growth on poverty is conditional on initial literacy rates, agricultural productivity, the degree of urbanisation and the size of the rural–urban income gap. The importance of initial literacy rates is consistent with findings of Lin (1999) for the PRC that years of schooling are a significant determinant of non–farm household income. If very few have schooling, then the bulk of the income from non–farm employment will accrue to the few. High literacy and schooling rates should spread income gains more widely.

Lin (1999) decomposes Hunan county–level Gini coefficients for total household income into a rice income Gini, a non–rice agricultural income Gini, and a non–farm income Gini. A striking result is the much higher Gini on non–farm income than on the two types of agricultural income. Even though non–farm income represented only about a quarter of total household income in the sample, it made an identical contribution to rice to overall household income inequality. Thus, as rural households come to depend less on farming and more on non–farm activities, we would expect rural inequality to increase significantly. Clearly, though, a widening distribution need not imply increasing absolute poverty. One can imagine a situation in which the relatively uneducated, land–poor come to derive a growing share of their income from non–farm employment, with their sheer numbers competing wages down, while the educated few leave agriculture behind for better–paid employment in non–farm businesses, professions, etc. At the margin, the low–skilled wage earners would presumably be at least as well off as if they had stayed in agriculture, while a substantial number are probably better off. What is the probability of their moving out of poverty?

That depends on some of the other factors identified by Ravallion and Datt (1997). For instance, the productivity of the agricultural sector is likely to affect the returns to non–farm employment insofar as a more dynamic agriculture will generate greater local intermediate demand for inputs and services as well as construction (housing, farm structures) and final consumption demand. The proximity to markets — as reflected in the condition of rural infrastructure and the degree of urbanisation — is also an important determinant of the returns to non–farm employment. Not only does proximity to urban areas raise the possibility of temporary employment–related migration, but it also facilitates the spill–over of labour–intensive industrial activities from cities to their lower–cost hinterlands. The following figure from Fan *et al.* (1999) illustrates the strong complementarity between the productivity and poverty–reduction effects of rural road investment in India. This has much to do with providing direct employment to the poor on road projects and something to do with getting traditional food crops to market and critical inputs delivered to farmers in a timely fashion. It also has a great deal to do with allowing greater diversification of the rural economy, including in agriculture (e.g. into vegetables, fruits and other perishables for urban markets) and into non–farm production, and with the cheapening of manufactured imports from the cities.

Figure 2. **Increases in Growth of Productivity and Reduction in Poverty as a Result of Additional Government Expenditure**



Note: Based on spending of an additional Rs 100 billion in 1993 constant prices.
Source: Fan *et al*. (1999).

Differential Rates of Technical Progress across Sectors

Having looked at technological change — reflected in productivity growth — in agriculture and non–agriculture separately, let us return to the big picture, considering the economy–wide effects of differential productivity growth across sectors. First, do sectoral TFP growth rates differ over long periods of time and, if so, how? A common and longstanding assumption among many economists has been that agricultural productivity growth lags that of manufacturing, because of either a more limited scope for division of labour (Adam Smith) or diminishing returns to the fixed factor, land (David Ricardo). Martin and Mitra (2001) examine the evidence, exploiting a new dataset (constructed by Larson and Mundlak) on capital stocks in agriculture and manufacturing for a large sample of countries over a quarter century beginning in 1967. They consistently find the opposite result, whether with a Cobb–Douglas or a translog production function specification — agricultural TFP growth significantly exceeds manufacturing TFP growth. In a translog specification, the former averaged double the latter for low–income and middle–income developing countries. There is also strong evidence of productivity convergence to US levels in agriculture but less in manufacturing. They suggest that one reason for the finding may be that the dataset covers essentially the period of the green revolution. Be that as it may, what do these trends imply for poverty reduction?

Higher productivity growth does not necessarily imply higher value–added growth; indeed, we know that, with economic development, agriculture's share of GDP tends to shrink, in part as a result of Engel's law. The relative growth of industry, however, would appear to owe more to capital deepening and resource reallocation from agriculture — including through rural–to–urban migration — than to faster productivity growth. Whether this benefits the poor depends to a degree on whether the reallocation results from unaided market forces or is abetted by industry–biased government policy. In the former case, while manufacturing may on average have a higher capital–labour ratio than agriculture, the sort of manufacturing that thrives in a labour–abundant economy should be of the labour–intensive variety. Government policy, on the other hand, is usually designed to give a head start to more capital–intensive endeavours, with more adverse consequences for non–farm employment demand.

Whether the economy is a small open economy or a large, presumably less open one can also make a difference. In the former case, with prices determined on world markets, the effect of differential sectoral rates of productivity growth should be primarily of a Rybczynski kind, i.e. with the faster–growing sector drawing resources away from the less dynamic one, causing it to shrink. (Is 1980s Chile an example?) Where the economy is large (and closed), the effects are more likely to be felt through movement of the commodity terms of trade against agriculture, transferring resources to industry. In this case, the effects on the poor depend heavily on the nature of non–agricultural labour markets, in particular their degree of segmentation and any resultant entry barriers to rural migrants.

Information and Communications Technology for the Poor

Distance — remoteness from markets — remains strongly associated with poverty. While the last several decades have seen major advances in international freight and passenger transport, transport within poor countries has not often seen comparable improvements. To a degree, telecommunications is similar, but there are also important differences, resulting notably from their very different technological trajectories. Land transport remains much the same today as a half–century ago, but telecommunications is vastly different. Still, the problem of connecting remote areas and their poor inhabitants economically to population centres remains, whether the connection is a road or a telecommunications mainline. Understanding ICTs' potential to improve poor people's welfare requires answers to three questions:

— What are the principal sorts of information that poor people need to make them better off?

— Which of that information is currently not being supplied effectively (on time, in a readily usable form)?

— Can ICTs remedy the deficiency cost effectively?

A few examples help illustrate the sorts of information available with ICTs that can benefit the poor:

— In India, agricultural workers paid in kind can ensure fair wages by having independent access to information on the market price of rice;

— Farmers can check seed prices and decide on that basis whether to plant hybrid varieties; and

— Sugar farmers can contact an entomologist for advice on pest management.

In each case, timing is crucial and the timeliness of the information available with ICTs (whether by telephone or the internet) gives it its value. Ironically, we tend to think of the expression "time is money" as a product of advanced capitalism, but timing is perhaps even more crucial for the poor farmer. Selling a crop at just the right time can make a big difference for profits.

Another popular conception is that ICTs are particularly well suited to advanced capitalist economies with large service sectors that generate heavy demands for information processing, management and sharing. Perhaps, but another stylised feature of developed economies is that their markets work reasonably efficiently, with low transaction costs. Developing economies, on the other hand, have pervasive market imperfections and, presumably, high transaction costs. There is little systematic evidence to support this hypothesis but much of the anecdotal kind (cf. Goldstein and O'Connor, 2000, for a survey). Assuming it is so, then ICTs (in particular, internet–based e–commerce/e–business) have greater efficiency–enhancing potential there than in the developed countries. The significance of this for the poor appears ambiguous. On the one hand, if middlemen who capitalise on an information monopoly cause the inefficiencies, both the consumer and the poor producer — whether of agricultural goods, handicrafts, or light manufactures — could benefit from disintermediation, sharing the cost savings between them. On the other hand, some poor people — e.g. truck drivers, porters, and warehouse workers — no doubt depend on the distribution sector for their livelihoods; they may be adversely affected by sectoral cost–cutting in the event of a profit squeeze. While for the moment only an intuition, the first effect on the poor would seem the more important. The next section takes a formal look at how transactions–cost–reducing technologies (transaction technologies for short) may affect both overall economic efficiency and income distribution.

A further non–trivial contribution that ICTs could make to help the poor is in realising cost savings through rationalisation of government functions. Areas of considerable wastage in many countries include non–competitive procurement (e.g. of vaccines and medicines, school textbooks, building materials and construction services), poor storage, poor inventory management and erroneous demand projections, most of which are amenable to amelioration through ICT use (Bloom *et al.*, 2000).

One perhaps undervalued contribution of ICTs to human development and, potentially at least, to the welfare of the poor lies in facilitating advanced scientific research in a whole range of disciplines but notably in genomics, biotechnology and their application to drug development and agriculture. The current pace of technical progress in these fields would have been inconceivable before the advent of powerful electronic computers. The internet and other technologies for sharing large–scale databases have tremendously facilitated collaborative scientific research[8].

Transaction Technologies: Theory and A Simple Numerical Model

Transaction Costs Theory

The seminal work of Coase (1937) sought to explain the simultaneous existence of markets and firms, reasoning that if markets were efficient forms to organise production and exchange there would be no need for firms to emerge, and if firms had pervasive cost advantages over markets, we should observe a single giant firm producing all that is demanded. His fundamental intuition was that differential transaction costs across activities explain why both firms (or institutions) and markets exist. In certain types of activities, costs of market transactions are sufficiently high to warrant the internalisation of exchanges within firms, while for other types markets operate with low transaction costs. This work has spawned a voluminous literature, both theoretical and empirical[9], that is not without its critics. In Goldberg's (1985) words, explaining economic phenomena by appeal to transaction costs "is the all encompassing answer that tells us nothing".

Another approach starts from the premise that transaction costs are pervasive and asks how exchanges take place in markets affected by variations in transaction costs within a standard general equilibrium framework. In an effort to enrich the theory of general equilibrium as formulated by Arrow and Debreu (see Debreu, 1959), a few authors[10] have studied how it should be modified to incorporate transaction costs and what consequences such a modification would have for the major predictions of the standard theory. In Foley's words, "the key aspect of the modification I propose is an alteration in the notion of 'price'. In the present model there are [...] a buyer's and a lower seller's price [and their] difference yields an income which compensates the real resources used up in the operation of the markets" (Foley, 1970) When the operation of a market needs intermediaries that provide information or other services to buyers and sellers so that they can complete a transaction, then these intermediaries would generate an income by charging a transaction fee (= cost) equal to the value of their marginal product.

Another form of transaction costs has been considered in international trade and explicitly incorporated into models since Samuelson's 1954 article on transport costs. The basic idea here is that trade involves transaction costs and that these may be simply thought of as a fraction of the traded good itself, as if "only a fraction of the ice exported reaches its destination as un–melted ice". This "iceberg model" clarifies how a reduction in transaction costs saves real resources and makes an economy more efficient.

In practice, transaction costs may arise from a variety of sources. Some may be amenable to technology — like high transport and distribution costs — and some (e.g. reduced bureaucratic red tape and corruption) may require policy intervention.

A Simple Numerical Model with Simulations for India

This section examines the poverty effects of changes in transaction costs, using numerical simulations based on a theory–consistent general equilibrium model calibrated on data for India. It uses 1994 data on production, consumption, factor and intermediates use, aggregated to a two–commodity, two–factor, two–household classification[11]. It abstracts from international trade and focuses on a closed economy. The introduction of import and export flows, while making the prices of tradeables exogenous and determined in world markets, would not affect the determination of factor prices (unless factors are internationally mobile). Technology shocks are not modelled as exogenous productivity changes, but as alterations of a transaction–cost mark–up.

Production. The economy produces two goods, an aggregate primary commodity (mainly agriculture, A) and a composite manufacturing–service commodity (B), using intermediates inputs in fixed (Leontief) shares and combinations of labour and capital in a Cobb–Douglas constant returns to scale technology as follows:

$$Q_i = \eta_i L_i^{\alpha_i} K_i^{1-\alpha_i} \qquad \text{with the commodities index i = A, B} \qquad (1)$$

where Q_i represents the quantity produced of the two goods, h_i a parameter standing for the sector–specific technical level, and a_i and (1– a_i) the Cobb–Douglas output elasticities with respect to labour and capital. Factor–neutral technology shocks similar to those mentioned above would entail changes in the parameter h_i.

Factor markets. Assume full employment of fixed endowments of capital ($\overline{K}$) and labour ($\overline{L}$), so that their supplies will be completely inelastic with respect to their prices. These are thus determined by firms' demands that, in competitive markets, are equal to their marginal product in value:

$$w = \alpha_i Pva_i \frac{Q_i}{L_i} \qquad \text{i = A, B} \qquad (2)$$

$$r = (1-\alpha_i) Pva_i \frac{Q_i}{K_i} \qquad \text{i = A, B} \qquad (3)$$

where *w* and *r* are the wage and rental rates respectively, and *Pva* is the value–added price, i.e. the commodity sale price minus intermediates costs.

Transaction Costs are modelled as a mark–up on commodity prices. This is equivalent to an excise tax or a transport margin and thus does not increase with the value of the exchanged commodity but is proportional to the quantity exchanged:

$$Pt_i = P_i + t_i \qquad \text{i = A, B} \qquad (4)$$

where revenues generated by the wedge t_i between the seller and buyer's price are equal to $\sum_i t_i Q_i$, and are used to buy transaction services from sector B of the economy.

Therefore, in this case, sector B receives income by selling its *normal* output plus transaction services.

Consumption. The model includes two households, one rural (R) and one urban (U), that receive incomes from selling factor services and demand commodities via optimisation of a Cobb–Douglas utility function. Households are thus differentiated by their consumption patterns and their ownership shares, with the urban household demanding more of commodity B, owning a larger share of capital and representing the rich household. Derived consumption demands are as follows:

$$Qd_{H\,i} = \beta_{H\,i} \frac{Y_H}{Pt_i} \quad \text{with the household index H = R, U and i = A, B} \qquad (5)$$

where *Qd* represents the household–specific quantity demanded, β an utility share parameter, and *Y* the household's income.

Equilibrium Conditions. Factor–market clearing conditions simply state that the sums of factor demands must equal the fixed factor endowments.

$$\sum_i L_i = \overline{L} \qquad \text{and} \qquad \sum_i K_i = \overline{K} \qquad \text{i = A, B} \qquad (6)$$

Commodity prices are derived from the equality of supply and demand where the latter includes final consumption as well as intermediate and transaction service demands:

$$Q_i = \sum_H Qd_{H\,i} + \sum_j a_{i,j} Q_j + Qt_i \qquad \text{i = A, B} \qquad (7)$$

where $a_{i,j}$ represents the Leontief input coefficients for intermediates and *Qt* the quantity of transaction services. As mentioned above, these are provided exclusively using sector B's technology and their total value is equal to the *revenues* from the transaction cost mark–up.

In this simple model, one can solve for household income distribution based on household factor ownership and changes in factor rewards. Given fixed factor ownership shares for the rural and urban households and setting a poverty line, it would not be difficult to calculate absolute household poverty measures. Considering household–specific absolute poverty indices has the advantage of allowing one to trace the effects of changes in transaction costs not only on the supply/income side, but also on the demand/expenditure side.

This simple general equilibrium model can be used to conduct some basic experiments aimed at investigating the analytics of the link between transaction costs and poverty. The following numerical results should not be considered exact estimates, but just indications of the potential magnitude and direction of that link. The crucial characteristics of the initial data for India are shown in Table 1, where it is possible to observe the following:

Table 1. **Initial Data: Main Characteristics**

Sectoral Variables	Sector A	Sector B
K/L	0.81	1.28
Transaction Costs *ad valorem* (per cent)	19	12
Intermediates as per cent of Production	43	44
Transaction Services as per cent of Output	0	26
Ownership Shares (per cent)	Labour	Capital
Rural Households	56	40
Urban Households	44	60
Total	100	100
Consumption Shares (per cent)	Rural Household	Urban Household
Sector A	71	58
Sector B	29	42
Total	100	100

Source: Authors' calculations based on Indian input-output data and expenditure surveys.

— Sector A is labour intensive and uses more or less the same percentage of intermediates as sector B;

— Exchanges, among producers as well as between producers and final consumers, of the commodity produced by A entail larger transaction costs than those of commodity B; and

— Transaction services are produced exclusively by sector B and account for about a quarter of its total output.

— Compared with urban households, rural households own a larger share of labour and a smaller one of capital and consume far more commodities of type A than of type B.

Most of these numbers are direct calculations from India's national accounts and input–output table, but transaction costs have been estimated using raw data on inputs of transport/communication/distribution services by sector, with an additional mark–up for sector A to reflect the assumed greater remoteness from markets and more limited access to basic services such as banking. Although these preliminary estimates need to be improved, it seems reasonable to expect that, at a similar level of intermediate use, sector A's agricultural commodities and rural light manufacturing (such as textiles) have to incur larger transaction costs than typical sector B commodities. Indeed, post–harvest losses in agriculture remain a widespread problem.

The first experiment, simulating a situation where new transaction technologies are adopted, consists of a shock that reduces the transaction cost mark–up by 50 per cent for both commodities. Its main effects are summarised in Table 2, and the causal relationships work as follows. The initial shock reduces the wedge between the buyer and seller's price and the *revenues* from transaction cost mark–ups. This immediately affects those intermediaries who were delivering transaction services according to the technology of sector B (notice the reduction of 46 per cent in the value of transaction services), and frees labour and capital resources. Given that sector B is more capital intensive than A, its overall reduction releases capital at a faster rate than that needed to expand the labour–intensive sector A, and this entails an increase in the wage–to–rental ratio. Even with *no sector bias* in the reduction of transaction costs, a reduction in relative poverty occurs and, due to their factor ownership and consumption patterns, rural households' income and consumption increase faster than those of urban households.

Table 2. **Basic Experiment of Reduction in Transaction Costs**
(Variations in per cent from initial equilibrium)

Output, Sector A	11.8	Rural Consumption of Commodity A	14.3
Output, Sector B	-9.0	Rural Consumption of Commodity B	10.8
Transaction Services	-46.1	Urban Consumption of Commodity A	13.9
		Urban Consumption of Commodity B	10.4
Wage: w	6.1		
Rental rate: r	3.7	Income, Rural Households	4.0
w/r	2.4	Income, Urban Households	3.4

The different sectoral factor intensities largely determine changes in the wage to rental ratio. The initial sectoral transaction–cost mark–ups differ too, however, and it would be interesting to know the relative importance of these two initial differences in explaining the final outcome. To decompose the contribution of each, a set of experiments changes factor intensities and mark–ups in sequence. The four columns of Table 3 answer the following question. What happens when transaction costs are reduced by 50 per cent across all commodities and the economy initially has *a)* no sectoral differences in factor intensities or mark–ups; or *b)* differences in transaction costs alone, or *c)* differences in factor intensities alone; or *d)* differences in both mark–ups and intensities?

Table 3. **Controlling for Initial Differences**
(Variations in per cent, given a 50 per cent reduction in transaction costs)

	a	b	c	d
Mark-up	Equal	Different	Equal	Different
K/L Ratio	Equal	Equal	Different	Different
Wage	3.94	4.90	4.85	6.14
Rent	3.94	4.91	3.03	3.68
w/r	0.00	0.00	1.77	2.38

The results show that factor intensities play a crucial role and that when they are equal across sectors relative poverty does not change with transaction–cost reductions. Yet, as shown by the changes between columns c) and d), differential mark–ups intensify the factor–intensity effect. Even with a proportional 50 per cent reduction in mark–ups equal across sectors, in the situation depicted by the rightmost column, sector A benefits from a larger absolute decrease in the mark–up. This results in a more significant drop in the price paid by the buyers of commodity A and a larger increase in demand, and it raises the relative reward to the factor — labour — used intensively in its production.

Based on this last observation one can in fact construct numerical examples where sectoral factor intensities combined with sector–biased reductions in transaction costs produce worse relative and absolute poverty outcomes. Consider a case opposite to the situation observed in the Indian data, where transaction services are provided by the labour–intensive sector and the reduction in mark–up is confined to the capital–intensive sector. Simple manipulation of the original Indian data can generate such a case and make sector B, the transaction services provider, become labour intensive (with a K / L ratio now equal to 0.6 instead of the original 1.3). Table 4 displays the results for two experiments: *a)* a 50 per cent reduction of transaction costs is applied to all commodities, and *b)* it is applied only to commodity A. The results show clearly that, when labour is used more intensively by transaction services, a reduction in their cost may imply a decrease in the w/r ratio and a worsening in relative poverty. A reduction in absolute poverty, recorded by a reduction in the wage in case *b)*, requires that transaction–cost innovations benefit just the capital–intensive sector.

Table 4. **Can Transaction-Cost Reduction Hurt the Poor?**
(Variations in per cent)

	a	b
Wage	1.51	-0.42
Rent	7.71	4.42
w/r	-4.64	-5.75

To this point, the analysis has focused mainly on the production and income–generation side of the story, but important links between transaction costs and poverty operate on the consumption side as well. It seems clear that whenever transaction costs affect more heavily commodities figuring prominently among those demanded by the poor, a reduction in their price should benefit them. The last experiment demonstrates this. Here, a reduction of transaction costs concentrates on commodity A. Table 5 reproduces the initial experiment in column a), and column b) shows an experiment in which total transaction–cost *revenues* are the same as in a) but transaction mark–ups are reduced only for commodity A. Given that the poor have a larger share of A in their total consumption (see Table 1), this translates into much larger increases in demand for this commodity and in larger incomes (there are no savings in the model).

Table 5. **The Consumption Side**
(Variations in per cent)

	a	b
Rural Consumption of Commodity A	14.3	19.6
Rural Consumption of Commodity B	10.8	2.6
Urban Consumption of Commodity A	13.9	19.0
Urban Consumption of Commodity B	10.4	2.0
Income, Rural Households	4.0	5.1
Income, Urban Households	3.4	4.7

These examples show that the simple analytical structure used here can generate a range of results, depending on whether transaction–cost innovations are heavily sector–biased and/or factor–biased. Thus, the question whether an improvement in transaction costs benefits the poor is essentially an empirical one.

The Role of Institutions in Technology Development and Diffusion to the Poor

While ultimately poor people themselves make the decisions whether to use certain technologies — be they poor farmers considering hybrid seeds or rural Bangladeshi women looking at mobile phones — institutions can play an important role in shaping those decisions. In the case of HYVs, for example, public agricultural extension services have been instrumental in "spreading the gospel" of the green revolution and providing technical advice to adopting farmers. In the private sector, seed and agrochemical companies perform a similar function. Extension services can also play an important role in fostering crop diversification. In Bangladesh, Sen (2001) observes that one reason why local farmers have had only limited success in meeting growing demand for meat and vegetables is that an overburdened extension service has been unable to perform basic soil testing for crop suitability and input requirements on more than half of the arable land, increasing significantly the risk to farmers.

For mobile phones in Bangladesh, the Grameen Bank network provided the institutional infrastructure for extending credit to rural women to lease the phones and for bill collection. The absence of institutional or physical infrastructure can prove a serious hindrance to technology diffusion. This is evidenced, for instance, by the huge wastage of vaccine materials in tropical developing countries lacking adequate refrigeration[12] (Bloom *et al.*, 2000; see also Lanjouw and Cockburn, 2001, for a discussion of the importance of delivery systems for new drugs).

Institutions differ in the degree to which their viability depends on collective action. Markets are at one extreme, where the institution takes shape from the decisions of multiple agents acting more or less independently, although their effectiveness clearly depends on participants' agreeing to a basic set of endogenously generated or externally imposed rules. Competitive markets are not always adequate mechanisms for ensuring a socially optimal level of technology development; neither do they always suffice to ensure optimal diffusion of a technology. For example, development and maintenance of irrigation systems normally involve a high level of social co–operation that has traditionally been organised through non–market institutions. Since access to a complementary input like irrigation water can substantially affect the returns to investment in HYVs, the institutional arrangements for water control and allocation clearly matter to technological outcomes. In a rural economy, property rights in land are often the major source of wealth and hence of local political influence. The land–poor lack political clout. That is why the 2000/2001 World Bank *World Development Report* on “Attacking Poverty” mentions empowerment as an essential condition of poverty alleviation.

For information and communications technologies, the crucial complementary input that many poor people lack is literacy, basic as well as the computer kind. Arguably, the former is by far the more important, as many users of computers and the internet even in OECD countries would not qualify as computer–literate in any but the most rudimentary sense. As most governments in the world have the intention if not the capacity to offer publicly subsidised universal primary education, the answer to the question of why so many people remain illiterate must be sought elsewhere. Social institutions and culture no doubt play an important role, but one would expect that, if the private economic benefits of educating girls came to be widely recognised, institutional, cultural and political resistance would wither. This may indeed be happening in some societies, but apparently not in all. While it is premature to draw firm conclusions, it is possible that, in some poor countries at least, the diffusion of information and communications technologies throughout the economy would generate significant new demand for literate workers. In any case, the least educated, usually the poorest members of the workforce, are not likely to be the first to benefit from such demand (Panagariya, 2000)[13].

Intellectual Property Rights, Technology Access, and the Poor

One institution closely linked to technology development and diffusion is that of intellectual property protection. In the last decade and a half, developing countries have come under growing pressure from OECD countries to strengthen intellectual property rights (IPR) regimes. This is also required under the 1994 WTO Agreement on TRIPS[14]. Designing an appropriate legal framework for IPRs involves balancing two objectives: ensuring that adequate incentives are in place to encourage innovation, and ensuring that the fruits of innovation are widely accessible. While IPRs are not the only incentive to innovation, they are now the predominant one — at least for private–sector innovators — in OECD countries.

Developing–country governments have until recently resisted strong IPR protection, on the grounds that the costs are likely to exceed benefits for countries that are not major innovators but depend heavily on borrowed technology. As Maskus (2000) explains, there is a sound economic argument that optimal protection of intellectual property is an increasing function of income and technological capacity. With rising incomes people demand higher quality, differentiated goods, with trademarks and copyrights being a key aspect. At the same time, with an economy's growing technological sophistication, inventors are likely to demand greater protection for their works. In effect, globalisation has accelerated the whole process by exposing low–income countries to the IPR preferences of inventors in technologically advanced societies. In this case, unlike in some other areas of development economics, small country size may be a blessing, in that international companies are apt to be less inclined to press for strict enforcement in markets too small to matter to global profits.

There is a legitimate concern that poor people might not be able to afford highly beneficial R&D–based products — like new medicines — if companies are free (and choose) to incorporate full royalties into the price. An even more fundamental question concerns the direction of R&D efforts *vis–à–vis* the poor, who may simply not be an attractive enough market to justify development of technologies specifically tailored to their needs. Put simply, if the developers receive no IPR protection, they have no incentive to develop them, but if they do receive protection and charge accordingly, they have no market. Under the circumstances, perhaps the best that poor people can hope for from privately funded R&D is to benefit from technologies of broader applicability developed to serve a wider market, where there is a possibility of price discrimination between rich and poor countries (as for example with patented AIDS drugs). Alternatively, the public sector and private philanthropic foundations may be able to steer private R&D efforts toward poor people's health, nutritional, or other needs through innovative financing arrangements — like vaccine funds. Even then the amounts involved are likely to be small by comparison with self–generated private R&D funds, so this approach may be more effective in mobilising research efforts in universities than in private firms.

Biotechnology poses a particular set of IPR challenges. The first is the risk that the patenting of basic DNA sequences could hamper rather than foster the downstream development of useful biotechnology products by private or public research institutions. Because developing countries lag far behind in appropriation of patents for DNA sequences, they are especially vulnerable. Access to genomics databases and effective search software at reasonable cost are also crucial to biotechnology research institutions in developing countries. Developing countries also are concerned to share in any financial rewards deriving from research based on their indigenous genetic resources. In this connection, the increase in collaborative plant breeding and other collaborative research programmes involving farmers, their communities and research scientists raises new questions about recognition of collaborative innovation. These questions that may not be adequately addressed by either breeders' rights (which permit plant breeders to exclude others from commercialising material of a specific plant variety for 15–20 years) or the farmers' privilege (which leaves farmers free to use their own harvested material of protected varieties for the next production cycle on their own farms) (IDRC 2001). Developing countries may be able to negotiate contracts with international biotechnology companies, whereby the former gain access on favourable terms to biotechnology patents and genomic databases in exchange for the right of access to their germplasm and bioresources (de Janvry *et al.*, 1999).

Intimately related to the farmers' privilege is the question of how new bio–engineered plants reproduce and whether improved genetic traits would continue to be available to farmers beyond a single planting cycle. Work on terminator genes has had the objective of turning off those traits in plant offspring. Were that to become commonplace, the farmers' privilege would effectively be denied. The type of IPR protection afforded plant varieties is also crucial, since under patent law (as opposed to the *sui generis* legal regime of plant breeders' rights established by the International Union for the Protection of New Varieties of Plants, founded in 1961) on–farm seed saving of protected plant varieties may entail patent infringement (van Wijk *et al.* 1993).

In the domain of information and communications technologies, the main IPR issue is familiar: the risk of unauthorised copying of software and other information products. What is distinctive about this particular set of technologies is the economics, where potentially enormous fixed costs of software development combine with negligible costs of reproduction.

Maskus and Penubarti (1995, 1998) have estimated the effects of patent protection regimes on bilateral trade flows for a sample of 22 exporting countries (mostly OECD members) and 71 importing countries at all levels of development. They hypothesise two main ones. First, by increasing monopoly power of exporters, they could reduce the elasticity of import demand and cause a reduction in trade. Second, especially in large countries, they could make local imitation more costly and encourage an expansion of export market shares. Which of the two effects predominates? If the former, then, by the predictions of recent work on trade–related R&D spillovers (Coe and Helpman 1995; Coe *et al.* 1997), stronger patent protection could actually slow technology transfer and, in the process, domestic TFP growth. The authors find that, in the case of larger countries with strong technological capabilities, the market–expansion effect tends to predominate, because strong patent protection diminishes the credible threat of widespread imitation. By contrast, in poor countries with weak technological capabilities, the net effect of strong patent protection could be to reduce imports, since the market–power effect tends to outweigh any market–expansion incentive. Thus, for such countries, stronger patent protection could actually be counterproductive, reducing imports and perhaps thereby slowing TFP growth. In short, one size does not fit all.

Besides the IPR regime then, another set of policies, those affecting openness to trade and foreign investment, can have an important bearing on an economy's technological dynamism. Most developing countries depend on technology imported from more advanced countries and that technology usually enters through a combination of trade (technology embodied in imported capital equipment and intermediates) and foreign direct investment. Historically, trade barriers have operated to raise the costs of imports, including imported capital equipment. Connolly (1999) suggests that imported intermediates and capital goods can contribute to local technological advance in two ways: directly by improving process efficiency and product quality, and indirectly by allowing reverse engineering (learning to learn) to enhance future domestic R&D. Connolly raises the possibility that South–South regional trade agreements could, through trade diversion, substitute less technologically advanced imports from member developing countries for more advanced imports from non–member developed countries. It is hard to draw normative conclusions from this, since the less advanced technologies may be more suitable to local factor endowments and technological capabilities.

Final Thoughts on a Policy–Oriented Research Agenda

This review of literature and preliminary mapping of technology–poverty links point to a number of areas where further research is needed. The evidence from Ravallion *et al.* (various years) on *conditional* poverty reduction from non–farm output growth in India, while suggestive, leaves much unexplained. First, better understanding is needed of just what sorts of skill or other attributes lie behind the result that the initial human capital matters to a wider sharing of benefits from growth. Second, since most non–farm output is produced by either informal or formal enterprises, a better understanding is needed of how enterprise or sectoral characteristics may affect the incentives for technology upgrading. Does export orientation, for example, provide an inducement to technology acquisition? One would expect this to be the case in small countries at least, since any fixed cost involved could be spread over a larger output and higher export–market prices might also generate a higher return on such investment. Moreover, even if the introduction of new technology should be associated with a higher capital–output ratio, rapid expansion of the successful adopting firms could well more than compensate in terms of labour demand for any shrinkage of more labour–intensive and less competitive non–adopters. Again, it is the sector–wide, and ultimately the economy–wide, effects that are important in assessing impacts on the poor.

On agricultural biotechnology, Serageldin and Persley (2000) suggest two broad directions for future research to enhance benefits to poor people:

— *Contextualisation*: better understanding of complex farming systems in specific agro–ecological regions with a view to ensuring that new technologies are a) environmentally sustainable and b) well adapted to the social context of expected introduction.

— *Refocusing*: to exploit the potential of biotechnology to address the specific needs of poor farmers and poor consumers. This raises the question of what combination of public policy and private institutions can act as an effective "focusing device" (in Rosenberg's phrase) on the problems of the poor.

The likely long–run impact of information and communications technology on poverty remains speculative. The research need in this area is to move beyond anecdotes to the formulation and testing of hypotheses about the precise ways in which these technologies are likely to affect the poor. One such approach has been outlined here, using a simple general equilibrium simulation model. Econometric analyses suffer from the problem of a relatively short history of technology use, especially in developing countries; by default, any such analyses would have to be largely cross–sectional, with all the pitfalls that involves in this context. Time series estimates of the growth impacts of earlier communications technologies — mainly the telephone — are available, but they have focused almost exclusively on aggregate growth impacts.

The half of Lipton's virtuous circle running from poverty reduction to technical change also warrants further investigation. Craig *et al.* (1997) find that life expectancy has a larger and more significant impact on labour productivity in agriculture than commercial fertiliser use, tractor horsepower, and research expenditures. While it is possible that investments in health would have a bigger productivity payoff than agricultural input subsidies, the authors note that confirmation of this awaits better measures of human and physical capital inputs.

The design of intellectual property regimes suitable to developing country agriculture would benefit from research on costs and benefits. Blakeney *et al.* (1999) note that "virtually no empirical analyses, either sociological or economic, have been done on the impact of IPR on food and agriculture, especially in developing countries" (p. 225). At the same time, the authors acknowledge the difficulty of undertaking such research, especially in the short time frame for bringing national IPR policies into conformity with requirements of international agreements like TRIPS.

Notes

1. Thanks go to Andrea Goldstein for comments on an earlier draft and to Michael Lipton, who provided valuable feedback as discussant. The usual disclaimer applies.

2. One explanation of Solow's "productivity paradox" is that it takes time for organisations (specifically, firms) to adapt to the requirements of effective use of a new technological innovation — in this case, the computer (Bresnahan, 1997).

3. One might make the case that modern medicine and pharmaceuticals rival agricultural technologies in importance to the quality of life of poor people. Be that as it may, the focus here is on the latter, although to a degree the issues of *i)* how to encourage greater expenditure of R&D effort on the problems of the poor, and *ii)* how to make the technologies accessible to the poor, are common to the two sets of technologies.

4. See Helpman (1998) for a thorough theoretical and empirical discussion of GPTs.

5. While within-country Ginis may not vary much over time, even small variations can make a big difference in how much the poor share in growth.

6. Once a given technology is adopted, however, further productivity improvement mostly involves learning-by-doing, for which experience is more important than formal schooling.

7. The International Rice Research Institute (IRRI) has pioneered development of HYVs of rice and given its initials to the major green revolution rice varieties grown in Asia.

8. See David (2000) for a cautionary note on the implications of the March 1996 EU European Database Directive for open, collaborative scientific research, which threatens an "overfencing of the public knowledge commons" to the detriment of poor countries.

9. A few fundamental contributions can be found in: Coase (1937), Williamson (1975, 1985) and Wallis and North (1986). For a recent survey see Williamson (2000).

10. Kurz (1974), Hahn (1971), Foley (1970).

11. These data were obtained from a Social Accounting Matrix estimated by Pradhan *et al.* 1999. More details are available upon request.

12. Biotechnology holds promise in this domain, since DNA-based vaccines remain stable without refrigeration or special handling requirements.

13. See also Quibria and Tschang (2000), who find a strong positive relationship in a cross-country regression between internet and personal computer use on the one hand and tertiary education on the other, but no such relationship with primary education.

14. TRIPS, the Agreement on Trade-Related Aspects of Intellectual Property Rights, gives protection to many forms of intellectual property (copyright, trademarks, service marks, geographical indicators, industrial designs, patents, trade secrets, etc.), requiring that appropriate legal avenues of recourse are available when infringement is alleged to have occurred, and ensuring any resulting dispute is resolved in the same manner as other trade disputes (KPMG, 2000). The TRIPS Agreement requires all signatory countries to provide at least a *sui generis* system of protection for plant varieties (Serageldin and Persley, 2000).

Bibliography

BLAKENEY, M., J.I. COHEN AND S. CRESPI (1999), "Intellectual Property Rights and Agricultural Biotechnology", *in* J.I. COHEN (ed.) .

BLOOM, D.E., RIVER PATH ASSOCIATES AND K. FANG (2000), "Social Technology and Human Health", Background Paper for *Human Development Report 2001,* United Nations Development Programme, NY, processed.

BOUIS, H.E. (2001), "The Role of Biotechnology for Food Consumers in Developing Countries", *in* QAIM *et al*. (eds.).

BRESNAHAN, T.F. (1997), "Computerization and Wage Dispersion: An Analytical Reinterpretation", NBER Working Paper 5057, Cambridge, Mass, March.

BRUNO, M., M. RAVALLION AND L. SQUIRE (1998), "Equity and Growth in Developing Countries: Old and New Perspectives on the Policy Issues", *in* V. TANZI AND K–Y. CHU (eds.).

BYERLEE, D. (1996), "Modern Varieties, Productivity, and Sustainability", *World Development,* 24(4).

COASE, R. (1937), "The Nature of the Firm", *Economica*, 4, November.

COE, D.T. AND E. HELPMAN (1995), "International R&D Spillovers", *European Economic Review*, 39(5).

COE, D.T., E. HELPMAN AND A.W. HOFFMAISTER (1997), "North–South R&D Spillovers", *Economic Journal*, 107, January.

COHEN, J.I. (ed.) (1999), *Managing Agricultural Biotechnology – Addressing Research Program Needs and Policy Implications*, CAB International, Oxon, UK.

CONNOLLY, M. (1999), "The Impact of Removing Licenses and Restrictions to Import Technology on Technological Change", Background Report for *World Development Report 2000/ 2001*, Duke University, 30 July, processed.

CRAIG, B.J., P.G. PARDEY AND J. ROSEBOOM (1997), "International Productivity Patterns: Accounting for Input Quality, Infrastructure, and Research", *American Journal of Agricultural Economics*, 79, November.

DAVID, P.A. (2000), "The Digital Technology Boomerang: New Intellectual Property Rights Threaten Global 'Open Science'", Stanford University Economics Department Working Paper 00–016, October.

DEBREU, G. (1959), *Theory of Value: An Axiomatic Analysis of Economic Equilibrium*, Wiley, New York.

DE JANVRY, A., G. GRAFF, E. SADOULET AND D. ZILBERMAN (2000), "Technological Change in Agriculture and Poverty Reduction", A Concept Paper for the *World Development Report* on Poverty and Development, 2000/01, World Bank, Washington, D.C., processed.

DE JANVRY, A., G. GRAFF, E. SADOULET AND D. ZILBERMAN (1999), "Agricultural Biotechnology and Poverty: Can the Potential Be Made a Reality?", University of California, Berkeley, 12 June, processed.

DOLLAR, D. AND A. KRAAY (2000), "Growth *is* Good for the Poor", Development Research Group, World Bank, Washington, D.C., processed.

ENGERMAN, S.L. AND R. GALLMAN (eds.) (1986), *Long Term Factors in American Economic Growth*, University of Chicago Press, Chicago.

FAN, S., P. HAZELL AND S. THORAT (1999), *Linkages between Government Spending, Growth, and Poverty in Rural India*, Research Report 110, International Food Policy Research Institute (IFPRI), Washington, D.C.

FEDER, G., R.E. JUST AND D. ZILBERMAN (1985), "Adoption of Agricultural Innovations in Developing Countries: A Survey", *Economic Development and Cultural Change*, 33(2).

FEIWEL, G.R.(ed.) (1985), *Issues in Contemporary Microeconomics and Welfare,* Albany SUNY Press.

Financial Times, 30 May 2001.

FOLEY, D.K. (1970), "Economic Equilibrium with Costly Marketing" *Journal of Economic Theory*, 2.

GOLDBERG V. (1985), "Production Functions, Transaction Costs and the New Institutionalism" *in* G.R. FEIWEL (ed.), *Issues in Contemporary Microeconomics and Welfare,* Albany SUNY Press.

GOLDSTEIN, A. AND D. O'CONNOR (2000), "E–Commerce for Development: Prospects and Policy Issues", OECD Development Centre Technical Paper No. 161, October.

HAHN, F.H. (1971), "Equilibrium with Transaction Costs" *Econometrica*, 39.

HELPMAN, E. (ed.) (1998), *General Purpose Technologies and Economic Growth*, MIT Press, Cambridge, Mass.

HUANG, J. AND S. ROZELLE (1996), "Technological Change: Rediscovering the Engine of Productivity Growth in China's Rural Economy", *Journal of Development Economics*, 49.

IDRC (2001), *Seeding Solutions*, Volume 1, Ottawa.

KPMG (2000), *The Impact of the New Economy on Poor People and Developing Countries*, Draft Final Report to the UK Department for International Development, 7 July.

KURZ, M. (1974), "Equilibrium with Transaction Cost and Money in a Single Market Exchange Economy", *Journal of Economic Theory*, 7.

LANJOUW, J.O. AND I.M. COCKBURN (2001), "New Pills for Poor People? Empirical Evidence after GATT", *World Development*, 29(2).

LI, H., L. SQUIRE AND H.–F. ZOU (1998), "Explaining International and Intertemporal Variations in Income Inequality", *The Economic Journal*, 108, January.

LIN, J.Y. (1999), "Technological Change and Agricultural Household Income Distribution: Theory and Evidence from China", *The Australian Journal of Agricultural and Resource Economics*, 43(2).

LIPTON, M. (2001), "Reconnecting Agricultural Technology to Human Development", Background Report for UNDP *Human Development Report 2001*, processed.

LIPTON, M. (1999), "Reviving Global Poverty Reduction: What Role for Genetically Modified Plants?", *1999 Sir John Crawford Memorial Lecture*, CGIAR International Centers Week, Washington, D.C., 28 October.

LIPTON, M. AND R. LONGHURST (1989), *New Seeds and Poor People*, Johns Hopkins University Press, Baltimore.

MADDISON, A. (2001), *The World Economy: A Millennial Perspective*, Development Centre Studies, OECD, Paris.

MARTIN, W. AND D. MITRA (2001), "Productivity Growth and Convergence in Agriculture and Manufacturing", World Bank Development Group, Washington, D.C., processed.

MASKUS, K.E. (2000), *Intellectual Property Rights in the Global Economy*, Institute for International Economics, Washington, D.C., August.

MASKUS, K.E., P.M. HOOPER, E.E. LEAMER AND J. DAVID RICHARDSON (1997) (eds.), *Quiet Pioneering: Robert A. Stern and His International Economic Legacy*, University of Michigan Press, Ann Arbor.

MASKUS, K.E. AND M. PENUBARTI (1998), "Patents and International Trade: An Empirical Study", *in* MASKUS, K.E. *et al.* (1997) (eds.).

MASKUS, K.E. AND M. PENUBARTI (1995), "How Trade–Related are Intellectual Property Rights?", *Journal of International Economics*, 39.

PANAGARIYA, A (2000), "E–Commerce, WTO and Developing Countries", *World Economy*, 23 (8).

POMP, M. AND K. BURGER (1995), "Innovation and Imitation: Adoption of Cocoa by Indonesian Smallholders", *World Development*, 23(3).

PRADHAN B., K.A. SAHOO AND M.R. SALUJA (1999), "A Social Accounting Matrix for India, 1994–95", Special Article, *Economic and Political Weekly*, Mumbai, India.

QAIM, M., A. KRATTIGER AND J. VON BRAUN (eds.), (2001), *Agricultural Biotechnology in Developing Countries: Towards Optimizing the Benefits for the Poor*, Kluwer Academic Publishers, Dordrecht.

QUIBRIA, M.G. AND T. TSCHANG (2000), "Information & Communication Technology & Poverty: An Asian Perspective", Asian Development Bank Institute, 25 November, processed.

RAVALLION, M. (2000), "Growth, Inequality and Poverty: Looking Beyond the Averages", Development Research Group, World Bank, Washington, D.C., 20 September.

RAVALLION, M. AND G. DATT (1995), "Growth and Poverty in Rural India", Policy Research Working Paper 1405, World Bank, Washington, D.C., January.

RAVALLION, M. AND G. DATT (1996), "How Important to India's Poor is the Sectoral Composition of Economic Growth?", *World Bank Economic Review*, 10(1).

RAVALLION, M. AND G. DATT (1997), "When is Growth Pro–Poor? Evidence from the Diverse Experiences of India's States", World Bank, Washington, D.C., processed.

RAVALLION, M. AND G. DATT (1999), "When Is Growth Pro–Poor? Evidence from the Diverse Experience of India's States," Policy Research Working Paper, World Bank, Washington, D.C.

ROMER, P.M. (1986), "Increasing Returns and Long–Run Growth", *Journal of Political Economy*, 94, October.

SAMUELSON, P.A. (1954), "The Transfer Problem and Transport Costs, II: Analysis of Effects of Trade Impediments", *The Economic Journal*, 64.

SEN, B. (2001), "Poverty in Bangladesh: A Review", processed, downloaded from http://www.sdnbd.org/sdi/international_day/poverty/povertyinbd–bids.htm.

SERAGELDIN, I. AND G.J. PERSLEY (2000), *Promethean Science: Agricultural Biotechnology, the Environment, and the Poor*, CGIAR, Washington, D.C.

SPILLANE, C. (2000), "Could Agricultural Biotechnology Contribute to Poverty Alleviation?", *AgBiotechNet*, 2, March.

STRAUSS, J. AND D. THOMAS (1998), "Health, Nutrition, and Economic Development", *Journal of Economic Literature*, Vol. XXXVI, June.

TANZI, V. AND K.–Y. CHU (eds.) (1998), *Income Distribution and High–Quality Growth*, MIT Press, Cambridge, Mass.

TAYLOR, J.E. AND A. YÚNEZ–NAUDE (1999), *Education, Migration and Productivity: An Analytical Approach and Evidence from Rural Mexico*, Development Centre Studies, OECD, Paris.

VAN WIJK, J., J.I. COHEN AND J. KOMEN (1993), "Intellectual Property Rights for Agricultural Biotechnology: Options and Implications for Developing Countries", *ISNAR Research Report 3*, The Hague.

WALLIS, J.J. AND D. NORTH (1986), "Measuring the Transaction Sector in the American Economy, 1870–1970" *in* S.L. ENGERMAN AND R. GALLMAN (eds.).

WILLIAMSON, O. (2000), "The New Institutional Economics: Taking Stock, Looking Ahead", *Journal of Economic Literature*, Vol. XXXVIII, September.

WILLIAMSON, O. (1985), *The Economic Institutions of Capitalism*, Free Press, New York.

WILLIAMSON, O. (1975), *Markets and Hierarchies*, Free Press, New York.

WORLD BANK (2001), *World Development Indicators 2000-01*, CD–ROM, Washington, D.C.

Intellectual Property Rights in Global Agriculture and their Impact on the Diffusion of Productivity Gains

Timo Goeschl and Timothy Swanson[1]

Introduction

Over the past 50 years, technological change within global agriculture has generated substantial increases in yields and productivity. Between 1950 and 1998, world per capita grain production increased by 15 per cent while global per capita harvested acreage declined by 50 per cent (Zilberman and Heiman, 1997). This occurred despite the pronounced increase in the world population over the same period. Table 1 gives a survey of yield developments in the eight most widely cultivated crops[2] — barley, cotton, maize, millet, rice, sorghum, soybeans and wheat — between 1961 and 1999. These are the major agricultural crops globally with global acreage of between 34 million hectares (cotton) and 214 million hectares (wheat); they are important crops in most parts of the developing and developed world[3].

Table 1. **Acreage, Global Distribution, Growth and Relative Yield Gap in Eight Major Crops**

Crop	Global acreage in million ha in 1999	Share of developing countries[a] in 1999 (%)	Share of developed countries[a] in 1999 (%)	Annual growth rate at the frontier, 1961–1999 (%)	Relative yield gap in 1999 (%)
Barley	58.6	28	72	1.53	-59.9
Cotton	34.3	72	28	2.45	-47.4
Maize	139.2	67	33	2.27	-72.4
Millet	37.2	96	4	0.93	-57.4
Rice	153.1	97	3	0.85	-57.9
Sorghum	44.8	90	10	2.08	-67.2
Soybeans	72.1	55	45	1.24	-40.0
Wheat	214.2	48	52	1.75	-54.5

a. The definition adopted in this table is based on the FAO definition. This differs slightly from the established definition used in the wider literature. The rest of this paper, adopts the customary definition Pardey *et al.* (1991).

Source: FAO; authors' calculations.

These global gains are very impressive in terms of aggregate yields and productivity, but they have not been distributed uniformly; many peoples benefit more or less than others from these changes in global agriculture. The uneven distribution of yield gains becomes evident in comparisons of current yields across large groups of countries — developed *versus* developing countries, for example. Table 1 reports the *relative yield gap* between developed and developing countries for each of these major crop varieties, i.e. the percentage by which developing countries lag behind the yield in developed countries in the specific crop. It shows that wide differences in global agricultural productivity persist. Across these crops, average yields in developing countries are about 57 per cent lower than the crop yields in developed countries[4]. Developing countries are therefore operating far off the productivity frontier in the agricultural sector and participating less in the general gains in global agriculture.

Why is technological change within agriculture benefiting some countries and not others? This might be expected on the grounds of differential capital endowments, infrastructure, climate or other factors that put producers in developing countries at a disadvantage[5]. The focus here, however, is on the persistence of such yield gaps in the presence of rapid technological change, i.e. on the phenomenon of diffusion. Why is it that yield gains resulting from technical change (admittedly occurring at the developed frontier) take significant amounts of time to diffuse to the developing countries within the frontier?

Any plausible explanation for this phenomenon must also explain another important and related characteristic: this relative yield gap differs significantly between crops. The gap for soybeans, for example, is around 40 per cent while for maize it is around 72 per cent. These are significant differences in experiences between crops, and they are the motivating evidence on which this paper rests. The authors believe that the primary factor explaining the variation in diffusion rates across crop varieties is the variation in property–rights structures affecting those crops. The object of the paper is to demonstrate how these structures have contributed to differential rates of diffusion of technical change, and hence to the uneven distribution of global yield gains. The aim is to review the evidence on differences in the patterns of diffusion of crop innovations, and in doing so to provide a case study of the contributions of various factors for the broader questions of innovation, property rights, diffusion and global welfare impacts. Situating the inquiry in the context of agriculture follows a tradition in the literature on the economics of technological change that originated with Griliches' seminal work on the diffusion of innovations (1957), Schmitz and Seckler on the social welfare impacts of mechanised production (1970), and Evenson *et al.* (1979) on the economic benefits from R&D.

The paper argues that differences in types of intellectual property rights protection can best explain these differences in relative yields across crops. This argument is based on the idea that the question of varying yield gaps is best analysed as a problem in the diffusion of innovations from an expanding productivity frontier to a set of receiver countries. Property–right regimes differ with respect to both the incentives for innovation and their impacts on the rate of diffusion. Strong regimes over innovations have two clear effects, advancing the rate of innovation at the frontier but also slowing the rate at which these innovations diffuse to countries off that frontier (Maskus, 2000). This implies a clear trade–off inherent within strong intellectual property right protection, which varies with the vantage point of the particular country concerned. The perceived benefits of strong protection depend on the country's initial positioning with respect to the technological frontier[6].

These questions are examined on the basis of a panel study of the yield development of eight crops across developing countries from 1961 to 1999[7]. These crops can be distinguished by the modes of property–right protection that innovations receive, with two enjoying technological ("strong") protection and six legal ("weak") protection[8]. The development of the crop yields across developing countries is examined for evidence on convergence and rates of diffusion; the likely explanations underlying this evidence are discussed and the evidence related to the respective property–rights regimes.

The analysis begins with a very simple model taken from Barro and Sala–i–Martin (1995) that captures concisely the link between innovation and diffusion and allows formulation of the equation estimated in the main part of the paper. It examines the empirical evidence on the convergence of crop yields in developing countries to developed–country levels over the observation period. This extension to the cross–sectional evidence presented in Table 1 is necessary in order to separate the spatial and inter–temporal factors that give rise to the pattern shown there. It then proceeds to estimate the rates of diffusion for each crop on the basis of the innovation–diffusion model of Barro and Sala–i–Martin. It also presents a decomposition of yield development in the average developing country into innovation, diffusion and structural components. These results are discussed and tested for robustness against other specifications. The final section argues that differences in the IPR regimes available for different crop varieties can best explain the measurable differences in the rate at which developing countries can benefit from innovations at the yield frontier. The paper concludes with a discussion of the implications of this result for optimal R&D policies in agriculture and the wider economy.

A Model of Innovation and Diffusion

A simple model of technological diffusion can be based on a theoretical framework commonly used in the context of growth and innovation. For the details of the model, see Barro and Sala–i–Martin (1995, Ch. 10). In this model, the source of technological progress lies in constant returns to scale to innovation in intermediate goods, in the spirit of Romer (1990). The particular multi–economy setting explored here is a leader–follower model in which there is a technological frontier at which innovations occur and are imitated by countries off the frontier. Countries have different endowments of inputs that allow them to produce final output and generate new products through innovation (leader) or imitation (follower). As Barro and Sala–i–Martin (1995) show, this setting allows a straightforward estimation of a convergence model.

Assume that a follower country's cost of imitation, v, is an increasing function of the ratio of the number of intermediate goods in the follower country (N_F) and the leader country (N_L), such that:

$$v = \psi\left(\frac{N_F}{N_L}\right) \qquad (1)$$

with $\psi' > 0$ and $\psi'' < 0$. The usual conditions apply[9]. Barro and Sala–i–Martin then show that it is possible to derive the optimal ratio of goods in equilibrium, $R = N_F/N_L$, as a function of the factor endowments and the cost of imitation only. In other words, there is an R^* that is unique and optimal. If $N_F/N_L = R^*$, then the leader and the follower country are in a steady state characterised by a constant growth rate of N_F and N_L. If $N_F/N_L < R^*$, then $v < v^*$, i.e. imitation becomes cheaper as there is an abundance of useful products available to be copied. The result is a model with common convergence characteristics. An economy grows proportionately faster the farther it is below its steady state. Barro and Sala–i–Martin then formulate the result as a log–linear approximation such that:

$$\gamma_F = \gamma_L - \mu \cdot \log\left[\frac{R}{R^*}\right] \qquad (2)$$

with γ denoting the growth rate of the follower and leader country, respectively, and μ denoting the speed of convergence. This can be transformed directly into:

$$\gamma_F = \gamma_L - \mu \cdot \log\left[\frac{y_F / y_L}{\left(y_F / y_L\right)^*}\right] \qquad (3)$$

This gives the growth rates for a country off the frontier (a follower) as the growth at the technological frontier (a leader country) minus the "friction" induced because imitations do not diffuse without cost, as μ is a positive transformation of the cost–of–imitation equation (1).

In the context of diffusion of innovations in crops, structural factors inhibit the diffusion of innovations and are likely to remain constant over time (Evenson and Kislev, 1973). The most important such factor involves agro–ecological barriers to diffusion that will limit the amount of innovations useful in a follower country. One way to interpret these barriers is to see them as equivalent to intrinsic productivity differences between the leader and follower countries in a particular crop. This can be accommodated within the given model as a statement that R^* is constant over time and specific to each follower country, implying a specific transmission ratio of innovations from the frontier to follower countries. With R^* constant, one can transform (3) to estimate the following model for each country:

$$\Delta G_{it} = a_i + \beta_i G_{i,t-1} + \varepsilon \qquad (4)$$

with $G_{it} = \log\left(\frac{y_{i,t}}{y_t^*}\right)$ such that β is an estimator of the catch–up rate of the country i to the development at the frontier, denoted by a star (*), and $a_i < 0$ represents a measure of the country–specific structural barrier to an innovation from outside. Equation (4) states that differences in the growth path of crop yields can originate from two sources. First, inherent and persistent problems in the follower country impede it from keeping up with the yield dynamics in the leader country. These are captured in a country–specific estimation of a. Second, problems in the diffusion of innovations from the leader to the follower country are captured in the catch–up parameter β. Barro and Sala–i–Martin interpret the catch–up rate as a measure of the costs of imitation in the follower country. The higher β, the slower diffusion will occur.

Two fundamental assumptions underlie this model. One is that innovations take place only in those countries that make up the frontier. This paper claims that even though total expenditures on agricultural R&D in the developing countries combined are roughly the same as those in developed countries combined (Alston *et al*., 1998)[10], technological factors result in the developed countries' R&D production function being significantly more efficient than that of developing countries. In sum, the vast majority of yield–enhancing innovations have been generated in the developed countries. One must concede, however, that in some crops, such as millet, the picture may be less clear cut. The second fundamental assumption is that country–specific factors are not allowed to influence the coefficient that estimates the rate of diffusion.

A couple of practical difficulties arise in the estimation. The most obvious is the meaningful definition of a frontier. Choosing a single country makes it difficult to distinguish between genuine technological progress and short term fluctuations in output. Second, interest centres on the differences in diffusion parameters between different crops, not the differences in diffusion between different countries. The question of the definition of the frontier will be settled in the next section and a first, indicative set of results on absolute convergence will be presented. The meaningful pooling of the data will then be addressed.

Growth in Crop Yields: Absolute Convergence to the Frontier

The first piece of empirical evidence is the yield frontier[11], reported in the third column of Table 1. For some degree of comparability between crops and years, the frontier is defined uniformly as the average yield in developed countries[12]. The yields at the productivity frontier in all of these crops rose steadily over 1961–99. The accumulated gains at the frontier varied considerably between crops, however. Rice had the smallest gains, an average of 0.9 per cent per year[13], while the improvements in cotton cultivation resulted in an average annual growth rate of 2.5 per cent. Other crops with comparable gains have been maize, sorghum and wheat, the yields of which more than or almost doubled.

The second piece of evidence concerns the success of developing countries in catching up to the frontier that has been expanding at different rates for different crops. A general claim within growth theory is that we would expect countries with lower productivity to experience more rapid productivity growth than the countries at the frontier. This process is known as "convergence". Table 2 reports the results from a study of productivity growth rates in developing countries that regresses the average growth rate in country yields on the country's initial productivity value across all countries for each crop. Figure 1 gives graphical representations of the procedure for maize, sorghum, wheat and rice. This exercise estimates a model of the standard form:

$$AVG = c + \beta \log\left(Y_{1961}\right) + \varepsilon \tag{5}$$

where AVG is the average growth rate over the observation period and Y_{1961} is the yield level in 1961. For most crops, the hypothesis that productivities converge over time is not rejected by the values of the coefficients: There is a negative relationship between initial yield levels and a country's average growth rate over the following 38 years. This relationship is particularly strong in cotton, rice and wheat, somewhat less so in millet, soybeans and barley. What is striking is that for two crops, namely sorghum and maize, absolute convergence is rejected by the data.

These results imply little evidence that developing countries have experienced any catching–up in the yields of maize and sorghum. They are somewhat counter–intuitive. In these two crops, yield growth at the frontier has been at the higher end of the distribution, as Table 1 shows, which would be conducive to a catching–up process in developing countries. Support for this intuition comes from a significantly positive correlation between the growth rate at the frontier and the convergence coefficient β for all other crops except maize and sorghum. The correlation coefficient between the growth rate at the frontier and β is –0.01 based on the estimates of all eight crops. When omitting maize and sorghum, it jumps to 0.67, suggesting a significantly positive correlation.

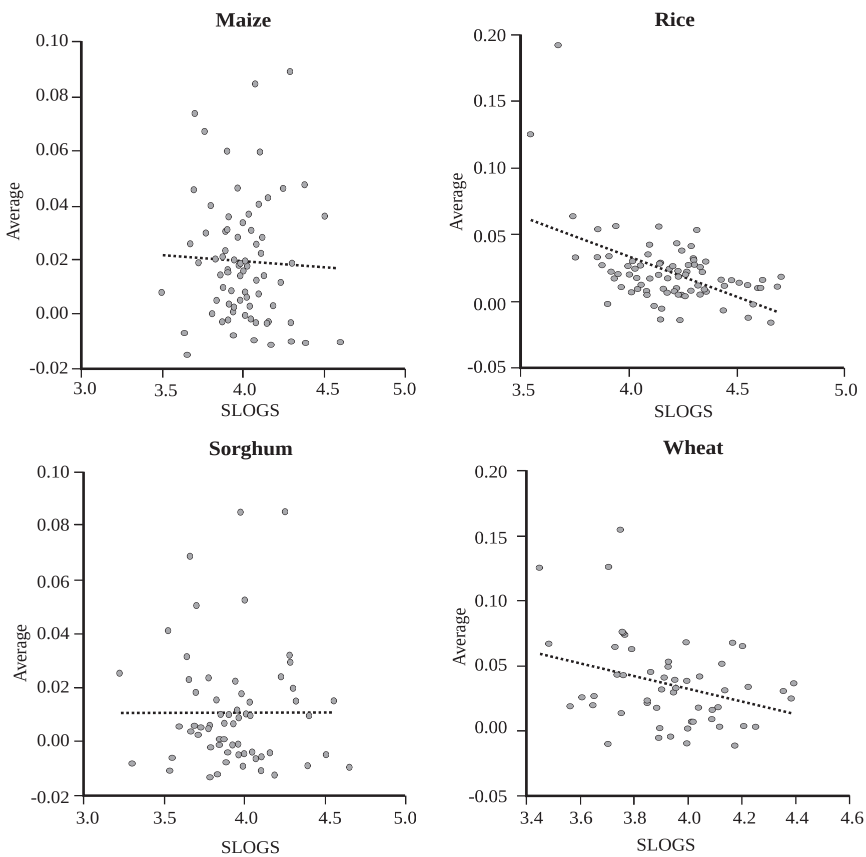
The empirical account of yield growth at the frontier and of the catching–up process of those countries that lag behind the frontier has two major implications. First, there is evidence that differences in the yield gaps between crops presented in Table 1 reflect more than a historical carry–over from some initial distribution of gaps. Otherwise, the evidence on convergence would not correlate so closely with growth at the frontier for most crops. Differences in the rate of expansion do matter. After all, one explanation could have been that the reason for the current gaps can be found in the same gaps being present 40 years ago, thus pointing to some factor that remained invariant across this period[14]. Second, the account raises questions about the presence of unconditional convergence in yields in developing countries. The data for maize and sorghum (see Figure 1) indicate that crucial determinants of the rate of convergence

Table 2. **Regressions for Convergence of Crop Yields, 1961-99**

	Barley	Cotton	Maize	Millet	Rice	Sorghum	Soy	Wheat
β	-0.0409	-0.0930	-0.0046	-0.0417	-0.0607	-0.0002	-0.0383	-0.0501
	(0.0143)**	(0.0150)**	(0.0134)	(0.0124)**	(0.0114)**	(0.0105)	(0.0112)**	(0.0204)*
R^2	0.180	0.399	0.016	0.203	0.265	0.000	0.280	0.104
(No. of obs.)	(39)	(60)	(75)	(46)	(80)	(63)	(32)	(54)

Notes: Standard errors in parentheses; * refers to significance at 5 per cent level, ** to significance at 1 per cent level.

Figure 1. **Growth versus Initial Yields in Four Crops**



Note: SLOGS = log (Yield initial year). Average = avg. yield growth rate.

exist *other than* the yield gap that ensures that developing countries can benefit from a technological gradient. The remainder of this paper aims to provide an answer to this puzzle of conditional convergence in crops. Its main proposition is that the solution lies in rates of diffusion of yield gains to developing countries that differ significantly between crops.

The Diffusion of Innovations

This section estimates the rates of diffusion of innovations for different crops in order to resolve the puzzle of the relative gaps and of conditional convergence. The crop specificity of technological protection enables comparing the performance of each of these regimes with respect to diffusion. A particular feature of this analysis is its decomposition of the development of the yield gap in each crop into its three basic components: *1)* innovations at the frontier, *2)* the diffusion process of these innovations to developing countries, and *3)* the country–specific factors that impact on the capacity for yield growth, such as specific agro–ecological conditions. The first will tend to increase yields as the set of technological possibilities expands. The second will decelerate the speed at which these gains reach developing countries, and the third will determine the long–run capacity of a country to experience yield growth in a particular crop at a rate above or below the growth rate at the frontier.

Estimating the Econometric Model

To assess the diffusion patterns in each crop, one can study the development of agricultural yields in developing and developed countries for the eight crops chosen, based on FAO data covering 39 years, from 1961 to 1999. The amounts of data available for each crop differ due to varying cultivation areas and completeness of data over the entire estimation period. For soybeans, there are 38 observations available from 27 countries, while for maize there are 38 observations from 82 countries[15].

The method used is a fixed–effect panel estimation model that allows for heterogeneity among the countries through variable intercepts (Hsiao, 1986). To estimate the Barro–Sala–i–Martin diffusion model consistently, one must convert it into a form that presumes that all developing countries are subject to the same exogenous stochastic shock, in this case an innovation that sets countries back in their relative yields. It then estimates for each crop the rate at which this shock is compensated for, allowing for heterogeneity in the intrinsic “rate of recovery” between countries. The model has the form:

$$\Delta G_{it} = a_i + \beta G_{i,t-1} + \varepsilon \qquad (6)$$

where G is the gap in growth rates between the specific country and the lead country, Δ signifies the change in the gap and ε is a normally distributed random variable with $E(\varepsilon)=0$ and a known variance. The intercept term a denotes the long–term difference in productivity growth in equilibrium, regarded as a country–specific intercept that captures the agro–ecological and institutional factors that influence the overall productivity development of the country. In this it captures the content of the hypotheses that claim country–specific factors as responsible for the disproportionate yield gap for maize and sorghum. The coefficient β to be estimated then reports the diffusion coefficient of the particular crop.

Empirically, the growth rates of the frontier and the country *i* enter in the form of $log\ (y_{it})$ with *y* denoting the yield of country *i*. The diffusion coefficient β is then estimated as a GLS–regression, correcting for cross–section heteroskedasticity in the residuals by down–weighting each pool equation with an estimate of the cross–section residual standard deviation[16].

Econometric Results

Table 3 reports the results for the different crops. Each of the estimations delivers a coefficient β that is statistically highly significant. Also reported is a parameter $\tilde{a}$ that denotes the *average* intercept for all countries in the estimation. Since the model is restricted to a common slope coefficient, a high number of observations can be expected to result in a low R–squared. The Durbin–Watson coefficients indicate that serial correlation is not a particular problem for this estimation, thus strengthening a claim that the results provide an analysis independent from the trends at the frontier.

Table 3. **Regressions for Diffusion of Innovations in Different Crops**

	Barley	Cotton	Maize	Millet	Rice	Sorghum	Soy	Wheat
β	-0.326	-0.318	-0.249	-0.335	-0.254	-0.283	-0.469	-0.387
	(0.0203)**	(0.0150)**	(0.0117)**	(0.0184)**	(0.0142)**	(0.0138)**	(0.0271)**	(0.0184)**
$\hat{a}$	-0.339	-0.294	-0.365	-0.294	-0.230	-0.369	-0.291	-0.384
R^2	0.171	0.166	0.135	0.172	0.154	0.160	0.244	0.234
(No. of obs.)	(35)	(54)	(82)	(44)	(71)	(62)	(27)	(48)
DW-Statistic	2.40	2.26	2.40	2.45	2.23	2.42	2.27	2.30

Notes: Figures in first set of parentheses are standard errors; ** refers to significant at the 1 per cent. level.

Before interpreting the results, some convenient algebra can bring the model into a simpler form. Re–arranging (2) produces the following equation for the growth rate of yield, $\Delta\hat{y}_t$, in the average developing country:

$$\Delta\hat{y}_t = \Delta y_t^*(1+\beta)G_{t,t-1} + \hat{a} + \varepsilon \qquad (7)$$

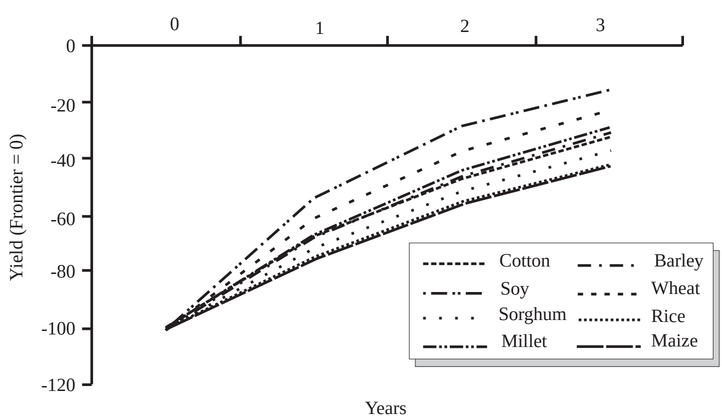
This formulation reveals the separate components that drive the growth rates of yields. The first is the yield gain at the frontier Δy^*. It reflects the expansion of the set of technological possibilities. The second captures the extent to which an innovation can diffuse in the country, with the gap *G* defined to take on positive values. The expected sign on β thus is negative (indicating that innovations do not have a negative effect on growth) and the closer the coefficient is to –1, the more rapid the gains dissipate from the frontier to the average developing country. The third parameter, $\hat{a}$, summarises the country–specific growth lags as an average. A positive value would indicate that, on average, developing countries have a higher "intrinsic" rate of yield growth in the crop.

Interpreting the Results: Diffusion

The results indicate considerable differences among the diffusion coefficients in the crops under examination. The crops fall roughly into three groups. Rapid diffusion happened only for soybeans with a diffusion coefficient well below –0.45 (in absolute terms). Moderate diffusion (below –0.3) occurred in wheat, millet, barley, and cotton. In sorghum, rice, and maize, diffusion has been slow (above –0.3), such that gains from innovation have taken a relatively long time to reach developing countries.

To give a more concrete impression of the differences in the rates of diffusion, Figure 2 displays the results of a simulated diffusion situation. It shows the process of catching up in different crops after an innovation at the frontier in the initial period that sets back all crops by the same amount. The graph demonstrates how differently diffusion occurs in these crops.

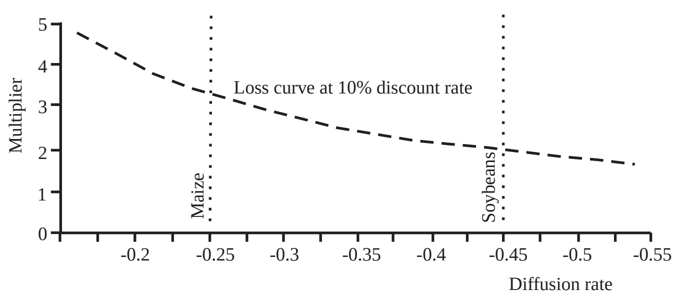
Figure 2. **Catching up under Different Rates of Diffusion**



After two periods, the "best"–diffusing crop has made up 72 per cent of the initial shock while the "worst"–diffusing crop has compensated for only 43 per cent. The absolute difference carries on for another year before the slower–diffusing crops start to close the gap. Yet even after nine periods, when the yield in the "best" crop, soybeans, has converged to more than 99 per cent of the frontier yield, the "worst" crop, maize, still lags by more than ten per cent. Eventually, of course, all crops catch up.

For individuals cultivating different crops, an important criterion for evaluating them is the loss of yield suffered as a result of slow diffusion. This throws a different light on the problem, as it looks at the impacts of the cumulative process of diffusion. Figure 3 reports the multiplier to the initial shock, to estimate the net present value of the loss at a ten per cent discount rate[17]. The graph shows that the differences between the rates of diffusion in maize and soybeans cause a farmer to suffer roughly double the economic loss in maize compared with soybeans when an innovation at the frontier shifts the farm away from the frontier.

Figure 3. **Loss Multiplier as a Function of the Diffusion Rate**



Other Effects: Country–Specific Lags

A second set of important differences arises from the country–specific data on "individual growth capacity". It reveals first that, on average, developing countries would experience slower growth in all crop yields, because the coefficient ($\hat{a}$) is below zero for all crops. These impediments to growth differ between crops, however, ranging from rice, with good intrinsic growth potential at $\hat{a} = -0.230$, to wheat, with high average barriers to growth at $\hat{a} = -0.384$. This captures the history–dependent nature of diffusion for each crop. The level of the coefficient indicates whether the pattern of diffusion encounters local conditions either more beneficial or more adverse to successful cultivation of the plant[18]. There is no correlation between parameter estimates of $\hat{a}$ and β, which indicates that the processes of diffusion are disjoint from the effects of local conditions[19]. Another informative statistic shows how diverse countries are in their experience. In sorghum, cotton and soy, there is a wide dispersion of local coefficients, indicated by the variance–to–mean ratio $r=s_i^2/m_i>5$, while they are fairly similar between countries for the other crops, where $r<4$.

In general, the other factors explored generate little more explanatory value[20]. It seems that the rate of innovation at the technological frontier and the rate of diffusion of innovation within the frontier explain the vast majority of the patterns of yield growth across the developing world. Annex A contains diagrams demonstrating the actual and fitted patterns of yield development across developing countries, showing the manner in which this development tracked that at the frontier for the various crop varieties.

Testing for the Role of Property Rights in Diffusion

This paper has put forward three sets of observations on crop–yield developments across developing countries. The first set out the average yield gaps between developed and developing countries. They are large across the entire range of crops (between 40 per cent and 60 per cent) but the two outliers in the group clearly are maize (72 per cent) and sorghum (67 per cent). The second consisted of a test for “absolute convergence” across all varieties — whether countries with lower yields at the beginning of the period (1961) experienced higher average growth rates over the ensuing years to 1999. This exercise showed that only sorghum and maize do not exhibit absolute convergence, indicating the presence of convergence–limiting factors for these two species. The third examined the rates of diffusion from the technological frontier to developing countries. It revealed significant differences in the rates of diffusion of innovation between crops, with diffusion particularly slow in maize, sorghum. Based on a standard innovation–diffusion model (Barro and Sala–i–Martin, 1995), this can be interpreted as evidence for higher imitation costs in these two crops. In each part of the study, maize and sorghum emerged as the distinctive crops in the relationship between developed and developing country crop yields. What can one hypothesise concerning the reasons underlying these observations of these crops’ relative performances?

In the diffusion model used here, differences in the diffusion coefficients indicate differences in the cost of imitation, i.e. the cost of transferring an innovation from its developed–country origin to a developing–country context. An important determinant of that cost for crops is how readily the value–adding traits in a novel variety from the leader country can be identified and extracted by the follower. This in turn is significantly influenced by the form of property–right protection afforded to the value–adding traits within the innovative variety.

There is no question that property rights may be claimed in innovative plant varieties[21], but the capacity to protect these claims varies. At present there are two principal forms of protection: *1)* “Legal protection”, which is dependent for effect on the resources expended on monitoring and enforcement by the follower country; and

2) “Technological protection”, which is independent of the resources expended by the follower for effectiveness. It is probably fair to assert that over the past 40 years little legal protection has been afforded to intellectual property–rights claims to innovations in plant varieties throughout most of the developing world. Since most developing countries have had little to gain from expending resources on the implementation or enforcement of property rights for the benefit of innovators situated primarily overseas, there have been minimal incentives for such expenditures[22]. Therefore, it is likely that the primary route available for the effective protection of intellectual property right claims in developing countries has been technological.

Currently, technological protection is available only in the form of modern hybrid varieties, and thus limited in practice to the “outbreeding crops”, maize and sorghum. Hybridisation affords protection to improved varieties of these species, because the seed from them sold to farmers represents a relatively diverse gene pool and subsequent re–plantings generate widely divergent varieties. The other crop species reproduce asexually, making parents and offspring identical in genetic structure. Sales of improved varieties from these species may be copied perfectly (and almost costlessly) from purchased seed, unless national laws effectively prevent such practices.

For these reasons, one can claim that the technologically protected species act in effect as a case study on the impact of effective or “strong” property rights in innovation. They may be contrasted with the impacts of innovations in the non–technologically protected species that act, in developing countries, as “weakly” protected innovations. Maize and sorghum have the unique capacity for technological protection of innovations; they represent the lines down which strong property rights protection has been in effect over the past fifty years[23].

Modelling Diffusion under Varying Property Right Regimes

One may test for the presence of a differential in the rate of diffusion through a dummy variable for observations involving a hybrid crop. The model then estimates for each category the rate at which the shock (innovation) is compensated, allowing for heterogeneity in the intrinsic “rate of recovery” between countries. The model has the form:

$$\Delta G_{it} = a_i + \beta G_{i,t-1} + \gamma D G_{i,t-1} + \varepsilon \qquad (8)$$

where G is the gap (difference) in logarithm between the yields in a specific country and the lead country and Δ signifies the change in the gap. The intercept term a_i denotes the long–term difference in productivity growth in equilibrium. As noted above, one way of interpreting a_i is to regard it as a country–specific intercept that captures the agro–ecological and institutional factors that influence the overall productivity development of the country. In this it captures the content of the hypotheses that claim country–specific factors as responsible for the disproportionate yield gap that exists for maize and sorghum. The estimated coefficient β then reports the diffusion coefficient across all crops and γ is the diffusion rate differential for hybrids crops identified through the dummy variable D[24]. Empirically, Fisher's test as proposed by Maddala and Wu (1999) serves as a panel data unit root test. The diffusion coefficient β and the diffusion rate differential γ are estimated according to equation (9) as a GLS–regression, correcting for cross–section heteroskedasticity in the residuals by down–weighting each pool equation with an estimate of the cross–section residual standard deviation[25].

Econometric results

The estimation delivers coefficients β and γ that are statistically highly significant. It also delivers, as in the previous exercise, the average intercept for all countries in the estimation denoted by $\hat{a}$. Before interpreting the results, it is once again convenient to perform some algebra to convert the model into a simpler form. Re–arranging (8), the following equation emerges for the growth rate of yield, $\Delta\hat{y}_t$, in the average developing country:

$$\Delta\hat{y}_t = \Delta y_t^* - (1 + \beta + \gamma D)G_{t,t-1} + \hat{a} + \varepsilon \qquad (9)$$

This formulation highlights the separate components that drive the growth rate of yields. The first component is the yield gain at the frontier Δy^*. It reflects the expansion of the set of technological possibilities. The second component captures the extent to which an innovation can diffuse in the country, with the gap G defined to take on positive values. Therefore, one would expect that the coefficient β is negative (indicating that innovations do not have a negative effect on growth) and that the closer the coefficient is to –1, the more rapid the gains dissipate from the frontier to the average developing country. The third component, γD is the effect of hybridisation on the growth rate. The fourth parameter, $\hat{a}$, summarises the country–specific growth lags as an average. A positive value would indicate that on average, developing countries have a higher "intrinsic" rate of yield growth in this crop and vice versa.

Table 4 shows the results of the econometric estimation. The most important result is that hybridisation has a measurable impact on the rate of diffusion. The coefficient of the hybrid dummy variable is highly significant, despite allowing for fixed effects both by country and by crop. The rate of diffusion of innovations from the frontier to developing countries across all crops was such that crops carried over roughly 69 per cent of the gap opened by an innovation into the next year. The "diffusion penalty" involved in having innovations occur predominantly in hybridised crops is about 7.1 per cent per year. This means that developing countries retained about seven per cent more of the yield gap each year in hybrids than in non–hybrids. It explains an important part of the cumulative yield gap that has developed in hybrids. The results also indicate merit in the idea that structural effects, such as agro–ecological conditions, have contributed to inhibiting yield growth of hybrids in developing countries. The parameter $\hat{a}$ is the mean of the individually estimated parameters a_i. The means computed for hybrids and non–hybrids indicate that in hybrids

Table 4. **Regressions for Diffusion of Innovations in Different Crops**

β	γ	$\hat{a}$	R^2	DW-statistic
-0.313	0.071	-0.33611	0.16	2.39
(0.008)**	(0.011)**		No. of obs.: 14 858	

Note: Standard errors are in parentheses. ** refers to significance at the 1 per cent level.

the average developing country has had a greater negative long–term deviation from the growth rate of the frontier than in non–hybrids. The combination of structural and diffusion effects is therefore responsible for the significant gap in yields that persists between developed and developing countries in hybrid crops.

The authors believe that the observed differences in yield growth and diffusion across crop varieties are attributable to the distinctive property–right regimes available for claiming rights to innovation in these varieties. The observations are consistent with the idea that strong property–right regimes have resulted in varying costs of imitation across countries, which increase with the distance of the country from the technological frontier. This increasing cost of imitation translates into the observed consequence that innovations are impacted and slow to diffuse, especially for the two crops afforded effective protection. The ultimate outcome is that the two crops in which strong property rights exist are the only two which do not exhibit absolute convergence. The poorer countries fail to “catch up”, only for those crops where strong intellectual property rights regimes prevail. Finally, this failure to catch up is captured in aggregate terms in the relative lags between the yields in developing and developed countries. All of the observations on crop yields and changes across the past forty years are consistent with the hypothesis that strong property–rights protection over innovations inhibits their diffusion across the developing world.

If this is the case, it provides significant evidence in the general debate about the global impact of enhanced property–right regimes. These observations imply that the receipt of benefits from strong property–rights protection is inversely related to the distance of the particular country from the technological frontier. Thus, even if innovation occurs more rapidly under strong protection, countries far from the frontier might prefer the combined rate of innovation/diffusion inherent within a weaker form of regime. All intellectual property rights regimes would entail an inherent trade–off between innovation and diffusion, and the preferred regime would depend upon the perspective (i.e. technological level) of the country concerned (Krugman, 1979; Lai, 1999).

Conclusion

This paper has examined the development of yields in developing and developed countries in the eight most important agricultural crops over a period of almost forty years. The results indicate that although yield growth has been impressive, problems in global distribution of agricultural productivity persist and give cause for concern. They also indicate significant differences that require explanation in both the dynamics of yield growth in the developed countries and the diffusion between crops of these gains to developing countries. Evidence on the convergence of yields in developing countries shows that it occurs in all crops examined with the exception of maize and sorghum. Exploring the reasons for this difference by estimating the diffusion coefficients of innovations from the yield frontier to developing countries leads to a conclusion that the failure of convergence in maize and sorghum can be explained by the exceptionally low rate of diffusion in these two crops. At the same time, agro–ecological factors are likely to affect diffusion, but cannot explain the exceptional cases of maize and sorghum.

Maize and sorghum are exceptional because hybrid seeds have been available for them alone over the past fifty years. This has led to higher than average yield growth through the mobilisation of private R&D efforts. At the same time, the results here indicate that the technological protection of property–rights claims afforded by hybridisation has had a negative effect on the rate of diffusion of these innovations. The existence of this innovation–diffusion trade–off highlights the problematic international welfare implications inherent in choosing a particular intellectual property protection regime. This empirical study quantifies the trade–off exactly for the main crop varieties and decomposes yield growth in the average developing country as a combination of innovation at the frontier, diffusion to the developing country and structural factors in the adoption of new varieties.

Crop varieties provide a possibly unique setting within which the debate over the impacts of enhanced property–right regimes might be tested. The initial evidence here indicates an inherent trade–off between enhanced rates of innovation (and thus growth) and enhanced rates of diffusion (and hence distribution). This means that there are frictions within the system of technological dissemination that inhibit the flows of beneficial information, and that enhanced property–rights regimes will work most prominently against the interests of those states farthest from the frontier. Although the results are preliminary, they give cause for concern about the promotion of property–rights regimes with such profound distributional implications.

Notes

1. This research has its origins in a research grant from the UK Department for International Development. We are grateful to Robert Carlisle for encouraging us to explore this area. We are particularly grateful to James Symons and Hashem Pesaran for helpful discussions on the econometrics and comments, and grateful to Mark Rogers and Keith Maskus for helpful discussions and comments, without implicating any of them in any way in the remaining errors.
2. The criterion applied here is the global acreage of a crop.
3. All of these crops are grown both in developing and developed countries, although some are clearly more prevalent in one region than the other. For example, rice has 97 per cent of its acreage in the developing countries and millet 96 per cent. Barley has 72 per cent in developed countries.
4. This estimate gives equal weight to each country and is based on the country classification adopted in Pardey *et al.* (1991) and taken up by the wider literature on agricultural R&D. A comparison of yields on an area–weighted basis directly based on FAO data and its classification of developing and developed countries produces an even more dramatic picture while leaving the ranking of crops basically unaffected (see Goeschl and Swanson, 2002).
5. For example, recent work has demonstrated a general relationship between climate and development status. (Masters and Sachs, 2001). It might be argued on the basis of such evidence that climatic conditions systematically favour production within developed countries (often in temperate zones) over developing ones (often in tropical zones). This study includes agro–ecological conditions, but the authors believe that the primary factors of concern should relate in some clear manner to the transferability of technical change.
6. This paper thus falls in the theoretical line established by Krugman (1979) and leading to Lai (1999), but its approach is empirical. The distributional implications of the arguments are more fully simulated and expounded in Goeschl and Swanson (2000).
7. The argument presented here does not rule out that other factors impinge on the transferability of innovations in agricultural technology, such as agro–ecological factors or crop–specific complementary inputs biased against developing countries. These are the points commonly put forward to explain this diversity of gaps. By abstracting from these factors, this paper points instead to a broader problem in the area of agricultural R&D, namely the conflict between stimulating an optimal amount of R&D and ensuring optimal diffusion of the resulting innovations.

8. This distinction between strong and weak property right regimes is delineated further on page 61.

9. The $\psi(1)$ is sufficiently large in order to prevent the possibility of total imitation in the limit and the $\psi(0)$ is sufficiently small that there is a minimum of imitation going on at any point in time.

10. In 1991, agricultural R&D expenditures in 131 developing countries combined were 8 009 million 1985 international dollars and in 22 developed countries combined $6 941 million. For 1981, the data were $5 503 million and $5 713 million, and for 1971 $2 984 million and $4 298 million respectively (Alston *et al.*, 1998). Thus, over the entire period, R&D expenditures were of roughly comparable size.

11. The term "frontier" refers to the outer margin of production possibilities at a given time. In the given application, it refers to the best yields achievable in a given year.

12. See endnote 4. The growth rates in developed countries are a sufficiently accurate representation of yield growth at the frontier and a more robust estimate than the maximum yield achieved by whichever country. The problem with the latter method is that it suffers from *1)* sampling error (the observations in 1961 and 1999 are realisations of some random process), and *2)* measurement error (the FAO data are not fully reliable). The maximum yield method puts a lot of weight on an individual year/country observation and makes it unsuitable for drawing conclusions from it.

13. Rice may be somewhat an exception as it started out from relative high yield levels in 1961 of five tonnes per ha.

14. The favourite explanation along these lines is the agro–ecological hypothesis. It claims that yield gaps exist because developing countries are situated in climate zones that feature adverse production conditions. The suitability of a crop for use in developing countries would thus be inversely related to the productivity gap observed. This hypothesis is dealt with again later.

15. The country yield data suffer from several deficiencies. The most obvious is that they do not appear particularly reliable for some countries. Fortunately, this tends to be more the case the smaller the production. Another is that some crops were introduced into countries only during the observation period. Here the rule is adopted that only those countries that cultivated the crop in 1961 should be included in the sample, because adopters are likely to under–perform at early stages of cultivation and thus to bias the estimation. For soybeans, this led to a fairly high number of discarded observations.

16. The presence of heteroskedasdicity tends to lead to higher diffusion coefficients. This weighting procedure corrects for that. The White test for cross–section heteroskedasticity is performed for all estimations and reports consistent parameters for all crops.

17. The curve is fairly robust against changes in the discount rate. A higher rate pushes the curve down slightly, and *vice versa*.

18. There are for each crop countries in which the intrinsic growth rate of the yield is basically equal to or above that prevalent in the frontier countries. For barley, this holds in Zimbabwe; for cotton, in Israel and Syria; for maize, in Chile; for millet, in China; for rice, in Egypt and Korea; for sorghum, in Egypt and Israel; for soybeans, in Ethiopia; and for wheat, in Egypt and Zimbabwe.

19. The correlation coefficient between $\hat{a}$ and β is 0.02.

20. The authors also investigated the importance of increased allocations of land and of agro–ecological circumstances, and found these factors to be either of no significance or much lower impact than the factors discussed here.

21. The so–called UPOV convention provides that each member state should provide property–right protection in innovative plant varieties. It is also possible to take traditional forms of patent rights in innovative seeds.

22. Maskus (2001) cites two types of evidence for this proposition. First, there is the generally observed positive correlation between national income and adoption of IPR regimes. Second, there is the positive correlation between national income and perceived effectiveness of such regimes, as demonstrated in the World Economic Forum's surveys of perceived strength of IPR enforcement (the index for 21 developed countries is 50 per cent greater than that for 18 developing countries).

23. An interesting future issue is the impact of technological change that affords technological protection to other crop species, the so–called genetic use restriction technologies, and the welfare implications for various countries (Goeschl and Swanson (2000).

24. For observations involving hybrid crops, $D=1$.

25. See endnote 17.

Bibliography

ALSTON, J.M. AND R.J. VENNER (1998), “The Effects of the US Plant Variety Protection Act on Wheat Genetic Improvement”, paper presented at the symposium on “Intellectual Property Rights and Agricultural Research Impact”, sponsored by NC 208 and CIMMYT Economics Program, El Batan, Mexico, March 5–7.

ALSTON, J.M., P.G. PARDEY AND VINCENT H. SMITH (1998), “Financing Agricultural R&D in Rich Countries: What’s Happening and Why?”, *The Australian Journal of Agricultural and Resource Economics* 42(1).

BARRO, R., AND X. SALA–I–MARTIN (1995), *Economic Growth*, McGraw–Hill, New York.

EVENSON, R. AND Y. KISLEV (1973), “Research and Productivity in Wheat and Maize”, *Journal of Political Economy*, 81(6).

EVENSON, R., P.E. WAGGONER AND V. RUTTAN (1979), “Economic Benefits from Research: The Case of Agriculture”, *Science*, 205.

GOESCHL, T. AND T. SWANSON (2002), “Diffusion and IPR Regimes in Biotechnology”, *in* T. SWANSON (ed.), *Biotechnology, Agriculture and the Developing World. The Distributional Implications of Technological Change*, Edward Elgar, Cheltenham.

GOESCHL, T. AND T. SWANSON (2000), “Genetic Use Restriction Technologies and the Diffusion of Yield Gains to Developing Countries”, *Journal of International Development,* 12.

GRILICHES, Z. (1957), “Hybrid Corn: An Exploration in the Economics of Technological Change”, *Econometrica* 48.

HSIAO, C. (1986), *The Analysis of Panel Data*, Econometric Society Monographs No. 11, Cambridge University Press, Cambridge.

KRUGMAN, P. (1979), “A Model of Innovation, Technology Transfer, and the World Distribution of Income”, *Journal of Political Economy,* 87.

LAI, E. L.–C. (1998), “International Intellectual Property Rights Protection and the Rate of Product Innovation”, *Journal of Development Economics,* 55(1).

MADDALA, G.S. AND S. WU (1999), “A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test”, *Oxford Bulletin of Economics and Statistics*, Special Issue.

MASKUS, K.E. (2000), *Intellectual Property Rights in the Global Economy*, Institute for International Economics, Washington, D.C.

MASTERS, W.A. AND J. SACHS (2001), "Climate and Development", Paper presented at the 2001 American Economic Association Meeting, New Orleans.

PARDEY, P.G., J. ROSEBOOM AND J.R. ANDERSON (eds.) (1991), *Agricultural Research Policy: International Quantitative Perspectives*, Cambridge University Press, Cambridge.

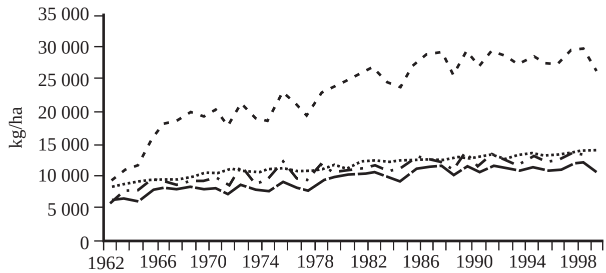
ROMER, P. (1990), "Endogenous Technological Change", *Journal of Political Economy*, 98 (5).

SCHMITZ, A. AND D. SECKLER (1970), "Mechanized Agriculture and Social Welfare: The Case of the Tomato Harvester", *American Journal of Agricultural Economics*, 52.

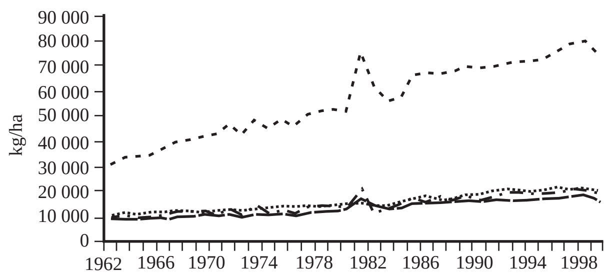
ZILBERMAN, D. AND A. HEIMAN (1997), "The Value of Economic Research", *American Journal of Agricultural Economics* 79(5).

Annex A. **Actual, Fitted and Simulated Yield Developments in Developing Countries**

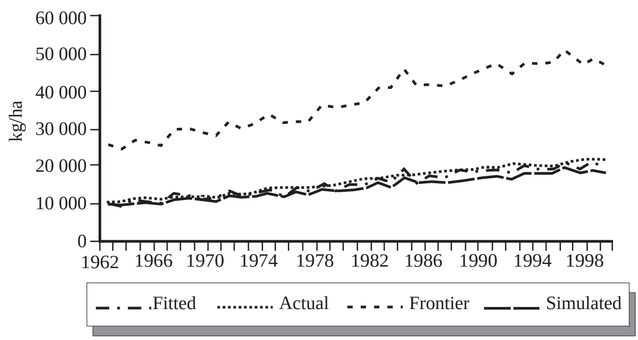
Development of Cotton Yields, 1962-1999



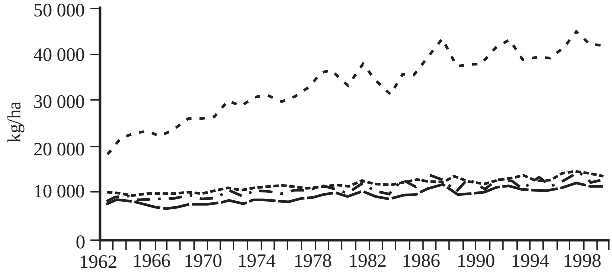
Development of Maize Yields, 1962-1999



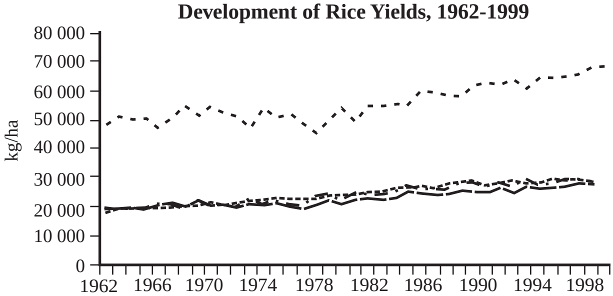
Development of Wheat Yields, 1962-1999



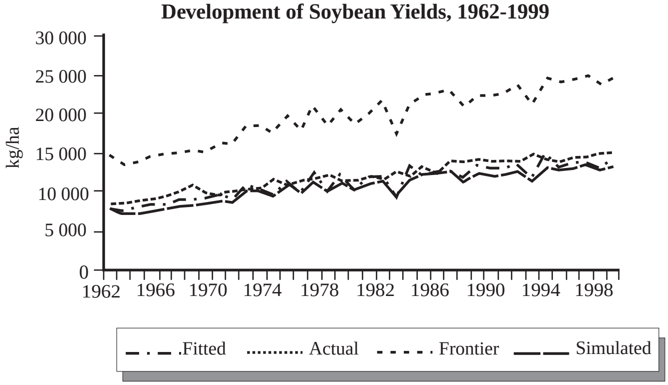
Development of Sorghum Yields, 1962-1999



Development of Rice Yields, 1962-1999



Development of Soybean Yields, 1962-1999



Poverty, Food Security, and Agricultural Biotechnology: Challenges and Opportunities

Nihal Amerasinghe[1]

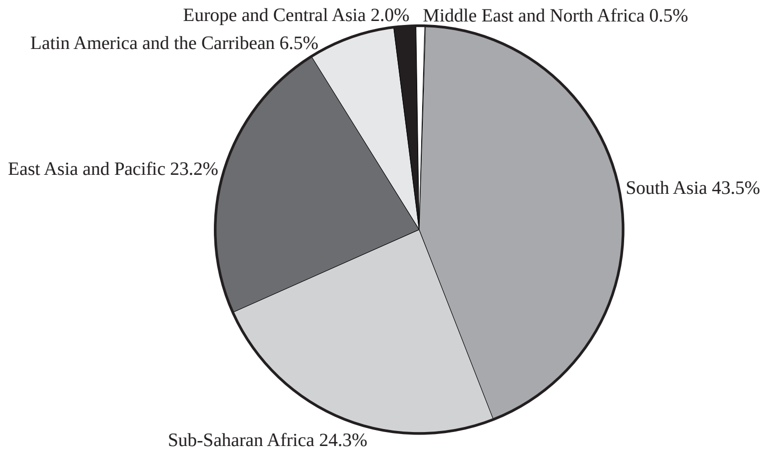
Poverty in an Unequal World

At the dawn of the twenty–first century the world is mired in poverty. Of the world's 6 billion people, 2.8 billion — almost half — live on less than $2 a day, and 1.2 billion — a fifth — live on less than $1 a day (World Bank, 2000). About 900 million or 68 per cent of the world's poor live in Asia; about 500 million in South Asia, 300 million in East Asia and 100 million in Southeast Asia and the Pacific (Figure 1).

About 526 million people are undernourished, including 160 million children (FAO, 1999). They lack not only sufficient money to buy food and other essentials, but also access to adequate schooling, housing and medical care. Those in rural areas are often short of water and fuel. Fertile land and water for farming are increasingly scarce. The urban poor lack money to buy enough food. What they can afford to buy may be deficient in proteins and essential vitamins and minerals.

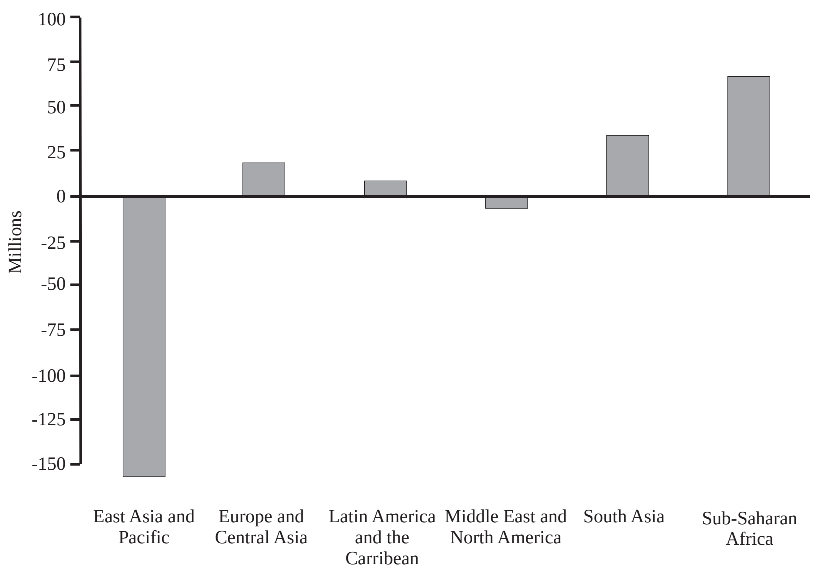
This widespread destitution persists even though human conditions have improved more in the past century than in the rest of history — global wealth, global connections and technological capabilities have never been greater. Yet the distribution of these global gains is extraordinarily unequal (Figure 2). In East Asia, the number of people living on less than $1 a day fell from around 420 million to around 280 million between 1987 and 1998, but in South Asia, Sub–Saharan Africa and Latin America, the number of poor people has risen. In the countries of Central Asia and Europe in transition, poverty has increased more than twenty fold (World Bank, 2000). The average income in the richest 20 countries is 37 times the average in the poorest 20 — a gap that has doubled in the past 40 years. Although the absolute numbers of people living in poverty in Asia today are unacceptable, the situation could have been much worse without the success of the green revolution. In 1970, about 60 per cent of all Asians lived in poverty. That figure was cut by almost half by 2000. Countries such as Bangladesh, the People's Republic of China, and India have moved from periodic

Figure 1. **Where the Developing World's Poor Live**
(Distribution of population of 1.2 billion living on
less than $1 a day, 1998)



Source: World Bank (2000).

Figure 2. **Where Poverty Has Fallen, Where it Has Not**
(Change in number of people living on less than $1 day, 1987-98)



Source: World Bank (2000).

famines to near self–sufficiency in food production. As shown in Tables 1 and 2, the impressive gains in Asia over the past three decades are masked by considerable diversity of experience among countries. While some countries, particularly in Southeast Asia, have moved ahead from poverty to become middle–income countries within a mere three decades, others in South Asia have lagged behind[2].

Food insecurity associates closely with poverty. About 800 million people do not have access to sufficient food to lead healthy, productive lives. About 280 million of these food–insecure people live in South Asia, 240 million in East Asia, 180 million in Sub–Saharan Africa and the rest in Latin America, the Middle East and North Africa. Clearly, further efforts are needed to reduce poverty and food security. According to recent FAO projections, the World Food Summit (WFS) goal of halving the number of food–insecure people from 800 million in 1995 to 400 million by 2015 will not be achieved until 2030 (Figure 3).

Results from the International Food Policy Research Institute's (IFPRI) revised and updated global food model suggest that there will be similarly slow progress in reducing child malnutrition (Figure 4). Under the most likely scenarios, 132 million children under the age of six years — one out of every four — will be malnourished in 2020. This represents a decline of only 20 per cent from 166 million in 1997.

During the next two decades, the world's population is projected to increase by 24 per cent to reach 7.5 billion in 2020[3] (Figure 5). Virtually all of the population increase will take place in developing countries, and much of it in urban areas.

With rising incomes and urbanisation, global demand for cereals is expected to increase by 35 per cent between 1997 and 2020 to 2 497 million tons and for meat by 57 per cent to 327 million tons. Almost all of the increase in demand will take place in developing countries (Figure 6).

How will increases in cereal demand of this magnitude be met? Primarily through increases in productivity, because the natural resources available for further expansion of farming have been virtually exhausted. The situation is particularly serious for Asia, where most good agricultural land is already farmed and the region as a whole may have passed the safe limits for agricultural expansion. FAO (1999) estimates that in South Asia, for example, with virtually no reserves of land with crop–production potential, land use per person will fall from 0.17 hectares in 1990 to 0.12 hectares in 2010. This pressure on the land will have three main effects. First, farming systems, traditionally in harmony with the environment as only low productivity was demanded of them, will become inappropriate. Second, increasing numbers of the rural population will be forced to farm marginal and unsuitable land, which becomes quickly degraded. Third, more people will move to urban areas, adding to congestion and pollution and removing yet more prime agricultural land from production. Agricultural land use increased by 13 per cent or 170 million hectares in the last 30 years, largely at the expense of lowland forests and their rich biodiversity (ADB, 2000).

Table 1. **Indicators of Change in Asia, 1970 to 1995**

	India	Other S. Asia[a]	People's Republic of China	Southeast Asia[b]	Developing Asia
Population (millions)					
1970	554.9	156.2	834.6	204.4	1 750.2
1995	929.0	293.9	1 226.3	343.7	2 792.9
% Change	67.4	88.2	46.9	68.2	59.6
Cereal Production (million metric tons)					
1970	92.8	25.4	161.1	33.8	313.2
1995	174.6	48.1	353.3	73.6	649.6
% Change	88.1	89.3	119.3	117.8	107.4
Per Capita Income ($/Year)					
1970	241.0	187.0	91.0	351.0	177.0
1995	439.0	299.0	473.0	1027.0	512.0
% Change	82.2	60.0	419.8	192.6	189.3
Calorie Consumption (Kilocalories/person/day)					
1970	2 083	2 184	2 019	1 945	2 045
1995	2 388	2 274	2 697	2 596	2 537
% Change	14.6	4.1	33.5	33.5	24.1
Cereal Area Harvested (million hectares)					
1970	100.4	21.3	91.1	25.0	237.7
1995	100.2	26.0	88.2	32.9	247.3
% Change	-0.2	22.0	-3.2	31.6	4.0
Cereal Yield (t/ha)					
1970	0.925	1.197	1.769	1.352	1.317
1995	1.743	1.846	4.007	2.237	2.627
% Change	88.4	54.2	126.5	65.6	99.5

a. Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka
b. Cambodia, Indonesia, Lao People's Democratic Republic (PDR), Malaysia, Myanmar, Philippines, Thailand, and Viet Nam.

Source: *Rural Asia: Beyond the Green Revolution* (ADB, 2000).

Table 2. **Poverty Changes in Asia, 1975 to 1990s**

	South Asia[a]	People's Republic of China	Southeast[b] Asia	Developing Asia
Poverty (millions)				
1975	472.2	568.9	108.1	1 149.2
1990s	514.7	269.3	40.2	824.2
Poverty (per cent)				
1975	59.1	59.5	52.9	58.7
1990s	43.1	22.2	11.5	29.9

a. India, Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka
b. Cambodia, Indonesia, Lao People's Democratic Republic (PDR), Malaysia, Myanmar, Philippines, Thailand and Viet Nam.

Source: *Rural Asia: Beyond the Green Revolution* (ADB, 2000)

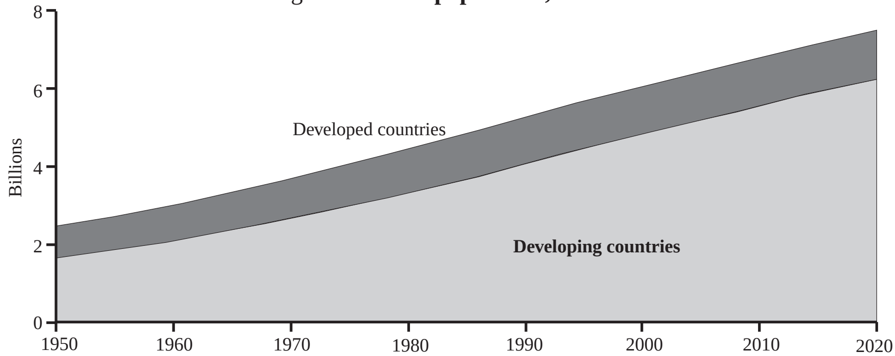
Figure 3. **Food Insecurity in the Developing World, 1969-2030**

Source: FAO (2001).

Figure 4. **Child Malnutrition in the Developing World, 1970-2020**
(children <6 years)

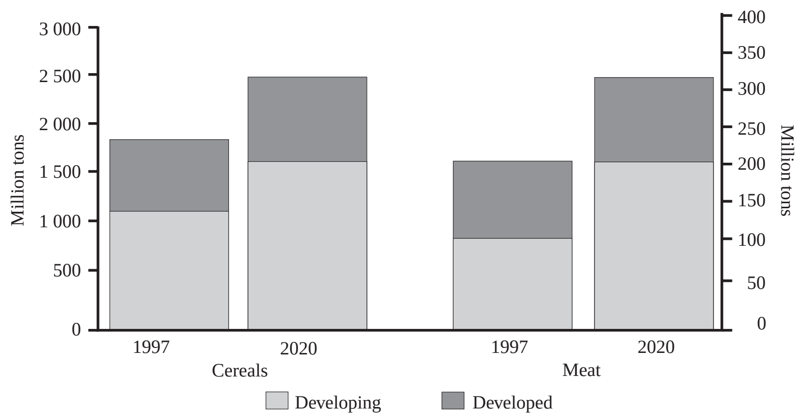
Source: 1970-95 data from Smith and Haddad (2000),
1997-2025 projections from IFPRI IMPACT simulations (October 2000).

Figure 5. **World population, 1950-2020**



Note: Medium-variant projections for 2000-2020.
Source: United Nations (1999).

Figure 6. **Total Demand for Cereals and Meat Products, 1997-2020**



Source: IFPRI IMPACT simulations (October 2000).

Agricultural Science and Poverty Reduction

Science and technology underpinned the economic and social gains in Asia over the past 30 years. In agriculture these gains came to be known as the Green Revolution. Between 1970 and 1995, cereal production in Asia doubled, calorie availability per person increased by 24 per cent and real food prices halved (IFPRI, 1997) (Table 1). Although the region's population grew by one billion, overall food production more than kept pace with this growth (McCalla, 1998). These food production increases were achieved largely by the cultivation of high–yielding varieties (HYVs) of rice and wheat, accompanied by expansion of irrigated areas, increases in fertiliser and pesticide use and greater availability of credit. Clearly, productivity improvement rather than area expansion was responsible for the phenomenal increase in production.

The scientific basis for the Green Revolution stemmed from national and international research programmes that led to the development and distribution of new HYVs, particularly of rice and wheat. The first generations of these new varieties were based on the introduction of new genes for dwarfing that made the HYVs shorter, more responsive to fertilisers and less prone to lodging when fertilised and irrigated. Subsequent varieties also carried genes that gave increased pest and disease resistance and improved taste and grain quality.

The key elements in improving food security in Asia in 1970–95 were government policies reflecting a belief that investments in increasing agricultural productivity were a prerequisite to economic development. Political leaders in Asia and both the public and private sectors of the international community supported these national policies. This mix of supportive public policies, scientific discoveries and public and private investments in rural Asia, particularly in irrigation, credit and inputs, led to substantial reductions in poverty and improved food security throughout Asia. Increased agricultural productivity, rapid industrial growth and expansion of the non–farm rural economy have all contributed to almost a tripling of per capita gross domestic product across Asia since 1970 (ADB, 2000; Pinstrup–Andersen and Cohen, 2000).

Despite these successes, problems remain. The intensification of agriculture and the reliance on irrigation and chemical inputs has led to environmental degradation, increased salinity and pesticide misuse. Deforestation, overgrazing and over–fishing also threaten the sustainable use of natural resources.

Green–revolution technologies had little impact on the millions of smallholders living in rain–fed and marginal areas, where poverty is concentrated. Furthermore, the Green Revolution has already run its course in much of Asia. Wheat and rice yields in the major growing areas have been stagnant or declining for the past decade, while population continues to increase (Pingali *et al.*, 1997). Three key lessons were learned from the Green Revolution. First, it has benefited farmers in irrigated areas much more than those in rain–fed areas, thus worsening the income disparity between the two groups. Second, it overlooked the rights of women to benefit from technological advances. Third, it promoted an excessive use of pesticides and in some situations indiscriminate use of fertilisers harmful to the environment.

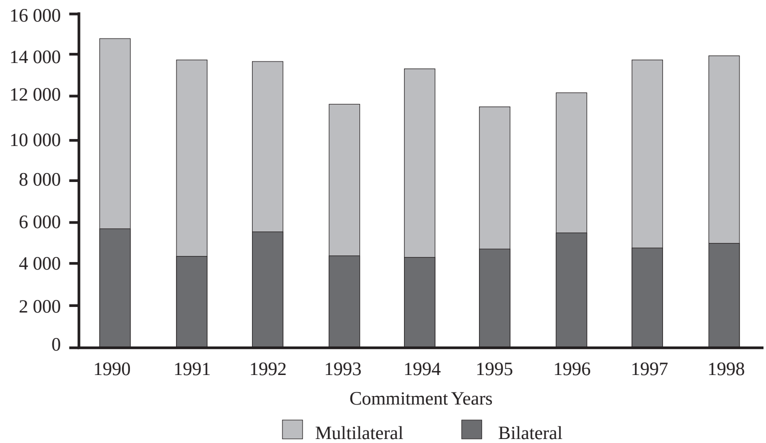
As countries have become self sufficient in food, government investments have declined in the agricultural sector and in science and technology across the region. This reflects a worldwide trend toward declining public investment in the rural sector and in agricultural research and development (R&D), nationally and internationally. These factors have been responsible for the decline in annual agricultural growth rates from an average of 3.3 per cent during 1977–1986 to about 1.5 per cent during 1987–1996. As Table 3 and Figure 7 show, government expenditures and external assistance to agriculture have virtually stagnated over the past decade.

Table 3. **Share of Government Expenditure for Agriculture in Total Expenditure by Developing Region (1990-98)**

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Latin America & Caribbean	3.2	4.6	3.9	4.2	3.9	3.4	2.7	3.3	1.9
Near East & North Africa	4.1	3.6	3.7	3.6	3.3	3.7	3.5	3.5	1.1
Africa South of Sahara	6.2	5.8	6.6	5.3	5.5	5.0	5.6	4.7	3.9
East & South East Asia	6.9	6.5	5.9	6.1	7.0	7.5	7.4	7.1	5.2
South Asia	8.4	10.0	10.4	10.5	11.2	11.2	8.8	6.3	5.4

Source: FAO (2001).

Figure 7. **Total Commitments of Funds for Agriculture by Main Bilateral and Multilateral Donors**
(millions of 1995 dollars)



Source: FAO (2001).

In Asia, private investments in the rural sector and related R&D have concentrated on export commodities. The downward trends in public investment by governments and development agencies in smallholder agriculture over the past decade have not been matched by a concomitant rise in private investment. Similarly, there is little private R&D (and few incentives for it) on the food crops, livestock, fisheries and aquaculture systems important for food security and poverty reduction in rural Asia.

The challenge for the future is how to keep ahead in the food–population race with diminished resources. Asia's population is projected to increase from 3.0 billion to 4.5 billion in the next 25 years. The urban population will nearly double from 1.2 billion to 2.0 billion, as rural people move to the cities in search of employment. These increases will place massive pressure on developing countries to increase food production. Food demand is influenced by population growth, urbanisation, income and associated changes in dietary preferences. Urbanisation and income growth frequently lead to shifts from diets based on root crops and cereals to more meat, milk, fruits, vegetables and processed foods. This dietary transition has already happened in much of the region (ADB, 2000). Meeting the food needs of Asia's growing and increasingly urbanised population requires increases in agricultural productivity.

To meet this demand, cereal production will need to increase by at least 40 per cent from the present level of about 650 million tons annually. Most of the increase will have to come from yield increases. In addition, meat demand will double during the period (Pinstrup–Andersen *et al.*, 1999). Production increases must be achieved by increasing yields in a sustainable way, to conserve diminishing and degraded natural resources. Nearly all of these production increases will need to take place in developing countries because on average 90 per cent of the world's food is consumed in the country where it is produced. Food imports not only are expensive but also discourage the creation of employment, which is badly needed in the rural areas of Asia.

In this millennium, we face a food, feed and fibre production challenge in highly complex farming systems, for several reasons:

— Water will become the most important limiting factor in agricultural production because its quality and quantity will decline as a result of pollution, forest degradation and increased agricultural, domestic, and industrial use (ADB, 2001*a*).

— Urbanisation will mean the loss of agricultural land to residential and industrial development and a decline in the number of farm workers.

— Most farmers are poor with small landholdings.

— Farming systems are commonly heterogeneous with mixes of food crops, livestock, and trees.

— About 70 per cent of the cultivated land is rain–fed, with unreliable distribution and intensity of rainfall.

— Thus, the increase in food production during the next 25 years will have to be achieved using less labour, water, and cultivated land. This can occur only if scientists can develop new crop varieties with high yield potential and high water–use efficiency. New understanding of plant and animal genes may offer ways to increase crop yields to the levels required to feed the growing population in Asia adequately and sustainably. Increasing smallholder agriculture productivity will not only increase food supplies, but also reduce poverty and malnutrition, increase food access and improve living standards of the poor (McCalla and Brown, 2000).

Strategies to meet the required increases in food supply in Asia include:

— Sustainable productivity increases in food, fuel and fibre crops;

— Reducing chemical inputs of fertilisers and pesticides and replacing them with biologically based products;

— Integrating soil, water and nutrition management;

— Improving the nutrition and productivity of livestock and controlling livestock diseases;

— Achieving sustainable increases in fisheries and aquaculture production; and

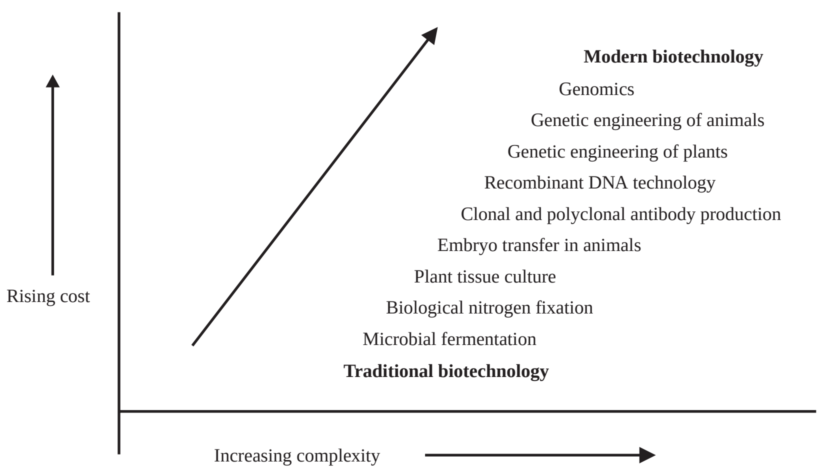
— Increasing trade and competitiveness in global markets.

The challenge is how to use new developments in modern science in concert with information and communications technology, and new ways of managing knowledge, to make the complex agricultural systems of Asia more productive in sustainable ways.

Biotechnology Potential

Modern science has led to rapid progress in understanding the genetic basis of living organisms. This has transformed our ability to develop new products and processes useful in human and animal health, food and agriculture and the environment. Biotechnology has opened a range of opportunities (Figure 8).

Figure 8. **Gradient of Biotechnologies**



Source: Persley (1990) and Doyle and Persley (1996).

Biotechnology has the potential to increase crop and animal productivity, improve nutritional quality, broaden tolerance of crops for drought, salinity and other abiotic stresses and increase resistance of crops to pests and diseases. The use of modern molecular genetics for gene mapping and marker–assisted solutions could speed the development of improved crops, livestock, fish and trees. Tissue culture and micropropagation are used for multiplication of disease–free planting materials. New diagnostics and animal vaccines are being widely adopted for the diagnosis, prevention, and control of livestock and fish diseases (Table 4). These potential benefits of a range of new tools will have significant impact on increasing food production and reducing poverty in developing countries — if they can be applied to problems of poor farmers.

Table 4. **Possible Applications of Modern Biotechnology to Agriculture**

Sector	Applications
Crop Production	*Diagnostics.* Diagnose plant pests and pathogens, contaminants and quality traits.
	Micropropagation techniques or tissue culture. Multiply disease-free planting materials on a large scale.
	Development of transgenic crops. Develop commercially new genetically modified crop varieties.
	Modern plant breeding. Develop superior plant varieties rapidly and more precisely.
	Marker-assisted selection. Use genetic markers, maps and genomic information in breeding for high-yielding, disease- and pest-resistant varieties.
Forestry	*Gene-mapping.* Accelerate breeding of forest trees.
	Macropropagation. Rapid propagation with cuttings from large plantations of pines and other trees.
	Micropropagation by tissue culture. Large-scale multiplication of genetically superior plantlets.
	DNA finger printing. Differentiate species, strains, and cultivars accurately.
	Wood security. Select genetically superior trees for breeding.
Livestock	*Livestock improvement.* Speed up animal reproduction, allowing more generations to be produced.
	Transgenic livestock. Development of transgenic lines of virus-resistant poultry and other animals.
	Livestock health. Applications of diagnostics for the control of major livestock diseases.
	Vaccine development. Development of vaccines for the control of epidemic viral diseases.
Fisheries	*Use of molecular markers in biodiversity.* Research, genomic mapping, and trait selection in fish and other aquatic organisms.

Source: ADB (2001*b*).

Current Status of Agricultural Biotechnology in Asia

Several countries in Asia, including the People's Republic of China, India, Indonesia, Malaysia, Pakistan, Philipp ines, Thailand and Viet Nam, are making significant investments in modern biotechnology to further the aim of improving food security and reducing poverty. Several regional and international programmes and a growing number of private companies are working on biotechnology.

The global area under transgenic crops has expanded in recent years (Table 5). In Asia, the PRC is the most advanced in the use of genetically modified crops, with at least 500 000 ha of such crops grown commercially. Commercial production of transgenic cotton and soybean with resistance to insect pests is expanding. A major contribution of biotechnology toward increasing yields will arise from decreasing losses from diseases and pests while minimising the use of pesticides.

Table 5. **Global Area of Transgenic Crops, 1998-2000**
(million hectares)

	1998	Per cent	1999	Per cent	2000	Per cent
Soybean	14.5	52	21.6	54	25.8	58
Maize	(0.3)	30	11.1	28	10.3	23
Cotton	(0.5)	9	3.7	9	5.3	12
Canola	(0.4)	9	3.4	9	2.8	7
Potato	(-)	<1	<0.1	<1	<0.1	<1
Squash	0.0	0	<0.1	<1	<0.1	<1
Papaya	0.0	0	<0.1	<1	<0.1	<1
Total	**27.8**	**100**	**39.9**	**100**	**44.2**	**100**

Source: James (1998; 2000).

National biotechnology programmes in Asia receive assistance from various bilateral and multilateral sources. Most support is country–specific and directed toward providing infrastructure, equipment and postgraduate training. All donors support applications of biotechnology through specific projects. Private companies and non–government organisations support national or regional activities. Several IARCs supported by the Consultative Group on International Agricultural Research, and the Asian Vegetable Research and Development Centre, use new biotechnology techniques to increase the productivity of the major cereal, legume and vegetable crops, characterise and conserve the genetic resources of crops and trees, and improve the health and increase the productivity of livestock and fish.

Potential Contribution of Biotechnology toward Poverty Reduction and Food Security

Agricultural biotechnology is expected to contribute significantly to poverty reduction and food security in Asia through increased productivity, lower production costs and food prices and improved nutrition. Agricultural biotechnology could also help significant improvement in the environment. Public sector R&D has emphasised simple, low–cost technology appropriate for poor farmers in the rain–fed and marginal areas, despite human–resource and financial constraints that hinder progress. The focus has been on the so–called orphan crops (rice, tropical maize, wheat, sorghum, millet, banana, cassava, groundnut, oilseeds, potato, sweet potato and soybean) that the private sector has largely ignored because of their low return on investment. Enhancing co–operation between the public and private sectors would speed development and must be encouraged in efforts to reduce poverty.

Biotechnology tools could help plant breeders to achieve productivity gains, introduce resistance to pests and diseases, reduce pesticide use, improve crop tolerance for abiotic stress, improve the nutritional value of some foods and enhance the durability of products after harvest and during shipping. Biotechnology may offer cost–effective solutions to vitamin and mineral deficiencies by developing rice varieties that contain vitamin A and minerals. Raising productivity could increase smallholders' incomes, reduce poverty, increase food access, reduce malnutrition and improve the livelihood of the poor. In the PRC, cotton farmers that have adopted insect–resistant transgenic *Bt* cotton have reduced their use of highly toxic pesticides, which has helped in improving the environment and public health.

Key Issues

Potential Risks of Biotechnology

In public debate, the opponents of biotechnology have focused largely on Genetically Modified Organisms (GMO), one of the many products that may have food biosafety, environmental, socio–economic and ethical risks. Some of these risks are genuine and need to be addressed by the public and private sectors to ensure that GMOs are safe. An open, transparent and inclusive food–safety policy and regulatory process is required.

The potential long–term impact of genetically improved foods on human health and the environment is unknown. It requires monitoring and further research. Methods are available to test allergenicity and toxicity of genetically modified foods in humans before approving them for human consumption. Six potential environmental safety issues need to be considered when addressing risks posed by the cultivation of genetically modified plants: gene transfer, weediness, trait effects, genetic and phenotypic variability, expression of genetic material from pathogens and worker safety. The Cartagena Protocol on Biosafety, agreed by 130 governments in January 2000, specifies obligations for international transfer of living modified organisms. It also sets out means of risk assessment and management, and it advances informed agreement, technology transfer and capacity building. The Protocol establishes a Biosafety Clearing–House through which governments signal whether they will accept imports of agricultural commodities that include GMOs. It establishes labelling requirements for shipments of commodities that may contain GMOs. Developing countries in Asia will need to strengthen their biosafety regulations and enforcement to ensure that the risks of biotechnology can be minimised. Public awareness activities from the onset of a biotechnology work programme can greatly assist in gaining consumer acceptance of biotechnology products (Table 6).

Intellectual Property Management

A set of intellectual property right (IPR) issues is associated with biotechnology. They include lack of access of poor farmers to the new technologies and products, losses of ownership rights of some developing countries over their own indigenous genetic resources, lack of incentives for the free flow of technologies and products from developed to developing countries and a growing danger that the free flow of agricultural materials between countries will be impeded. The public and private sectors need to manage intellectual property to ensure that IPRs do not exclude developing countries from access to the benefits of new technology.

Economic Concentration in Agricultural Biotechnology

Multinational companies in the seed, agricultural chemicals, pharmaceuticals and food–processing industries in developed countries play a major role in biotechnology research. They have invested heavily in in–house research facilities, commissioned research, taken equity positions in new biotechnology firms or entered into contractual arrangements with public research institutions or universities. The development of new biotechnology applications in agriculture has become increasingly concentrated in the hands of a decreasing number of companies as a result of mergers and acquisitions. In the short term, most genetically engineered crops will be developed and grown in developed countries by large–scale farmers. Changing patterns of international trade in foods that result from genetic engineering in developed countries could have serious consequences for developing countries in Asia.

Table 6. **Summary of Perceived and Genuine Risks of Genetically Engineered Foods and Crops**

Nature of Risk	Type of Risk	Remarks
Food Safety	1.Toxins and poison. In 1998, a scientist in the Rowett Institute found that genetically engineered (GE) potatoes spliced with DNA from the snowdrop plant (a viral promoter) are poisonous to mammals.	The UK Government's Advisory Committee for Novel Food and Process examined the data and concluded that the experiment was faulty and the conclusions were wrong.
	2. Increased cancer risks. Monsanto's bovine somatotrophin (growth hormone) injected into dairy cows to produce more milk has been reported to cause human breast, prostate, and colon cancers.	This is not a GM food. In any event, Canada and the European Union have banned its use. A United Nations Food Standard body has not certified its safe use. The hormone is no longer widely used in the United States.
	3. Food allergies. In 1996, a Brazil nut gene spliced into soybean was reported to induce potentially fatal allergies in people sensitive to Brazil nuts.	The safety assessment confirmed that the protein was an allergen and the development was abandoned. A standard laboratory test has been available to test possible allergenicity in GE products.
	4. Contamination. StarLink, a GE maize variety approved for animal feed but not for human consumption, was found in an ingredient used by some US beer makers and in taco shells in the United States in 2000.	An accidental mix of StarLink with vast amounts of other maize during harvest, storage, and distribution caused the incident. The contaminated food was recalled and destroyed. A number of quick and cheap tests are available to determine the presence of GM products in food.
	5. Antibiotic Resistance. Use of an antibiotic marker gene in the development of GE crops may contribute to the growing public health danger of antibiotic resistance.	There is little or no evidence about this risk yet, but this is an emotive topic, and developers have now replaced the antibiotic marker with a safer one.
Environmental Risks	1. Increased pesticide residues. Farmers growing GE crops will use as many toxic insecticides and herbicides as conventional farmers, thus increasing pesticide residues in soils and on crops.	This risk is not yet proven statistically. There are reports that farmers growing GE crops resistant to pests and herbicides are able to reduce production cost significantly through the reduced use of pesticides. That was a major reason why farmers adopted GE crops widely in the PRC and the US.
	2. Genetic pollution. Wind, rain, birds, and bees have carried genetically altered pollen into adjoining fields, contaminating the DNA of organic, non-GE crops.	This genetic pollution is not an environmental issue unless the transfer of pollen causes some kind of environmental damage. Pollen contamination has taken place for centuries with or without genetic engineering.

Table 6 (continued)

Nature of Risk	Type of Risk	Remarks
	3. Damage to beneficial insects. Scientists from Cornell University found that pollen from *bacillus thuringiensis* (Bt) maize was poisonous to Monarch butterflies and possibly other beneficial insects.	Monitoring systems have been devised in the PRC and the United States to evaluate the long-term effect of GE crops on beneficial insects.
	4. Creation of superweeds. GE crops (soybean and canola) resistant to herbicides may transfer their resistance to weeds, turning them into superweeds, which cannot be controlled by herbicides.	This fear has yet to be proven. Scientists are closely monitoring the use of GE crops resistant to herbicides.
	5. Creation of superpests. GE crops (maize and cotton) resistant to pests may transfer their resistance to pests, turning them into superpests, which cannot be controlled by pesticides.	As above, this fear has yet to be proven in practice. There is no known mechanism by which pest resistance from a plant may be transferred to an insect pest.
	6. Creation of new viruses and bacteria. Biotechnology could help terrorists to create killer viruses or bacteria, which could be used in biological weapons.	This could happen even without biotechnology. Terrorists historically have managed to acquire and subvert beneficial technologies to antisocial purposes.
Socioeconomic Risks	1. Terminator technology will render seeds infertile and force hundred of millions of farmers to purchase more expensive GE seeds and chemical inputs from a handful of global biotechnology and seed companies.	The Monsanto Company has withdrawn the terminator gene from its GE crops following many complaints from farmers.
	2. High concentration of biotechnology research and development in developed countries will widen the income disparity between developed and developing countries, and between large and small farmers.	The public sector in Asia should accord high priority to biotechnology development that addresses the problems of small farmers.
Ethical Concerns	1. Biotechnology reduces all life to bits of information (genetic code) that can be rearranged at whim by scientists. The creation of the first genetically modified monkey in 2000 brings the possibility of genetic manipulation closer to humans. There is fear that the technique will be used to create “designer’ babies”.	Although most of these ethical concerns relate to non-agricultural biotechnology, they point to the need for the private sector to incorporate work ethics in biotechnology research and development.
	2. There seems to be little ethical concern in private companies over the use of GE animals to produce therapeutic drugs.	

Notes: Bt = *bacillus thuringiensis*, GE = genetically engineered, GM = genetically modified.

Source: Skerrit (2000); Wolfenbargen and Phifer (2000).

Need for Increased Public–Private Sector Collaboration

Public investment in agricultural biotechnology is crucial for achieving future food security and reducing poverty. The private sector is unlikely to undertake much of the R&D needed by small farmers because it sees little potential for return on investment. Accelerated public investments are needed to develop biotechnology applications that address difficult problems in rain–fed and marginal areas as such research will produce essential public goods. Additional private and philanthropic resources are required to bolster government efforts in agricultural research, which are constrained by lack of resources. The private sector has the knowledge, skills and capital for biotechnology research to solve the problems of small farmers. Financial or policy initiatives are essential for increased public and private collaboration in biotechnology R&D. Building on the comparative advantages of each sector, such partnerships are powerful new mechanisms to mobilise global science and technology. Forging public–private partnerships is an essential part of the solution to world hunger. It is not a handout and it is not about dependency. Instead, such partnerships are two–way streets that can benefit both partners (Krattiger, 2000.)

Policy and Priority Setting

Considerable biotechnology R&D is already being carried out in Asian countries, particularly in the larger economies such as the PRC, India, Indonesia, Philippines and Thailand. They and other Asian countries should establish clear policies and priorities in agricultural biotechnology R&D to ensure that the output will contribute significantly toward poverty reduction and food security. Policies will need to take into account:

— The high level of capital and technical skills biotechnology requires;

— The often inadequate capacity that constrains public and private biotechnology R&D in developing countries;

— The reluctance of the private sector to invest in technology for Asia's poor farmers;

— The inherent risks in some uses of biotechnology; and

— The difficulty of establishing and implementing effective biosafety regimes.

Concluding Remarks

During the next 25 years, Asia will face a serious challenge to reduce poverty and achieve food security. It faces an absolute increase in population, the doubling of its urban population, continued deterioration of its soil, water and forestry resources and the need to produce food where it is consumed, because the share of total grain production traded has remained stable at about 10 per cent. The most attractive strategy to meet this challenge is to increase smallholder agricultural productivity. This strategy will not only increase food supplies, but also increase smallholders' incomes, reduce malnutrition and improve the livelihoods of the poor. The challenge has to be addressed by modern science since the Green Revolution has run its course in much of Asia. It has also bypassed the rain–fed and marginal areas where most of the poor are concentrated.

The Green Revolution in the late 1960s and 1970s illustrated how important agricultural productivity is for rural prosperity and food security. A total of two billion tons of cereals are produced today on 700 million hectares (FAO 1997). Without green revolution technologies, India would need to cultivate another 100 million hectares to feed itself (Krattiger, 2000). With pre–1960s technologies, the world would need another 1.7 billion hectares for cereals alone. Where could that land come from? It is critical to continue to invest in and deploy new technologies to maintain prosperity. The world must increase agricultural production in an environmentally sound and sustainable way but it should also do so more equitably. Agricultural biotechnology will play a large role.

The risks of biotechnology to human health and the environment are confined largely to the development of transgenic crops and livestock. Other components of biotechnology, such as microbial fermentation, tissue culture, marker–selected breeding and disease control, are relatively safe. Biotechnology consists of a gradient of technologies ranging from simple, low risk ones to complex, expensive and high–risk ones. Governments therefore have a choice of technologies to invest in, depending on the availability of human and financial resources and their capacity to monitor and evaluate potential risks.

Agricultural biotechnology is not the sole means of achieving food security, but it could be a powerful tool in the fight against poverty, in conjunction with complementary activities. Such activities would include a favourable policy environment, good governance, investments in rural infrastructure, agricultural research, extension, rural finance and marketing. The importance of agricultural biotechnology in the fight against poverty and world instability is aptly captured by a statement made by Jimmy Carter, the former US President and Chairman of the Carter Center in a recent editorial: "Responsible biotechnology is not the enemy; starvation is. Without adequate food supplies at affordable prices, we cannot expect world health or peace" (Carter, 1997).

It is important not to deny people and nations access to new technologies, so long as they are fully aware of the potential risks and benefits and are able to make informed choices.

Notes

1. Paper presented by Nihal Amerasinghe, Director, Agriculture and Social Sectors Department (East), Asian Development Bank. The paper is based on a Staff Working Paper prepared in January 2001 (ADB, 2001*b*).

2. The primary responsibility for finding solutions to poverty lies with countries themselves, but success will depend on the united efforts of governments and civil society, and on strong and sustained support from the international community. To redouble its efforts in reducing poverty in Asia, the Asian Development Bank (ADB) launched its new strategy in November 1999. The ADB sees the twin pillars of pro–poor sustainable economic growth and social development as the key elements in any framework for reducing poverty. Successful achievement of either element requires sound macroeconomic management and good governance, the third pillar. Together, the three pillars result in socially inclusive development (ADB, 1999).

3. Medium–variant projection.

Bibliography

ADB (2001*a*), *Water for All: The Water Policy of the Asian Development Bank*, ADB, Manila.

ADB (2001*b*), "Agriculture Biotechnology, Poverty Reduction and Food Security", Staff Working Paper, ADB, Manila.

ADB (2000), *Rural Asia: Beyond the Green Revolution*, ADB, Manila.

ADB (1999), *Fighting Poverty in Asia and the Pacific: The Poverty Reduction Strategy of the Asian Development Bank*, ADB, Manila.

Carter, J. (1997), "Forestalling Famine with Biotechnology", *The Washington Times*, 11 July.

Doyle, J.J. and G.J. Persley (1996), *Enabling the Safe Use of Biotechnology: Principles and Practice*, Environmentally Sustainable Development Studies and Monograph Series No. 10, World Bank, Washington, D.C.

FAO – Food and Agriculture Organisation (2001), FAO Committee on Food Security, CFS: 2001/Int. 7, 2001, Rome, March.

FAO (1999), *The State of Food Insecurity in the World*, FAO, Rome.

FAO (1997), *The State of Food and Agriculture 1997*, FAO, Rome.

FAO (1995), *Agricultural Biotechnology in the Developing World*, FAO Research and Technology Paper No. 6, FAO, Rome.

International Food Policy Research Institute (IFPRI) (1997), *The World Food Situation: Recent Developments, Emerging Issues, and Long–Term Prospects*, IFPRI, Washington, D.C.

James, C. (2000), *Global Review of Commercial Transgenic Crops in 2000*. ISAAA Briefs No. 21, International Service for the Acquisition of Agricultural Biotech Applications, Ithaca, NY.

James, C. (1998), *Global Review of Commercialized Transgenic Crops in 1998*, ISAA Briefs No. 8, International Service for Acquisition of Agricultural Biotech Applications, Ithaca, NY.

Krattiger, A.F. (2000), "Food Biotechnology: Promising Havoc or Hope for the Poor?", *Proteus, A Journal of Ideas*, 17:3–8.

McCalla, A.F. (1998), *The Challenge of Food Security in the 21st Century*. Convocation Address, Faculty of Environmental Sciences, McGill University, Montreal, Quebec, 5 June.

McCalla, A.F. and L.R. Brown (2000), "Feeding the Developing World in the Next Millenium: A Question of Science?", *in* G.J. Persley and M.M. Lantin (eds.), *Agricultural Biotechnology and the Poor: Proceedings of an International Conference on Biotechnology*, Washington, D.C., 21–22 October 1999, Consultative Group on International Agricultural Research, Washington, D.C.

Persley, G.J. (1990), *Beyond Mendel's Garden: Biotechnology in the Service of World Agriculture,* CAB International, Wallingford, UK.

Persley, G. J. and M.M. Lantin (eds.) (2000), *Agricultural Biotechnology and the Poor: Proceedings of an International Conference on Biotechnology*, Washington, D.C., 21–22 October 1999, Consultative Group on International Agricultural Research, Washington, D.C.

Pingali, P.L., M. Hussein and R.V. Gerpacio (1997), *Asian Rice Bowl: The Returning Crisis*, CAB International and International Rice Research Institute, Wallingford, UK.

Pinstrup–Andersen, P. and M.J. Cohen (2000), "Modern Biotechnology for Food and Agriculture: Risks and Opportunities for the Poor", *in* G.J. Persley and M.M. Lantin (eds.), *Agricultural Biotechnology and the Poor: Proceedings of an International Conference on Biotechnology*, Washington, D.C., 21–22 October 1999, Consultative Group on International Agricultural Research, Washington, D.C.

Pinstrup–Andersen, P., R. Pandya–Lorch and M.W. Rosegrant (1999), *World Food Prospects: Critical Issues for the Early Twenty–First Century*, International Food Policy Research Institute (IFPRI), Washington, D.C.

Skerrit, J.H. (2000), "Genetically Modified Plants: Developing Conflicts and Public Acceptance Debate", *Ag Biotech Net 2* (ABN 040): 1–8.

Smith, L. and L. Haddad (2000), "Overcoming Child Malnutrition in Developing Countries: Past Achievements and Future Choices", *2020 Vision Discussion Paper* 30. International Food Policy Research Institute (IFPRI), Washington, D.C.

United Nations (1999), *World Population Prospects,* DESA, Population Division, New York.

Wolfenbargen, L.L. and P.R. Phifer (2000), "The Ecological Risks and Benefits of Genetically Engineered Plants", *Science*, 1:208–212.

World Bank (2000), *World Development Report 2000/2001, Attacking Poverty*, World Bank, Washington, D.C.

Information and Communication Technology in Developing Countries of Asia[1]

Brahm Prakash[2]

This paper reviews the development of information and communication technology (ICT) in the recent past and focuses on the pattern of its growth in Asian countries[3]. It tries to assess ICT's development potential for developing countries of the region where the bulk of the world's poor reside and to capture some of the challenges ICT now faces there.

Growth and Impact of the ICT Industry

Developments in ICT have changed the way economic activities are organised. The impact can be traced in two ways: first, how the ICT industry itself has changed during the last few years, and, second, how ICT has impacted on other economic activities such as manufacturing and services.

The ICT Industry

The beginnings of the ICT industry trace to the birth of the internet in the late 1960s and the appearance of the personal computer (PC) in the 1970s. Its development as currently understood actually picked up momentum in the early 1990s, however, when, assisted by communication technology, the PC and web–based technology joined to emerge as a powerful tool for business and development. Since then, ICT has integrated computing, communications and graphics through digitalisation. It has thrived on web sites with the use of broadband optical–fibre lines. It has already made headway into the wireless mode and is becoming more and more personalised with greater use of personal digital aides (PDA). The pace of technological change has accelerated, driven by both hardware and software innovations (Gates, 1996). There is no reason to believe that we have come to the end of this process. Indeed, the changes are so deep–seated that we are not even fully aware of their full implications.

Qualitatively, an important change made possible by ICT is the further separation of product development from the production process (Ernst and Guerrieri, 1998). This is not entirely new; it began with the basic reorganisation of work with the division of labour (Smith, 1776). The Industrial Revolution accelerated it by imparting greater efficiency and productivity under the factory system[4]. ICT has further refined traditional production methods by shifting more value added to product development than to production itself (Talluri *et al.*, 1999). It pays much more to plan the product, design it, establish logistics for its manufacture, monitor its quality and manage the brand image than actually to produce it. ICT has accelerated this process beyond recognition and shortened the product–development period so much that it now is virtually "concurrent engineering". Network externalities have been the principal conduit through which ICT has brought about this transformation (Katz and Shapiro, 1985). The process has yielded the well–known economies of scale (large inputs of resources generating proportionately larger outputs) as well as economies of scope (manufacturing different products by deploying common resources). The linear production system of sequential steps has been rearranged such that different parts get outsourced to different places, often thousands of miles away in different countries, and transported to an assembly point for just–in–time delivery. This process is known as supply–chain management (SCM). Final assembly often responds to customer–demanded configurations.

The SCM process has totally altered the production dynamics in the ICT industry. Generally, the emphasis on product development has increased in relation to actual production. Within the production cycle, value added has shifted more to specific parts that contain greater technical complexity, like chips and software, as opposed to the assembly of the whole product — the so–called "Wintel" effect (Borrus and Zysman, 1997). This contrasts with industries in which whole products or brands carry the value addition, e.g. automobiles or wristwatches.

The complexities of this outsourced production system — computer–aided–design (CAD) and computer–aided–management (CAM), product design, specification and material content and movement through time and space — are all co–ordinated by a closely monitored information system. The logistics of this manufacturing system, impossible without ICT, have emerged as a task in itself, known as electronic manufacturing services (EMS). EMS involves a group of specialised companies whose scope includes order receiving, material procurement, SCM, design and prototype production or testing, and management of the distribution of finished goods (Ohki, 2001). These changes have altered the traditional roles of original equipment manufacturers (OEM), original design manufacturers (ODM) and contract manufacturers. Many mature industries now comprise low value–adding processes.

These qualitative changes have spread beyond isolated cases to become the norm in the entire ICT industry and especially the PC industry. The full scale of their impact appears more vividly with a view of the rate at which ICT has grown in recent years.

Global ICT Growth

Data on the growth of the ICT industry worldwide are provided in the Appendix. Table 1 gives selected highlights for Asia–Pacific sub–regions and country groupings. The data show the IT sector on an upward trend for all the countries and all the sub–regions surveyed, although its growth has been highly uneven. The Newly Industrialised Economies (NIEs) have 287 PCs for every 1 000 persons; almost 30 per cent of their combined population has access to PCs. The sub–regions of Southeast Asia and South Asia, and the People's Republic of China (PRC), lie far behind the more digitalised economies, attaining less than one–tenth of the PC penetration in the NIEs. The same holds for the measures of internet hosts and users. These numbers are alarming, especially for the Pacific sub–region, the PRC and South Asia, where not even one internet host per 10 000 persons is available. In terms of internet users, not even one per cent of the population of the Pacific sub–region uses the internet and only a little above one per cent of South Asia's population does so. This indicates limited outreach and how a large proportion of the population cannot take advantage of ICT, making it hard for the digitally backward and developing economies to catch up.

Table 1. **Selected IT Indicators**

	Personal Computers per 1 000 people 1997-2000	Per 10 000 people	
		Internet Hosts 1998-2000	Internet Users 1998-2000
Newly Industrialised Economies	287	190.6	1 820
People's Republic of China	11	0.4	88
Southeast Asia	25	7.2	227
South Asia	3	0.2	11
Central Asian Republics	n.a.	4.6	25
The Pacific	n.a.	0.6	3
Industrial Countries	375	1 113.6	2 578

Notes: The following countries were included for the computation of the sub-regional averages: *a) Newly Industrialised Economies*: Hong Kong, China, Republic of Korea, Singapore and Taipei,China (only for the data on Internet Users); *b) Southeast Asia*: Indonesia, Malaysia, Philippines, Thailand and Viet Nam; *c) South Asia*: Bangladesh, India and Pakistan; *d) Central Asian Republics* (CARs): Kazakhstan and Kyrgyz Republic; *e) The Pacific*: Papua New Guinea; and *f) Industrial Countries*: Japan and the United States.

Sources: World Bank, *World Development Report* (various years) and *World Development Indicators* database; ITU Telecommunication Indicators from website (www.itu.int/ti/industryoverview/index.htm).

Impact of ICT on Other Industries and Services

ICT is a general–purpose technology and thus has wide applicability in various manufacturing and services sectors. It has strong spread effects and extensive linkages with the rest of the economy. Its potential forward linkages extend to custom–made configuration while its backward linkages extend to material sciences. It thus has the potential to affect virtually all sectors of the economy by imbuing greater information and development content in products and processes. More importantly, it has spawned new products and made existing products more versatile. One can argue that it is this use of ICT in other larger sectors of the economy that determines its overall productivity impact (Kraemer and Dedrick, 2001). CAD/CAM applications and SCM systems initially developed for ICT are now permeating other industries. Product development time has been drastically reduced, sometimes by as much as two–thirds. Once developed, product components can be manufactured virtually anywhere. This results in at least two basic changes. It facilitates the process of disintermediation and SCM, with attendant implications for inventory management, etc. It also liberates the production process from spatial constraints and enables the production of different components in different regions, which in turn speeds up the process of globalisation (ADB, 2001).

Given the pace of changes in the industry and the rush to catch up, "first movers" gain tremendous benefits. This works as a major incentive to innovate, keep others out and stay ahead of the pack. On the other hand, as products mature, their production gets relocated to low–cost areas open to competition.

Given easier access to information and its processing, the market as an institution becomes more competitive and efficient. An important source of market failure, lack of information, begins to weaken. As a result, new forms of economic activity have emerged, e.g. business–to–business (B2B) and business–to–consumer (B2C) transactions. The entire field of e–commerce is changing the traditional form of market organisation. All these processes contribute to reducing resource intensity and production costs.

An important implication is that those not capable of taking advantage of ICT, or not keeping pace with the unfolding changes, are in danger of being left behind. As the frontier shifts forward and leaders pull ahead, the entire field of slower competitors is left behind. ICT in this sense has emerged to become yet another factor dividing the developed and developing countries.

ICT Development in Asia

The Asian and Pacific economies have played an important and active role in the development of ICT worldwide, especially in the PC industry. In a succession of waves, the industry has spread fairly widely throughout much of developing Asia. The surge began in Japan, the Republic of Korea and Taipei,China, which have been among the leaders. These economies have made significant contributions to the global supply of ICT products and components. Hong Kong, the People's Republic of China and Singapore have added further to the spread of ICT in the region and the world through their contributions in trading and manufacturing. Subsequently Malaysia, the Philippines and Thailand have joined through manufacturing and packaging.

During the last two to three years (rather long for the ICT industry), the large economies of the PRC and India have joined in ICT development. The PRC is poised to emerge as a major production hub for ICT products in the coming years, while India contributes through software development for overseas firms, especially those in the United States.

The cumulative effect of these developments has been tremendous growth in the whole range of ICT–related economic activities in Asian economies, *viz.* manufacturing, packaging, exports and services related to ICT. E–commerce, both B2B and B2C, has increased manyfold. Asian countries have been among the principal suppliers of ICT products to the United States and the rest of the world. Indeed, the growth of electronics exports from Asian countries has been so large that they have become excessively dependent on them. With the slowdown in the US economy, especially in the technology sector, fears have arisen that the growth prospects of Asian economies are being impacted adversely.

Singapore

Notwithstanding the general spread of ICT in developing Asian countries, many inter–country differences mask distinctive national features. Singapore, "the intelligent island", is one of the most developed countries in the world. It has made a systematic effort since the early 1980s to adopt and use ICT innovations. Its ICT infrastructure is well established, and skills and educational standards are very high — as is its use of PCs and the internet. The number of PCs per 1 000 persons increased from 332 in 1997 to 483 in 2000, an annual growth rate of more than 13 per cent. Similarly, the numbers of internet hosts and users jumped between 1998 and 2000 by about 250 per cent and 26 per cent, respectively. The percentage share of ICT–related goods (SITC 75–77) in total exports reached the high 50s during the late 1990s.

Its style and efficacy of corporate governance make Singapore an attractive regional centre for Western as well as Asian corporations. It uses networks (e.g. Enet and TradeNet) for promoting trade and supply–chain management. As a result, Singapore has been able to blend a full range of market institutions with its keen interest in ICT and has emerged as a major manufacturing and commercial hub for high–end ICT products. The country is currently pursuing a new development plan known as the ICT21 Masterplan, which, among other things, addresses the following: full liberalisation of the telecommunication industry; information and communication industry development; improving outreach; human–resource development; promoting e–government; and developing the private sector. Given Singapore's significance as a regional hub, the medium–term future of ICT there will be greatly affected by the full economic recovery of the crisis–affected economies of the region.

Malaysia

Malaysia is a prominent centre of ICT manufacturing, and electronics constitute a big share of its total exports. Exports of ICT–related goods (SITC 75–77) take about 50 per cent of its total exports. The government attaches high priority to ICT. Unlike Singapore, Malaysia is large geographically. The government's approach has been to focus on the development of a pre–selected area known as the multimedia super corridor. Within it, cyber cities are being developed to function as nodal points for ICT development. With 105 PCs per 1 000 persons and about 1 500 internet users per 10 000 persons, its current level of ICT penetration is somewhat limited. Much of ICT use tends to concentrate in export–related economic activities. The ongoing slowdown of the US economy has temporarily dampened ICT growth, but the commitment of the government to promote ICT use remains strong.

Thailand

In comparison with Singapore and Malaysia, Thailand has a relatively less–developed ICT sector, especially outside the urban metropolis of Bangkok. With 24 PCs per 1 000 persons and 266 internet users per 10 000 persons, the use of PCs and internet access are available to only a small segment of society. Aspirations for ICT development are high however, and the country produces significant amounts of PC components. The Government has launched the development of Phuket as Thailand's cyber island. That the economy is still to recover fully from the 1997 Asian economic crisis constrains further ICT development to some extent, and inadequate numbers of high–level scientific and technical personnel also hamper progress.

Philippines

The ICT industry has a significant presence in the Philippines. Many of the ICT–related manufacturing activities are relocated production facilities of Japanese firms. SITC 75–77 goods constitute a huge part of Philippine exports (69 per cent of total exports in 1998), and most of these go to the United States. The country has abundant educated and skilled personnel, but their potential has not been fully used for ICT development. There are 20 PCs per 1 000 persons and about 265 internet users per 10 000. The availability of ICT–related infrastructure is limited and confined to Metro Manila and its neighbourhood.

People's Republic of China

The PRC started slowly in ICT but during the last five years has picked up a tremendous pace. There are 16 PCs per 1 000 persons and about the same number of internet users. The PRC is now poised to emerge as one of the largest manufacturers of ICT products in the region. Much of the ICT investment comes from Taipei,China as relocated production facilities. SITC 75–77 goods constitute about 20 per cent of total exports. Although the PRC's major strength has resided largely in manufacturing, expectations are that it will soon start competing in the software industry. In the medium term, the PRC is expected to start impacting the world software market much as it presently does in ICT manufacturing.

India

India's entry into ICT and its role in the sector differ from the other Asian countries. From the early 1950s, India laid emphasis on training high–level scientific and technical personnel across a broad range of subjects. When the PC made its entry and the declining prices of hardware made access to computing possible for educated professionals, a window of opportunity opened for the growth of the software industry. Highly trained scientific and technical personnel from India had been steadily migrating to the United States throughout the 1960s and 1970s, and many of them were engaged in the development of computers, computer science and the communications industry. Their presence in the ICT industry, especially among the top professionals in the United States, worked as a shot in the arm. They provided high–level skills in bulk and led the industry to India, especially during the 1990s when it was growing fast. The Indian software industry discovered a reservoir of scientific and technical personnel at competitive prices to feed its rapid growth.

In the initial stages, India only supplied qualified personnel to do jobs on site. With the maturity of its software industry, the situation began to change, however. Several Indian firms were set up to supply software. Major ICT producers soon realised that the potential of the technical know–how available could be tapped more effectively by setting up subsidiary software centres in India. Texas Instruments, encouraged by its own Indian employees in the United States, established its first major centre in India in the early 1980s. India in 2000 accounted for about 20 per cent of the world custom–software market (estimated at about $500 billion). Almost all the major software producers in the world have a presence in the country, and Indian professionals work in the industry worldwide, especially in the United States. Some 40 per cent of the Fortune 500 corporations are clients of the Indian software industry (Giovanetti *et al.*, 2001).

In terms of the industry benchmark standard, more than 25 per cent of the Indian firms engaged in this business meet the requirements of ISO 9000. Of the 19 companies worldwide that have CMM–5 level capability (capability maturity model), 12 are Indian firms (Giovanetti *et. al*., 2001). That this standard is available at much lower prices (ranging from less than one–tenth to about one–third of US price levels), makes the Indian software industry very competitive. The value of software exports now exceeds $4 billion per annum. Yet there are also downsides that hamper Indian ICT growth. The limited nature of the country's telecom infrastructure underlies weak PC and internet penetration. India has only 5 PCs per 1 000 persons and 50 internet users per 10 000.

Challenge for ICT in Developing Asia

In addition to the major countries treated separately above, ICT development has also taken place in countries like Indonesia, Sri Lanka, and Viet Nam. Generally, healthy growth of ICT in Asian developing countries was much in evidence up to the first half of 2000. Yet some challenges have surfaced since then.

Economic Environment

Fuelled by the expansion of ICT, the US economy grew beyond its long–term potential through much of the 1990s, and economists became concerned about this unprecedented growth. Apprehending that it could not continue indefinitely, policymakers sought to ensure a soft landing for the economy[5]. Oil price hikes in the third quarter of 2000 also emerged as an additional constraint. The Federal Reserve repeatedly increased interest rates to slow the economy gradually, but when the economy responded in the fourth quarter of 2000, it slowed faster than expected. GDP growth in that quarter and the revised figures for the first quarter of 2001 showed an unexpected, sharp decline (ADB, 2001).

An equally strong performance of high–technology stocks worldwide accompanied exceptionally high long–run US growth. By mid–June 2000 the corrective process had set in. Since then the US stock market has gone through huge corrections and the leading technology stocks are currently at about one–third of their peak values. The long–term implications of the current scenario are not clear, although by some accounts the slowdown has already been longer than anticipated. Much depends upon how soon the US economy, which is also the leading ICT user in the world, turns around. The sudden slowdown caused ICT inventories to build up, although it seems that they are now being gradually brought down. Corporate profits of many ICT firms declined in 2000, which is likely to squeeze out fresh investments for the moment, especially for capital goods. Consumer spending in the US has somehow continued to be more robust than expected.

The recent issue of the IMF's *World Economic Outlook* (IMF, 2001*a*) reviews the impact of global technology corrections on the real economy. In an empirical exercise, it measures the effect of changes in stock–market valuations on consumption through the wealth effect and on investment through the cost of capital. It reports that an increase of one US dollar in technology stocks raises consumption by four per cent. Similar results are obtained for investment through a virtuous cycle of rising investment in ICT leading to higher productivity, hence higher stock prices and increased access to funding for new economic activities. It concludes that the downturn in stock prices will correspondingly dampen investment in ICT.

The results do not seem to be significant for Asia however (IMF, 2001*a*). One possible reason could be that the exercise focuses on the valuation of publicly listed stocks and not on the value of ICT production. Moreover, it does not include private manufacturers that are a significant part of the Asian ICT production system. That the recovery of the Japanese economy continues to be fragile does not help much to improve the prospects for Asian economies. Combined with the slowing of the US economy, it puts a lot of pressure on their immediate and short–run outlook. Apart from being the second largest economy of the world, Japan has a pivotal role in the ICT industry. Hence, the performance of the Japanese economy has special significance for ICT in general and on the development of ICT in Asian countries in particular. The prospects of a Japanese turnaround do not yet seem very encouraging, although there are high expectations from the new government.

Asia's Dependence on Electronic Exports

To the extent that technology stocks around the world tend to move together because of their inter–linkages and inter–dependence, technology stocks in developing countries too are now at lower levels. Given that the share of electronics in total exports of many East Asian countries varies from about one–third in Korea to about two–thirds for the Philippines and Malaysia, the US economic slowdown has affected their exports and overall GDP growth. This is certainly slowing demand for ICT goods and services, although the precise extent is not clear. India, for example, has adjusted the growth rate of its software exports from 60 per cent to about 40 per cent, a decline of one–third, and more recently from 40 per cent to 25 per cent. Similarly, ICT manufacturing countries are also expected to downgrade their growth rates anywhere from about one–third to about half of the earlier targets.

Another feature likely to affect ICT in Asia relates to the emergence of the PRC as the major producer of ICT goods. This might lead to greater competition for Southeast Asian countries. The immediate task of these economies is to cope with the slowdown of the US economy, but the medium–term risk, and the relatively more important one, is to adjust to the emergence of the PRC as a major ICT producer and competitor. That structural reforms are proceeding more slowly than expected in some of the East Asian countries, namely Indonesia, the Philippines and Thailand, could make things worse. Similarly, the presence of unresolved domestic political issues and policy emphases in Indonesia, the Philippines and Thailand may further thwart the return of investor confidence in these economies.

Potential of ICT within Asia

Asian countries have played an important role in the development of ICT. This sector is a powerful instrument of development and could be used to push them to a higher growth trajectory for years to come. Although the ICT industry in Asia has grown rapidly and performed as a tremendous source of supply for the rest of the world, its potential scope for further growth within the region is almost open–ended.

Many countries have been left out of the ICT revolution, and even among those that have done well, huge pockets of population remain outside the ambit of ICT. In the poorer countries of Asia, better access to ICT faces multiple challenges. In the absence of specific efforts to bridge the gap, prospects for economic development in these communities will be dim. The bottom line is that the poorer populations and inadequately equipped areas tend to lie beyond the reach of ICT. Hence, there is room for public policies to level the playing field. In the extreme case of the least–developed regions, ICT hardly has any role in the development process in the absence of basic services like water, health, literacy and housing. The debate revolves around whether ICT renders development of such regions more or less difficult. Given that Asia accounts for more than half of the world population and has as many as 900 milion living on less than one dollar a day, the issue has much significance.

This problem is popularly known as the *digital divide*. National and international policymakers have recognised and acknowledged the challenge of this negative fall–out effect of ICT. The G–8 group deliberated on the digital divide at its Okinawa Summit in 2000 (www.jetro.org/newyork/focusnewsletter/focus9.html). It set up a taskforce (Dot Force) to develop a plan to support the future development of ICT in the poorer countries, and Japan has earmarked a fund of $15 billion for the purpose[6].

Amidst the present global economic slowdown and uncertain prospects, one wonders whether the funds earmarked at the Okinawa Summit can be effectively deployed and provide the requisite shot in the arm for the ICT industry. Can we take advantage of Asia as the "world manufacturing centre of ICT"? (Ueki, 2001) Can the resources earmarked in Okinawa help developing countries ride out of the US slowdown without undue damage? These questions are significant because, although Asia has gained from the production of ICT hardware, it has generally not made much use of ICT to boost productivity (Kraemer and Dedrick, 2001).

Policy Requirements

Both domestic and regional policies are needed to ensure greater application of ICT within Asian economies, especially in the poorer and inadequately serviced regions. Given that different countries of the region have expertise in different parts of this new technology, greater application of ICT provides an opportunity for greater economic co–operation within Asia. The important question is to what extent the domestic demand for ICT products and services in the region can sustain the momentum.

The most basic problems and challenges that public policymakers must address to enhance IT diffusion and development are the lack of financial resources for large–scale IT–related projects, the maintenance of a stable macroeconomic environment and the adoption of appropriate sector policies to speed the creation of necessary infrastructure (ADB, 2000). The need for the continuous development of IT is highly relevant in this ever–changing technological world. The challenge of forging ahead, or at least catching up with the leaders, is important. Four sets of policies are important to ensure that the developing countries of Asia will not be left behind (ADB, 2000). First, stronger higher education in science and mathematics should follow basic education in science and technology. This will create a pool of highly qualified and skilled IT professionals that will serve as foundation for the region's or a country's IT sector. Second, it is important to promote R&D within each country and in the region as a whole. Third, protection of intellectual property rights is another important prerequisite for development. It must be implemented well to encourage further inventions and innovations. Finally, standardisation, regulation, and quality assurance must be imposed. These factors will keep competition in place.

Stronger economies like Korea and Taipei,China as well as Hong Kong, the PRC and Singapore, which have strong research and development bases and are regional hubs for exports, have a greater potential for moving up the value chain. The ASEAN countries, however, will have to strengthen their research and development, infrastructure and investments in human resources to stay in competition (Ueki, 2001).

Concluding Observations

This brief paper introduces the development of ICT in Asia. It describes certain features of the industry, especially the way organisational arrangements of ICT have evolved. Two particular points are noted — first, the value–chain pattern focused on individual components or parts of a PC and, second, the growing separation of product development from production processes. Led by Japan, the Republic of Korea and Taipei,China, Asian countries have contributed substantially to the way ICT has spread around the world, especially in relation to the division of labour, specialisation and mass production techniques. Malaysia, Thailand, and the Philippines have played an important role in furthering this process. India has contributed predominantly to the global software industry. The PRC is now emerging as the major hub for production of ICT hardware and is expected soon to make significant inroads into the software industry. In this sense, ICT has enabled many Asian countries to take up new technologies.

Nevertheless, even bigger chunks of population live beyond the reach of ICT in Asia due to lack of infrastructure, low levels of human–resource development and paucity of resources. So far, Asian countries have developed ICT for export markets. They have not used it extensively in the cause of rapid economic development and poverty reduction through higher levels of productivity. They have yet to fulfil the real potential of ICT.

It remains in question whether the current slowdown in technology stocks and consequent lower demand in the leading export markets will provide an opportunity to view the vast hinterlands of Asia as potential grounds for expansion of ICT. The resolution of the G–8 Okinawa Summit and Japan's commitment of financial resources for bridging the digital divide could hold some hopes. Can Asian countries get together and harness their internally available technology for the next round of development and poverty reduction?

Notes

1. This paper is a sequel to the special chapter on "IT and Development: Prospects and Policies" in the *Asian Development Outlook 2000 Update* (ADB, 2000). Technical assistance of Archimedes Gatchalian is gratefully acknowledged. The author is thankful to Rajah Rasiah, Patrick Safran and Jean–Pierre Verbiest for assistance and helpful comments on the earlier draft.

2. Assistant Chief Economist, Economic Analysis and Research Division, Economics and Development Resource Center, Asian Development Bank, Manila, Philippines. The views and opinion expressed in the paper are those of the author and do not necessarily represent those of the Asian Development Bank.

3. The paper has benefited in a large measure from the recent work on the subject edited by Kagami and Tsuji (2001).

4. Becker and Murphy (1993) make an interesting point in this regard. They point out that co–ordination costs determine the extent of the division of labour and specialisation. In view of the modern production techniques spurred on by ICT, this point assumes even greater significance than they perhaps originally intended.

5. Predictions (possibly also preparations) for a soft landing of the US economy have been around for many years (see, for example, various issues of the IMF's *World Economic Outlook*).

6. For a discussion of official development assistance in the context of ICT (so–called eODA) and illustrative initiatives to close the digital divide, see Shinohara (2000) and the World Economic Forum at www.weforum.org/digitaldivide.

Appendix

Table A1. **IT Indicators in Selected Countries: Telephones**

	Per 1 000 people									
	Telephone main lines					Mobile telephones				
	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
Newly Industrialised Economies										
Hong Kong, China	547	556	561	576	581	216	343	475	636	636
Korea, Republic of	430	444	433	438	464	70	150	302	500	567
Singapore	433	451	460	482	485	141	273	346	419	684
Taipei,China	465	500	524	545	568	45	69	216	522	803
People's Republic of China	44	56	70	86	86	6	10	19	34	67
Southeast Asia										
Indonesia	21	25	27	29	31	3	5	5	11	17
Malaysia	178	195	202	203	211	74	113	99	137	155
Philippines	26	29	34	39	40	13	18	22	38	84
Thailand	70	80	84	86	86	28	33	32	38	44
Viet Nam	16	17	22	27	27	1	2	2	4	4
South Asia										
Bangladesh	3	3	3	3	3	0	0	1	1	1
India	15	19	22	27	32	0	1	1	2	4
Pakistan	18	20	21	22	22	0	1	1	2	2
Central Asian Republics										
Kazakhstan	116	110	109	108	108	0	1	2	3	3
Kyrgyz Republic	75	76	76	76	76	n.a.	0	0	1	1
The Pacific										
Papua New Guinea	11	13	13	13	13	1	1	1	2	2
Industrial Countries										
Japan	509	521	534	558	558	214	304	374	449	526
United States	622	644	661	664	673	165	206	256	312	400

Sources: World Bank, *World Development Report* (various years), World Development Indicators database, and ITU Telecommunication Indicators, website (www.itu.int/ti/industryoverview/index.htm)

Table A2. **IT Indicators in Selected Countries: PCs and Internet Penetration**

	Per 1 000 people				Per 10 000 people					
	Personal computers				Internet Hosts			Internet Users		
	1997	1998	1999	2000	1998	1999	2000	1998	1999	2000
Newly Industrialised Economies										
Hong Kong, China	229	256	291	347	123.78	166.89	336.90	1 495	2 519	3 359
Korea, Republic of	151	169	183	190	40.15	60.99	84.10	668	1 468	4 025
Singapore	332	375	437	483	140.76	269.75	492.30	2 371	2 946	2 987
Taipei,China	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1 373	2 051	2 813
People's Republic of China	6	9	12	16	0.14	0.57	0.55	17	70	176
Southeast Asia										
Indonesia	8	8	9	10	0.75	1.01	1.26	15	19	68
Malaysia	46	60	69	105	22.00	27.03	29.34	368	687	1 505
Philippines	13	15	17	20	1.26	1.66	2.58	21	67	266
Thailand	20	22	23	24	3.40	6.60	10.47	33	67	266
Viet Nam	5	6	9	9	0.00	0.02	0.02	1	13	13
South Asia										
Bangladesh	0	1	1	1	0.00	0.00	0.00	0	2	4
India	2	3	3	5	0.13	0.23	0.35	5	20	49
Pakistan	4	4	4	4	0.24	0.35	0.46	5	6	6
Central Asian Republics										
Kazakhstan	n.a.	n.a.	n.a.	n.a.	0.90	2.31	4.55	12	43	43
Kyrgyz Republic	n.a.	n.a.	n.a.	n.a.	3.29	7.57	8.76	8	21	21
The Pacific										
Papua New Guinea	n.a.	n.a.	n.a.	n.a.	0.26	0.72	0.92	0	4	4
Industrial Countries										
Japan	202	238	287	315	133.41	208.41	365.65	1 323	1 447	3 044
United States	407	456	511	585	1 120.69	1 925.14	2 928.32	2 205	3 982	3 466

Sources: See Table A1.

Table A3. **Other Indicators of the Status of IT in Selected Countries**

	Per million people			High-technology exports % of mfg. exports			
	Scientists & engineers in R&D						
	1981-95	1985-95	1987-97	1996	1997	1998	1999
Newly Industrialised Economies							
Hong Kong, China	n.a.	98	n.a.	19	21	21	21
Korea, Republic of	2 636	2 636	2 193	24	27	27	32
Singapore	2 512	2 728	2 318	56	57	59	61
Taipei,China	n.a.	n.a.	3 532	n.a.	n.a.	n.a.	n.a.
People's Republic of China	537	350	454	12	13	16	17
Southeast Asia							
Indonesia	181	n.a.	182	9	12	10	10
Malaysia	87	87	93	44	49	55	59
Philippines	90	157	157	58	67	72	59
Thailand	173	119	103	29	31	34	32
Viet Nam	334	308	n.a.	n.a.	n.a.	n.a.	n.a.
South Asia							
Bangladesh	n.a.	n.a.	52	0	0	0	n.a.
India	151	149	149	7	7	6	n.a.
Pakistan	54	54	72	0	0	0	0
Central Asian Republics							
Kazakhstan	n.a.	n.a.	n.a.	n.a.	n.a.	8	n.a.
Kyrgyz Republic	n.a.	703	584	18	n.a.	n.a.	6
The Pacific							
Papua New Guinea	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Industrial Countries							
Japan	5 677	6 309	4 909	26	26	26	27
United States	3 732	3 732	3 676	32	32	34	35

Sources: See Table A1.

Table A4. **Total Office Machines and Telecom Equipment Trade in Per Cent of GDP, Selected Countries, 1996-99**

	1996	1997	1998	1999
Newly Industrialised Economies				
Hong Kong, China	49.41	49.74	48.94	51.58
Korea, Republic of	9.77	11.47	15.26	16.62
Singapore	119.30	115.97	114.18	120.76
Taipei,China	19.41	21.57	23.35	25.60
People's Republic of China	3.79	4.23	4.91	6.12
Southeast Asia				
Indonesia	2.42	2.43	3.30	n.a.
Malaysia	58.43	60.17	77.52	88.27
Philippines	23.36	32.20	46.96	45.60
Thailand	13.24	16.59	19.93	20.08
Industrial Countries				
Japan	2.98	3.25	2.23	3.11
United States	3.14	16.15	1.30	3.25

Notes: Total trade is defined as exports plus imports.

Sources: WTO (2000) and IMF, (2001*b*) *International Financial Statistics* CD-ROM 2001

Table A5. **Exports of Office Machines and Telecom Equipment in Per Cent of GDP, Selected Countries, 1996-99**

	1996	1997	1998	1999
Newly Industrialised Economies				
Hong Kong, China	22.44	22.01	22.51	24.18
Korea, Republic of	6.13	7.11	10.04	10.55
Singapore	70.62	68.08	69.37	71.13
Taipei,China	12.70	13.79	14.46	15.63
People's Republic of China	2.09	2.38	2.63	3.04
Southeast Asia				
Indonesia	1.36	1.34	2.50	2.17
Malaysia	34.77	36.20	47.69	56.22
Philippines	12.14	17.25	28.44	30.12
Thailand	7.30	9.39	12.76	12.24
Industrial Countries				
Japan	2.04	2.26	2.23	2.10
United States	1.34	14.32	1.30	1.35

Sources: See Table A4.

Table A6. **Imports of Office Machines and Telecom Equipment in Per Cent of GDP, Selected Countries, 1996-99**

	1996	1997	1998	1999
Newly Industrialised Economies				
Hong Kong, China	26.97	27.73	26.44	27.41
Korea (Republic of)	3.65	4.36	5.23	6.08
Singapore	48.68	47.88	44.80	49.63
Taipei,China	6.71	7.78	8.89	9.98
People's Republic of China	1.70	1.85	2.29	3.08
Southeast Asia				
Indonesia	1.06	1.09	0.80	n.a.
Malaysia	23.66	23.98	29.82	32.05
Philippines	11.22	14.96	18.52	15.47
Thailand	5.94	7.21	7.17	7.85
Industrial Countries				
Japan	0.94	0.99	0.00	1.01
United States	1.80	1.83	0.00	1.90

Sources: See Table A4.

Table A7. **Exports of Office Machines and Telecom Equipment in Per Cent of Total World Merchandise Exports, Selected Countries, 1996-99**

	1996	1997	1998	1999
Newly Industrialised Economies				
Hong Kong, China	19.12	20.01	20.95	22.03
Korea, Republic of	24.57	24.87	24.05	29.65
Singapore	51.57	51.70	52.37	52.84
Taipei,China	30.68	33.05	34.95	37.07
People's Republic of China	11.39	11.75	13.80	15.44
Southeast Asia				
Indonesia	6.20	5.41	4.82	6.12
Malaysia	44.69	46.12	47.22	52.42
Philippines	49.27	56.68	63.14	63.00
Thailand	23.82	24.66	26.27	26.07
Industrial Countries				
Japan	22.86	22.58	21.92	22.30
United States	16.74	172.62	16.69	18.08

Source: See Table A4.

Table A8. **Imports of Office Machines and Telecom Equipment in Per Cent of Total World Merchandise Imports, Selected Countries, 1996-99**

	1996	1997	1998	1999
Newly Industrialised Economies				
Hong Kong, China	20.66	22.24	23.04	24.10
Korea, Republic of	12.61	14.37	17.77	20.65
Singapore	33.84	34.32	36.62	38.07
Taipei,China	18.53	19.82	22.64	26.00
People's Republic of China	10.04	11.74	15.71	18.39
Southeast Asia				
Indonesia	5.60	5.63	2.75	n.a.
Malaysia	30.38	30.43	37.11	38.84
Philippines	27.24	31.85	38.45	36.44
Thailand	14.94	17.28	18.70	19.40
Industrial Countries				
Japan	12.42	12.37	13.03	14.15
United States	17.11	16.88	16.51	16.70

Source: WTO (2000).

Table A9. **Growth Rates of SITC 75-77 Exports by Sub-Region**
(Per cent per year)

	SITC				Year Range
	75	76	77	75-77	
Newly Industrialised Economies	6.6	-28.4	-8.0	-9.0	1995-1998
People's Republic of China	123.4	19.7	38.4	49.4	1995-1998
Southeast Asia	78.1	-34.1	46.7	24.6	1995-1998
South Asia	0.5	-21.0	5.2	-0.7	1995-1997
Central Asian Republics	0.0	400.0	31.3	46.7	1995-1996
Industrial Countries	-2.6	-3.7	-8.0	-5.6	1995-1998

Note: The following countries comprise the various regions in the estimation of growth rates: *NIEs:* Hong Kong, China, Republic of Korea and Singapore; *Southeast Asia:* Indonesia, Malaysia, and Philippines; *South Asia:* India; *Central Asian Republics:* Kyrgyzstan; and *Industrial Countries:* Japan and the United States.

Sources: IMF (1998) and IMF (2000).

Table A10. **Growth Rates of SITC 75-77 Imports by Sub-Region**
(Per cent per year)

	SITC				Year Range
	75	76	77	75-77	
Newly Industrialised Economies	2.2	-31.0	-11.8	-13.7	1995-1998
People's Republic of China	86.8	-7.0	55.0	36.1	1995-1998
Southeast Asia	53.7	-51.5	7.4	1.7	1995-1998
South Asia	31.1	-7.1	-9.4	-1.5	1995-1997
Central Asian Republics	172.0	186.5	292.2	258.3	1995-1996
Industrial Countries	11.5	10.9	-2.3	5.3	1995-1998

Note: For the country composition of the various regions, see note to Table A9.

Sources: See Table A9.

Bibliography

ADB (2001), *Asian Development Outlook 2001,* ADB, Manila.

ADB (2000), *Asian Development Outlook 2000 Update,* ADB, Manila.

Becker, Gary S. and Kevin M. Murphy (1993), "The Division of Labor, Coordination Costs, and Knowledge" *in* Gary S. Becker (ed.), *Human Capital – A Theoretical and Empirical Analysis, with Special Reference to Education*, 3rd edition, University of Chicago Press, Chicago.

Borrus, M. and J. Zysman (1997), "Globalization with Borders: The Rise of Wintelism as the Future of Global Competition" *Industry and Innovation,* 4(2) December .

Ernst, D. and P. Guerrieri (1998), "International Production Networks and Changing Trade Patterns in East Asia: The Case of the Electronics Industry", *Oxford Development Studies,* 26(2), June.

Gates, B. (1996), *The Road Ahead*, Penguin Books, London.

Giovannetti, E., P. Kuttuman and T. McDaniel (2001) "Summary of the UK Team", *in* Kagami, M. and M. Tsuji (eds.), cited below.

Government of Japan (2000), "Okinawa Charter on Global Information Society", Tokyo, July 22.

IMF (2001*a*), *The World Economic Outlook*, IMF, Washington, D.C., May, various issues for other years.

IMF (2001*b*), *International Financial Statistics*, CD–ROM, IMF, Washington, D.C.

IMF (2000), *International Financial Statistics*, IMF, Washington, D.C., January.

IMF (1998), *International Trade Statistics Yearbook*, IMF, Washington, D.C.

InfoDev (2000), "The Networking Revolution — Opportunities and Challenges for Developing Countries", Global Information and Communication Technologies Department, World Bank, Washington, D.C.

International Telecommunications Union (ITU) (2001), *Telecommunications Indicators,* ITU website www.itu.int/ti/industryoverview/index.htm.

International Trade Centre (1999), *Trade in Information Technology Products and the WTO Agreements — Current Situation and Views of Exporters in Developing Countries,* Geneva.

Japan External Trade Organization USA: www.jetro.org/newyork/focusnewsletter/focus9.html.

Kagami, M. and M. Tsuji (eds.) (2001), *The 'IT' Revolution and Developing Countries: Late–comer Advantage?*, Institute of Developing Economies, Japan External Trade Organization, Chiba (Japan).

Katz, M.L. and C. Shapiro (1985), "Network Externality, Competition and Compatibility", *American Economic Review,* Vol. 75.

Kraemer, K. and J. Dedrick (2001), "Information Technology in Southeast Asia: Engine of Growth or Digital Divide", Center for Research on Information Technology and Organizations, University of California, Irvine, California, processed.

Ohki, H. (2001), "International Division of Labor in East Asia's IT Industry", *in* Kagami and Tsuji (eds.), cited above.

Shinohara, T. (2000), "IT Revolution and eODA," *JBIC Review*, Japan Bank for International Cooperation, Tokyo, 3 December.

Smith, A. (1776), *The Wealth of Nations*, 1910 ed., Everyman's Library, London.

Talluri, S., R.C. Baker and J. Sarkis (1999), "A Framework for Designing Efficient Value Chain Networks", *International Journal of Production Economics*, 62(1–2), May.

Ueki, Yasushi (2001), "Electronics Industry in Asia: Changing Supply Chain and the Effects", *in* Kagami and Tsuji (eds.), cited above.

US Department of Commerce (2000), *Digital Economy 2000,* Washington, D.C.

World Bank (various years), *World Development Report*, World Bank, Washington, D.C.

World Economic Forum: www.weforum.org/digitaldivide.

World Trade Organisation (WTO) (2000), *International Trade Statistics Yearbook*, WTO, Geneva.

World Trade Organisation (WTO) (1998), *International Trade Statistics Yearbook*, WTO, Geneva.

Financing Information Technology Diffusion in Low–income Asian Developing Countries

Yun–Hwan Kim[1]

Introduction

How to adopt information technology (IT) successfully in low–income developing countries (LIDCs) is one of the most pressing current developmental issues. Since IT became commercial in the early 1990s, it has diffused rapidly in developed countries but generally slowly in developing ones. This led to a widening IT gap, the so–called *digital divide* between the two groups. The IT gap among developing countries is also increasing. The more advanced, such as the Newly Industrialised Economies (NIEs), Brazil, Chile, Estonia and Malaysia, have made enormous progress toward a digital economy, but many of the rest of the developing nations remain much more backward.

The world has an estimated 350 million internet users. Over 90 per cent of them are in industrial countries, although developing countries comprise about 85 per cent of the world population[2]. Further, while internet use is not limited to certain groups of individuals (in terms of ages and sexes) in industrial countries, the internet users in developing countries are mostly young, male, urban individuals in the middle and upper income groups. In LIDCs, IT has not been effectively adopted by many micro–enterprises, agro–industries, small traders, farming/livestock households, public offices, schools, health centres, etc., particularly in rural areas.

National economies are increasingly tightly tied together globally by ultra high–speed information networks. In these circumstances, problems created by the digital divide include a vicious cycle. Lack of IT leads to lower productivity growth, loss of business opportunities and lower incomes[3], which in turn impede use of the latest technologies, including IT. An individual (or a country) that lags behind finds it difficult to catch up with the state–of–art IT because of this vicious cycle and the rapid progress in IT. It is therefore essential to expedite the diffusion of IT in LIDCs. The access of low–income individuals to IT will enable them to participate more actively in the development process. This paper identifies the primary bottlenecks to IT in LIDCs and discusses how to mobilise their financial resources to deal with them.

Technology Revolutions, Information, and Growth

Revolutions in Technology

Although tremendous technological advances took place over the past 100 years in several sectors, such as transport, communications, electrification and medicine, recent ones are much more comprehensive and powerful. Their salient characteristics involve convergence and interaction of many strands of technological change, with social consequences far more profound and far more difficult to foresee. They fall into three basic categories or strings of technical changes: in materials, in biotechnology and in information (Hallberg and Bond, 2000). Research has discovered many new, innovative materials. Transport enjoys lighter materials for fuel efficiency; health care takes advantage of dynamic images and intelligent prosthetics; and the energy sector benefits from many new materials as well. Biotechnological advances dominate in health applications (therapeutics and diagnostics) and are spreading quickly to other areas. Marine biotechnology leads to better disease prevention and reproduction control of fish, while biotechnological applications in agriculture increase productivity, improve animal health and diversify products. Bioremediation technology in the environment field provides new methods for waste and water treatment, waste–site cleanup and forest restoration. The revolution in IT has itself been brought forth by a company of innovations in telecommunications and informatics, made possible by cheaper new lightweight materials (e.g. optical fibres) transmitting information faster. Information flows faster and less expensively throughout the globe, but it will take substantial time to reach full digitalisation given the youth of IT.

Information and Economic Growth

Among the three strings of technological advance, IT is much more powerful than the others in deciding the magnitude and quality of economic production. Information, together with capital and labour, is a critical, essential production factor. It is a major contributor to labour productivity and total factor productivity. An increase in information content has significantly changed the concept of production, signifying the importance of timely information flows. Firms failing to incorporate new information can be left behind in gaining productivity and competitiveness, given that the scope of the impact of new information technology is much broader than that of other technologies. While they impact on limited sectors, IT does so across the board. IT also significantly changes corporate behaviour and organisation structure, which should increase productivity (Brynjolfsson and Hitt, 2000).

Many of the early studies on the role of information technology in productivity, which generally used economy or sector data, found little evidence of significance. See, for example, Roach (1987), Berndt and Morrison (1995), and Morrison (1996).

Since the mid–1990s, however, analyses at the firm level have begun to find positive effects of information technology on firms' productivity. Using data from over 300 large firms for 1988–1992, Brynjolfsson and Hitt (1995, 1996) and Lichtenberg (1995) found a clear, positive relationship between firm–level IT investment and multifactor productivity, despite a great deal of individual variation in firms' success with information technology. Many other studies also suggest that information technology contributed to substantial increases in output and productivity (Greenan and Mairesse, 1996; Kelley, 1994; Muhkopadhyay *et al.*, 1997). Brynjolfsson and Hitt (2000) examined the mechanism for productivity gains. Jorgenson (2001) made an attempt to explain why the US real GDP rose at such a high annual rate of over four per cent in the second half of the 1990s, a remarkable step–up from about 2.4 per cent during the first six years of the decade. Both a rebound in the growth of average labour productivity (ALP) and labour hours drove the rapid growth. Table 1 shows this, along with a breakdown of contributions to ALP growth. Information technology was clearly a large contributor in 1995–99. IT capital contributed significantly to rapid capital deepening, and IT was a major factor in the growth of total factor productivity. The contribution of labour quality actually declined in the second half of the decade.

Table 1. **Sources of US Real GDP and Average Labour Productivity Growth, 1973–99**

(Average annual rates of growth, in per cent)

	1973-90	1990-95	1995-99
Gross domestic product	2.86	2.36	4.08
Hours worked	1.59	1.17	1.98
Average labour productivity	1.26	1.19	2.11
Contribution of capital deepening	0.79	0.64	1.24
Information technology	0.35	0.43	0.89
Non-Information technology	0.44	0.21	0.35
Contribution of labour quality	0.22	0.32	0.12
Total factor productivity	0.25	0.24	0.75
Information technology	0.19	0.25	0.50
Non-Information technology	0.06	-0.01	0.25

Source: Jorgenson (2001).

An important related development was the continuing sharp increase in the income shares of the IT–related sector (hardware, software, and communication equipment), which picked up from 3.3 per cent in 1974–90 to 5.3 per cent in 1991–95 and further to 6.3 per cent in 1996–99 (Table 2). The shares of other capital and labour hours, in contrast, fell continuously. These trends match the much higher growth rates of IT inputs to production than of inputs of other capital and labour hours. Hardware and software IT inputs grew by 35.9 per cent and 13.0 per cent, respectively, in 1996–99, compared with 2.8 per cent and 2.2 per cent for other capital and labour hours.

Table 2. **Income Shares of IT and Other Factors in US Non-farm Business Output, 1974–99**
(Per cent)

	1974-90	1991-95	1996-99
Information Technology	3.3	5.3	6.3
Hardware	1.0	1.4	1.8
Software	0.8	2.0	2.5
Communication equipment	1.5	1.9	2.0
Other capital	27.9	26.8	26.7
Labour hours	68.9	67.9	66.9

Source: Oliner and Sicher (2000).

In Korea, the IT industry (IT services, hardware and software) expanded much faster than GDP in the 1990s (Cho, 2000). Table 3 gives the relevant statistical information. With this fast IT growth, the IT industry's share in GDP doubled, from 3.7 per cent in 1991 to 7.6 per cent in 1999. Total factor productivity (TFP) in the IT industry grew by 14.3 per cent per annum from 1994 to 1997, a rate much higher than in other industries, where it ranged between only 1 and 2 per cent. In the crisis period (1998 and 1999), high IT TFP growth continued (14.6 per cent in 1998 and 32.2 per cent in 1999), while other industries showed negative TFP growth. Cho (2000) concludes that the high TFP growth of the IT industry does not seem to have diffused to other industries yet, but it will increasingly and positively affect them as the IT capital stock increases. The IT capital stock remained at only 5.2 per cent of total capital stock in 1999.

Table 3. **Growth of IT Industry in the Republic of Korea**
(Per cent)

	1991	1994	1997	1998	1999	2000 January-June	1991-99 average
Real GDP Growth Rate	9.2	8.3	5.0	-6.7	10.7	11.1	5.9
Growth rate of IT industry	10.7	26.4	30.5	20.7	41.1	41.2	23.9
Contribution of IT industry to real GDP growth	0.3	1.0	1.9	1.5 – 1.7	4.1	5.1	About 1.5
Share of IT industry in nominal GDP	3.7	4.7	5.6	6.3	7.6	n.a.	5.6

Source: Cho (2000).

IT Diffusion in Asian and Pacific Developing Countries

Appendix Table A1 provides information on IT diffusion in selected Asian and Pacific economies and the United States. It is clear that the degree of IT diffusion has a strong positive correlation with the level of income per capita among these countries. The NIEs are in a position comparable to developed countries such as the United States, while the People's Republic of China (PRC), Malaysia and Thailand are in a much more advanced stage than the other developing countries in Southeast Asia, South Asia, Central Asia and the Pacific. For example, internet users per 1 000 people are: 260–420 in the NIEs, 69 in Malaysia, 17 in Thailand, 14 in the PRC, nine in Pakistan, seven in the Philippines, five in India and Kazakhstan, four in Sri Lanka, two in Indonesia, Kyrgyz, Nepal and Viet Nam and less than one in Bangladesh and Papua New Guinea. IT is beyond the reach of many micro–enterprises, agro–industries, traders, schools, health centres and governmental offices in rural areas in Asian LIDCs.

IT will become increasingly important to Asia and Pacific developing countries in determining productivity growth and industrial competitiveness. A critical question involves whether the new technology will benefit the LIDCs and the other countries to an equal degree, or widen the income disparity between the two groups. The large digital gap between them suggests a gloomy answer. The gap will become even wider unless a well designed long–term strategy for diffusing IT is urgently implemented. Internally within a country, the latest IT is used by only a limited group of citizens, namely young urban individuals at middle or higher income levels. Individuals who do not have satisfactory access to IT will suffer in terms of lower competitiveness and skills, and thus lower incomes.

Required Measures for IT Diffusion and Financing Options

Broadly–defined, IT services include the following:

— Facility–based telecommunications services such as local and long–distance call and wireless telephone service; as well as special telecommunications services[4], including internet phone, call–back, and voice resale;

— Value–added telecommunication services (e.g. PC communications and data services); and

— Broadcasting services such as TV and radio, CATV and satellite broadcasting.

This paper accords priority to the second and third, particularly the third, which has broader economic implications than the others. An array of barriers impedes the access of the low–income population to IT. Receiving information requires information producers (e.g. data services and consulting), information disseminators, physical infrastructures to convey information, equipment (e.g. PCs and monitors) to display it, literacy of recipients to read/understand it and ultimate application of the information to productive activities. The first two of these are beyond the scope of this paper and the fourth (equipment) is not a major problem.

Physical Infrastructures

A major barrier is the poor condition or limited availability of physical infrastructures in LIDCS. Existing telecommunications networks are often limited to urban areas only, and even these offer poor services in contrast with the ultra high–speed systems present in IT–advanced countries. Modernising existing infrastructures as well as building new ones in rural and remote areas are thus the key issues. The following considerations are important in augmenting IT infrastructures:

— They should be financially sustainable;

— Systems should meet satisfactory equity criteria; and

— Maximum use of the infrastructures must be ensured.

IT services generally are provided through telephone lines, and it is essential to build or improve these facilities in underdeveloped areas. Telecommunication line construction in remote areas, however, although responding to the equity consideration, will not ensure maximum use and will not be financially sustainable, with costs much higher than collectable service charges, given the low demand in such areas. Cheaper, complementary methods should therefore be identified as basic infrastructures are developed step by step. One would be to use satellites, which should cover as many areas as possible to ensure economies of scale and financial sustainability. Many countries use satellites as a major telecommunications infrastructure; they are particularly popular in Eastern European countries. Cellular–phone services, which do not require wires, offer another method. Wireless telecommunication services are rapidly replacing wired ones and are leading in the telecommunication markets. In the Republic of Korea, production of wireless telecom services has exceeded the wired telecom services since 1998 (Table 4).

Table 4. **Production of Wired and Wireless Telecom Services in the Republic of Korea**
(In billion won; percentages in parentheses)

	1997	1998	1999	2000[a]
Wired	6 403	6 124	6 254	7 480
	(57.0)	(48.5)	(39.2)	(39.5)
Wireless	4 837	6 498	9 701	11 455
	(43.0)	(51.5)	(60.8)	(60.5)
Total	11 240	12 622	15 955	18 935
	(100.0)	(100.0)	(100.0)	(100.0)

a. Preliminary.

Source: Hong (2001).

The next issue concerns how to distribute efficiently the information/data received from the infrastructures. Individual receiving is too costly in remote areas. An alternative uses a collective method — a telecentre. A telecentre provides the public with access to information and communication technologies for personal, educational, social and commercial/economic purposes. The first telecentre was established in the mid–1980s in a Swedish rural agricultural community[5]. It became a powerful concept to bring the latest technologies to remote communities traditionally neglected by the market.

The telecentres contributed to an equitable expansion of the telecommunications network and offered rural communities the chance to adopt information and communications technologies to their benefit, strengthening social ties within the community and economic ties with the outside world. Since then, the concept has spread rapidly around the world. Governments, development institutions, non–profit organisations and entrepreneurs operate them, in different forms to accommodate local conditions and opportunities. Telecentres have brought a visible and identifiable change in the skills and capacities of people and institutions in communities (Fuchs, 2000). Although their objectives, sizes and configurations can vary, the key characteristics of telecentres include (Shakeel, 2000):

— Geographic location — rural, urban or peri–urban;

— Physical location — in schools, public libraries, government offices or community centres;

— Services rendered — email, internet, phone and fax (common configurations range from phone shops providing public phone access to Multipurpose Community Telecentres (MCTs) rendering voice and data connectivity together with public services such as tele–education);

— Business models — subsidised public, cost recovery or profit making; and

— Partners — national or local governments, universities, NGOs or commercial groups.

Developing infrastructures is costly and requires heavy funding, which cannot be borne by individuals in rural communities. The problem relates not only to the costs themselves but also to financial sustainability of the infrastructures. Except in special cases, therefore, the local or national government must be involved in the construction of the projects with a notion that IT should be a universal service to all inhabitants of the country — a public–goods concept. International donors may co–finance the projects to bridge the funding gap.

If the circumstances allow the participation of private companies in developing the infrastructures, arranging co–financing with the provision of certain risk–hedging formulas should encourage their participation. Necessary legal/regulatory arrangements should facilitate efficient and effective private–sector operation and provide some incentives; for example, companies diffusing IT in IT–underdeveloped areas might be given priority to receive licenses to run commercial telecommunications services in other, profitable areas. Other measures that can encourage private participation include privatisation of state–owned enterprises[6] to increase market competition and economic efficiency; de–monopolisation of niche sectors (*e.g.* cellular phones); foreign participation; government guarantees; supports for financing arrangements; and policy and institutional reforms.

In the aftermath of the Asian crisis, private participation in infrastructure projects has been very cautious due to the underlying high macro uncertainties and foreign exchange risks. A well–designed policy is therefore required to attract foreign and domestic private investors. Various forms of public–private partnerships have been developed: build–operate–transfer (BOT), build–own–operate (BOO), build–own–operate–transfer (BOOT) and concessions. The appropriate mode depends on the character of the project. To promote private investment in infrastructure, competition, transparent tendering, effective regulation, long–term domestic financing sources and risk mitigation are most important (O'Sullivan, 2000). Natural monopoly should be reduced and competition promoted. Unbundling of infrastructure sectors is an important technique to this end, because many parts of networks can support competition. Establishing contestable environments is also essential, through effective competitive bidding for the sale or lease of assets and licensing or franchising of services, etc. (Box 1).

Box 1. **Unbundling of Hungarian Telecom Services**

In the early 1990s, Hungarian Telecoms Services were unbundled into cellular and regional concessions to provide local telecom services. The main telecom operator, Hungarian Telecom Corporation (HTC), remained responsible for the remaining regional areas as well as long–distance and international markets. A cellular company was awarded an exclusive concession in 1990 to develop a nation–wide analogue cellular network. By December 1993 the company had 40 000 customers, 10 000 more than originally expected. The venture's success encouraged the government to open the sector to competition, and in late 1993 two 15–year licenses were awarded to install nation–wide digital cellular systems. In 1994, the government awarded concessions to provide local telecom services in 23 regions. HTC provided interconnection services, but the regional licensees developed services within each area. This approach to harnessing private participation led to rapid entry of capital and technology. In one region (Pápa), telephone penetration was expected to increase by a factor of over three within five years (IFC, 1994).

Governments should play a very important role in reducing risks involved in infrastructure projects[7]. Table 5 presents a summary of various risks and mitigation measures. Governments in developing countries often must accept commercial risks, including foreign–exchange risk and demand risk. In developing countries in general, private funding of infrastructure requires a large amount of foreign financing. It involves high risks of currency mismatches and exchange–rate fluctuations, given that income is in local currency but the foreign financing generates debt servicing in foreign currency. During the Asian crisis, the depreciation of crisis–country currencies ranged from 50 per cent to 80 per cent, an unbearable level for foreign investors who want to remit their financial returns. Some governments provided guarantees against both foreign–exchange and demand risks. Yet the provision of guarantees involves negative impacts, including substantial contingent liabilities for governments that add to fiscal debt and foreign–exchange constraints, because the telecommunications sector does not directly generate foreign–exchange income.

Table 5. **Managing Project Risks as Seen from the Lender's Perspective**

Type of Risk	Risk Controllers	Risk Mitigation/Covering Measures
Commercial Risks		
Project-Specific		
Project concept and costs	Sponsor	Lessons from similar projects; careful cost review
Project supplies	Supplier	Supply contract: government guarantee
Demand (multiple users: toll road)	None	Independent survey: government guarantee
Demand (single purchase: power)	Purchaser	Take-or-pay contract; revolving letter of credit from purchaser
Sponsor Commitment	Sponsor	Equity commitments
Contractor/operator commitment	Contractor/operator	Insurance arrangements; penalty arrangements
Non Project-Specific		
Currency/interest risk	Basically host government	Hedging; sponsor guarantees to cover cost-overruns; use local financing; government agreement to link project tariff to debt service costs
Inflation	Basically host government	Use inflation index for estimating the tariff level.
Non-Commercial Risks		
Project-Specific		
Regulatory	Host government	Detailed concession agreement
Expropriation	Host government	Concession terms
Obligations of SOEs	SOE/government	Contracts; government guarantees
Non Project-Specific		
Country risk (e.g. Forex availability)	Host government	Government guarantee; project revenues paid directly to an offshore escrow account
Political	Government or none	Insurance; buy-out clauses
Legal	Host government	Use neutral-country contract law
Force majeure (e.g. earthquake)	None	Insurance

Source: IFC (1994) and the author.

The development of domestic financial markets is important to secure long–term domestic resources. The volume of funds raised in domestic financial markets, although still small, is growing in the Asian region. If private investors can mobilise resources from local capital markets, foreign–exchange risks and currency mismatches will be reduced. This local funding in return stimulates development of domestic capital markets.

Local financing can be sought through three channels. First, companies already engaged in IT infrastructures might raise funds through issuing equity on the domestic stock market. Telecommunications companies have been active equity issuers in many countries, such as Thailand and Argentina (IFC, 1994). A second source is debt financing provided by local commercial and development banks. Most projects have local financing requirements and local banks can extend credit if necessary, but the room for commercial banks to provide long–term project financing is generally very limited. Local bond markets provide a major source of funding for development banks and, more generally, bond issuance is the third channel for raising funds to finance IT infrastructure. Although the importance of domestic bond markets has been well recognised and significant development efforts have been made in several countries (particularly the crisis economies) since the outbreak of the Asian crisis, Asian bond markets still remain underdeveloped (Kim, 2000). Development of local bond markets is particularly important to IT project financing, which requires large–scale, long–term resources. Developing bond markets need a range of policy reforms that include creating a benchmark yield curve, improving corporate governance, strengthening the role of institutional investors and reforming regulatory and supervisory frameworks. Private placement of bonds should also be encouraged.

Education and Training

Education and training in IT cannot be separated from general education and training in developing countries because basic literacy and primary–level knowledge form an essential minimum requirement for understanding and using available information. A major problem faced by low–income Asian and Pacific developing countries lies in low literacy rates that block any policy action to diffuse IT. Appendix Table A2, which provides basic education indicators in those countries, shows that Afghanistan, Bangladesh, Bhutan, India, Lao People's Democratic Republic, Nepal, and Pakistan have particularly pressing situations. Male adult literacy ranges from 41 per cent (Nepal) to 69 per cent (Lao People's Democratic Republic), and female adult literacy rates are far lower.

Apart from low adult literacy, another discouraging factor is poor education of children in these countries, as revealed by low primary–school enrolment rates and high dropout rates. It is therefore crucial to improve adult literacy as well as children's school enrolment rates to keep pace with recent developments. It also is important to include IT training as a major educational subject, so that children can start to learn IT at early ages, which is now popular in IT–advanced countries. For children to miss IT education and be excluded from job markets will perpetuate poverty. Given that advanced IT work requires education higher than just the primary level, secondary and tertiary education are also important. Here again, the situation in Asian and Pacific developing countries is not encouraging (Appendix Table A3). Training for schoolteachers, particularly elementary and secondary teachers, is also essential.

Given that primary education is generally the government's responsibility, it is important to increase fiscal resources for primary education. This issue has been examined by many studies. Taxes, bond issuance, collection of education fees and international assistance are among the common methods to finance primary schooling in developing countries. Two issues connected with strengthening primary education are particularly important in LIDCs in Asia. One concerns the empowerment of local governments to provide education to children in their jurisdictions. The other involves augmenting their fiscal capability. Given that a local government understands local educational problems and needs well and is in a better position to find proper solutions, it would be desirable for local governments to bear the principal responsibility for designing and providing primary education. If the central or middle–level government (e.g. a state government) is responsible for the provision, it should hand over it to local governments. Fiscal strengthening of local governments then becomes crucial to enable them to provide adequate education services. There should be proper arrangements on fiscal decentralisation and intergovernmental fiscal transfers to this end.

Donation of relevant resources by business corporations, particularly those benefiting from IT, should be encouraged[8]. A special–purpose corporate income tax whose revenue would be used solely for IT education and training can also be collected, because companies benefit most from an IT–trained labour force. It is also essential to reprioritise fiscal expenditures to allocate more financial resources to education in IT skills.

Collection of Information and Application to Productive Activities

Another important objective is to understand community needs, disseminate necessary information and guide communities in applying the information to productive activities. The needs and interests of community members should first be clearly comprehended, so that the IT network can supply meaningful information and data. Next, based on this understanding, the most relevant information should be produced and disseminated to the needy. Last, communities (*e.g.* those producing cash crops, fishery, livestock and horticulture) must be helped to learn how best to apply the information for their production and trade. These three different facets can be managed by a single organisation or separately by different ones, but public agencies should guide the application of the information to various purposes, given that it requires research not financially lucrative to the private sector. The first and second activities should preferably be undertaken by private organisations charging fees for cost recovery. In principle, these activities should have commercial motivations. Commercially oriented organisations receiving fees can survey the needs and interests of communities and produce and disseminate necessary information to them. The information should cover demand and supply situations, price levels and trading conditions. As noted, however, experts with sufficient knowledge and practical experience should provide the guidance for applications, given the information's paramount importance for the medium–term production activities of its recipients. Horticulture in Korea follows such a pattern.

Need for Fiscal Reprioritisation

Responsibilities of the Government

Government should assume the primary responsibility for providing a favourable environment and basis for diffusion and development of IT in LIDCs where the private sector is financially weak. It should address several important policy issues. The first is to reprioritise budget allocations to make fiscal expenditure policy play a major role in promoting IT adoption in the national economy. The basic current fiscal framework in LIDCs was designed in the "Industrial Age" and retains an old expenditure structure not consistent with the "Information Age." Fiscal policy for industry, infrastructure, education, health, poverty, employment and civil administration should include an IT component as an essential parameter. For example, IT access should be made available in all education and health facilities. Fiscal policy should also accord priority to constructing IT–related infrastructures. If a conflict arises between IT–related expenditures and others, the first should receive a higher priority in principle, taking into account the tremendously important role of IT as a fundamental production factor. Further, the administrative system should be based on IT and open to the public to ensure its transparency as well as enhance its convenience.

To strengthen the resources of government, it is crucial to eradicate corruption and minimise government inefficiency, because both waste substantial fiscal resources. Reforming public–sector governance and government structures are essential to achieve this goal. Fiscal revenues increased through reforms can be channelled into IT projects, which will in turn contribute to more transparent and efficient government services and policies.

Role of International Aid Agencies

International donors increasingly emphasise the importance of IT and have already initiated some assistance programmes. The Okinawa Charter on the Global Information Society is one of them. In July 2000, the G8 countries issued the Charter on the Global Information Society at their summit meeting in Okinawa, recognising that IT is one of the most important issues faced by all nations[9]. At the meeting, Japan committed $15 billion to help create a global information society. Bilateral and multilateral aid agencies have also begun some actions to assist low–income developing countries in adopting IT. Whether IT diffusion will be successful in these nations depends on the countries' own efforts, however. With this in mind, international donors need to recommend and ask individual countries to seek "informatisation" through active policy dialogue and arranging assistance conditions[10]. Donors' assistance should be helpful for reducing the obstacles — problems of infrastructure, education facilities and low literacy — discussed earlier. Careful co–ordination of assistance among donors will raise the value and effectiveness of assistance by avoiding project overlaps.

Conclusions

Since the early 1990s, IT has made remarkable progress and diffused rapidly in developed countries as well as in some advanced developing countries such as the NIEs. It has provided individuals and communities with enormous opportunities to raise economic productivity, facilitate business transactions and create new businesses. The positive role of IT in economic activities has been well documented in some countries including the United States. Nevertheless, many low–income developing nations in Asia and the Pacific suffer underdevelopment both economically and digitally. Besides the *inter*national digital divide, a significant *intra*national digital gap also exists, because IT is unavailable in rural communities and even in some urban areas. IT is neither a luxury consumption item nor a special production input related to only limited economic commodities; it is a basic production factor required for every kind of economic activity in this "information age." If the underlying problem is not properly addressed in the low–income developing nations, the digital gap and resultant economic disparity between countries, communities and individuals may increase at an accelerating rate.

Given this formidable challenge, it is urgent for low–income developing nations in the Asian and Pacific region to make strong policy efforts to minimise the existing digital gap. To this end, it is crucial to adjust their fiscal and financial policies as well as regulatory and institutional frameworks to meet the changing economic and technological context. It is also of great importance to mobilise financial resources for the government to improve telecommunications infrastructures and education facilities, while privatisation of related projects and programmes needs to be vigorously pursued. Educational reform is also required. To increase fiscal allocations for IT–related projects and education investments, it is essential to reprioritise fiscal programmes in general and rationalise those related to old–type transport and telecommunications technologies. The international donor community should assist these nations in these efforts.

Notes

1. The views expressed are those of the author and do not necessarily reflect the policies and views of the Asian Development Bank.

2. Japanese Ministry of Foreign Affairs *et al.* (2000).

3. There are different views on the contributions of IT to production, but the most convincing one recognises the positive role of IT. The next section discusses the role of IT in determining productivity.

4. Special telecommunications and value-added telecommunications services do not require own infrastructures but provide facility-based services (e.g. voice) and value-added services (e.g. data), respectively.

5. Henning Albrechtsten, a writer and academic, established the facility to provide the information and communications services and related training to the local community.

6. A success example: In January 1988, the Government of Chile sold about 50 per cent of its telephone company, CTC, to a strategic investor after an international tender. CTC's 1989–93 $1.36 billion investment programme was completed six months early and 6 per cent under budget. Line capacity doubled, with 787 000 additional lines installed, which implied an annual growth of 23 per cent, one of the highest in the world. Efficiency also improved. The number of employees per 1 000 lines fell from 13.7 in 1989 to 6.2 in June 1993.

7. Parties involved in private infrastructure financing are sponsors (owners), who provide equity, contractors, who construct or operate, government (as a participant or regulator), customers and financiers.

8. For example, the Microsoft Company donates a large amount of money for training and education every year.

9. The Charter emphasises the role of IT in creating sustainable economic growth, increasing welfare and fostering social cohesion. It also suggests that both private and public sectors make efforts to bridge the digital divide, underscoring an effective partnership among stakeholders through close policy cooperation.

10. In April 2001, for example, the Asian Development Bank approved a loan (total project cost: $33 million) for Viet Nam for RMIT International University Viet Nam (RIUV), which will assist RIUV in providing IT training programmes.

Appendix

Table A1. **IT Diffusion in Selected Asian and Pacific Countries and the United States**
(Numbers per 1 000 people)

	Telephone Main Lines 1999	Cellular Phones 1999	Personal Computers 1999	Internet Users 2000
Newly Industrialised Economies				
Hong Kong, China	577.5	636.1	290.5	260
Republic of Korea	441.4	504.4	189.2	323.1
Singapore	482	418.8	527.2	419.1
Taipei,China	545.2	522.4	180.7	288.4
Other East Asian Countries				
People's Republic of China	85.8	34.2	120	13.4
Southeast Asia				
Indonesia	29.1	10.6	9.1	1.8
Malaysia	203	137	68.7	68.8
Philippines	39.5	36.6	16.9	6.2
Thailand	85.7	38.4	22.7	16.5
Viet Nam	26.8	4.2	8.9	1.3
South Asia				
Bangladesh	3.4	1.2	1	0.2
India	26.6	1.9	3.3	4.5
Nepal	10.6	n.a.	2.6	1.4
Pakistan	22.2	2.1	4.3	8.5
Sri Lanka	36.4	12.2	5.6	3.4
Central Asian Republics				
Kazakhstan	108.2	3	n.a.	4.2
Kyrgyz Republic	76.2	0.6	n.a.	2.1
The Pacific				
Papua New Guinea	11.4	n.a.	n.a.	0.4
Developed Countries				
Japan	494	449.4	289.6	213.8
United States	681.8	311.5	510.5	537.2

Sources: International Telecommunication Union (2000) and Nua Internet Surveys (2000) (cited in Quibria and Tschang, 2001, Table 2).

Table A2. **Basic Education Indicators in Asia and Pacific Developing Countries**
(Per cent)

	Adult Literacy Rate[a], 1995		Gross Primary School Enrolment Ratio, 1996	
	Female	Male	Female	Male
Afghanistan	15.0	47.2	34.1	68.4
Bangladesh	26.1	49.4	77.7	89.6
Bhutan	28.1	56.2	n.a.	n.a.
Cambodia	n.a.	n.a.	99.3	118.9
China (People's Republic of)	72.7	89.9	119.9	120.9
Taipei,China	91.1[b]	98.1[b]	101.8[b]	99.5[b]
Cook Islands	n.a.	n.a.	n.a.	n.a.
Republic of Fiji Islands	n.a.	n.a.	136.3	137.2
Hong Kong, China	88.2	96.0	98.1	96.2
India	37.7	65.5	90.4	110.0
Indonesia	78.0	89.6	112.3	116.9
Kazakhstan	n.a.	n.a.	95.9	95.3
Kiribati	n.a.	n.a.	n.a.	n.a.
Republic of Korea	96.7	99.3	94.5	93.7
Kyrgyz Republic	n.a.	n.a.	106.5	110.1
Lao People's Democratic Republic	44.4	69.4	97.0	124.5
Malaysia	78.1	89.1	91.8	90.2
Maldives	93.0	93.3	123.5[b]	127.0[b]
Marshall Islands	n.a.	n.a.	n.a.	n.a.
Fed. States of Micronesia	93.0	94.8	93.9	93.5
Mongolia	77.2	88.6	92.2[b]	88.2[b]
Myanmar	77.7	88.7	98.1	101.7
Nauru	n.a.	n.a.	n.a.	n.a.
Nepal	14.0	40.9	83.9	124.5
Pakistan	24.4	50.0	51.0	109.2
Papua New Guinea	n.a.	n.a.	72.9	85.3
Philippines	94.3	95.0	118.7	116.4
Samoa	n.a.	n.a.	103.4[b]	111.3[b]
Singapore	86.3	95.9	92.9	95.3
Solomon Islands	n.a.	n.a.	93.4	102.4
Sri Lanka	87.2	93.4	108.1	110.0
Tajikistan	n.a.	n.a.	91.8	95.3
Thailand	91.6	96.0	87.9	88.2
Tonga	n.a.	n.a.	n.a.	n.a.
Tuvalu	n.a.	n.a.	n.a.	n.a.
Uzbekistan	n.a.	n.a.	78.2	80.4
Vanuatu	n.a.	n.a.	104.2	105.3
Viet Nam	91.2	96.5	112.3	117.7

a. Refers to population of 15 years old and over, except for Taipei,China where the reference age is 25 years and over.
b. Refers to 1997.

Source: ADB (1999).

Table A3. **Secondary Level Education Indicators in Asia and the Pacific, 1996**
(Per cent)

	Gross Secondary School Enrolment Ratio	
	Female	Male
Afghanistan	11.4	31.8
Bangladesh	13.1	24.0
Bhutan	n.a.	n.a.
Cambodia	20.3	34.7
China (People's Republic of)	66.9	74.2
Taipei,China	98.9[b]	95.6[b]
Cook Islands	n.a.	n.a.
Republic of Fiji Islands	69.6	69.4
Hong Kong, China	77.3	72.8
India	39.2	58.7
Indonesia	47.6	55.8
Kazakhstan	88.9	80.3
Kiribati	n.a.	n.a.
Republic of Korea	102.0	101.6
Kyrgyz Republic	70.4	88.9
Lao People's Democratic Republic	22.7	36.3
Malaysia	66.1	57.5
Maldives	64.9	60.4
Marshall Islands	n.a.	n.a.
Fed. States of Micronesia	84.7[a]	78.4[a]
Mongolia	65.0	47.5
Myanmar	35.9	34.8
Nauru	n.a.	n.a.
Nepal	25.1	48.7
Pakistan	21.0	38.4
Papua New Guinea	11.2	16.4
Philippines	80.2	78.1
Samoa	65.8	59.4
Singapore	73.5	71.6
Solomon Islands	14.0	21.6
Sri Lanka	78.1	71.2
Tajikistan	71.7	80.6
Thailand	56.5	57.5
Tonga	n.a.	n.a.
Tuvalu	n.a.	n.a.
Uzbekistan	87.6	98.4
Vanuatu	19.0	23.0
Viet Nam	39.7	41.4

a. Refers to 1994.
b. Refers to 1997.

Source: ADB (1999).

Bibliography

Asian Development Bank (ADB) (1999), *Key Indicators of Developing Asia and Pacific Countries*, ADB, Manila.

Berndt, E.R. and C.J. Morrison (1995), "Hightech Capital formation and Economic Performance in U.S. Manufacturing Industries: An Exploratory Analysis", *Journal of Econometrics* 65:1, January.

Brynjolfsson, E. and L.M. Hitt (2000), "Beyond Computation: Information Technology, Organizational Transformation and Business Performance", *Journal of Economic Perspectives*, Vol. 14, No 4.

Brynjolfsson, E. and L.M. Hitt (1996), "Paradox Lost? Firm–level Evidence on the Returns to Information Systems Spending", *Management Science*, 42:4.

Brynjolfsson, E. and L.M. Hitt (1995), "Information Technology as a Factor of Production: The Role of Differences Among Firms", *Economics of Innovation and New Technology*, 3:4.

Cho, T.–S. (2000), "Impact of Information and Telecommunications Industry Development on Total Factor Productivity in Korea," *Monthly Bulletin*, the Bank of Korea, October.

Fuchs, R.P. (2000), "Little Engines that Did: Case Histories from the Global Telecenters Movement", http://www.idrc.ca/acacia/engine/index.html.

Greenan, N. and J. Mairesse (1996), "Computer and Productivity in France: Some Evidence," NBER Working Paper 5836, November, National Bureau of Economic Research, Cambridge, Mass.

Hallberg, K. and J. Bond (2000), "Revolutions in Technology for Development", World Bank, http://www.worldbank.org/html/fpd/technet/revol.htm.

Hong, D.–P. (2001), "ICT Sector in Republic of Korea – Recent Performance and Future Policy Directions," presented to the ADB–ADBI ICT Capacity Building Workshop, 21–27 February 2001, Singapore. (The paper obtained the data originally from the Korea Association of Information and Telecommunications for 1997–99 and KISDI for 2000.)

International Financial Corporation (IFC) (1994), *Financing Private Infrastructure Projects*, IFC, Washington DC, September.

Japanese Ministry of Foreign Affairs and Ministry of Finance, UNDP and World Bank (2000), *Proceedings of an International Symposium on Information Technology and Development Cooperation*, held on 3–4 July, Tokyo.

Jorgenson, D.W. (2001), “Information Technology and the U.S. Economy”, *American Economic Review*, Vol. 91, No 1, March.

Kelly, M.R. (1994), “Productivity and Information Technology: The Elusive Connection”, *Management Science*, 40:11.

Kim, Y.–H. (2000), “Post–Crisis Policy Agenda for Reforming the Financial Sector in Asia”, *in* OECD Development Centre Seminars, *Sustainable Recovery in Asia: Mobilising Resources for Development*, Asian Development Bank/OECD Development Centre, Paris.

Lichtenberg, F.R. (1995) “The Output Contributions of Computer Equipment and Personal: A Firm–level Analysis”, *Economics of Innovation and New Technology*, 3.

Morrison, C.J. (1996), “Assessing the Productivity of Information Technology Equipment in U.S. Manufacturing Industries”, *Review of Economics and Statistics*, 79:3.

Mukhopadhyay, T., S. Rajiv and K. Srinivasan (1997), “Information Technology Impact on Process Output and Quality”, *Management Science*, 43:12.

Oliner, S.D. and A.E. Sichel (2000), “The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?”, *Journal of Economic Perspectives*, Vol. 14, No. 4, Fall.

O’Sullivan, S. (2000), “Best Practices for Promoting Private Sector Investment in Infrastructure”, *in* OECD Development Centre Seminars, *Sustainable Recovery in Asia: Mobilising Resources for Development*, Asian Development Bank/OECD Development Centre, Paris.

Quibria, M.G. and T. Tschang (2001), “Information and Communication Technology and Poverty: An Asian Perspective,” ADB Institute, Working Paper 12, Tokyo, January.

Roach, S.S. (1987), “America’s Technology Dilemma”, *Morgan Stanley Special Economic Study*, New York, April.

Shakeel, H. (2000), “Barriers to Telecenter Implementations in Sub–Saharan Africa,” submitted as the term paper to Professor Deborah Hurley, Technology and Policy Program, Massachusetts Institute of Technology, Cambridge, Massachusetts, May.

Part Two

Policies to Make Technology Work for the Poor

Inaugural Address

François Huwart

I would like first of all to thank warmly Mr. Shin, who has travelled from Manila, and Mr. Braga de Macedo and his team from the OECD Development Centre, who are participating in this forum on Technology and the Fight Against Poverty in Asia and the Pacific.

To say that the new technologies are a true industrial revolution is both obvious and commonplace. Nonetheless, recall that our hopes for sustainable economic growth are based in fact on technological progress. The virtuous circle involving technological progress, globalisation, and economic growth may be our only and previously unimagined hope for truly staunching world poverty. Today, half of the planet's population lives on less than $2 a day, and, as the FAO reminded us last 18 April, 800 million people suffer from hunger and malnutrition. The globalisation of progress is an opportunity that we must not miss. Yet there is one necessary condition. We must share this progress. New wealth must not get confiscated by the rich. Ideas, knowledge and know–how must circulate freely. We must never lose sight of these imperatives.

The development of the new information and communication technologies (NICTs) has been as stunning as it has been celebrated. These technologies first transformed financial exchanges and markets, and they are now making revolutionary changes in teaching. World information flows are also creating new prerogatives for citizens and communities. Still, the NICTs are only one part of the technological revolution. They cannot be dissociated from the growth of nanotechnologies, the technologies of the infinitely small. Work is now under way at the atomic and molecular levels. Data storage, the resistance of new materials in carbon nanotubes and the selective treatment of cells are only the first applications of these nanotechnologies. Today's new health economy, linked to research on the human genome, is a medical revolution comparable to the discoveries of Pasteur over a century ago.

In agriculture, biotechnology has made it possible to improve crop production, reduce the use of pesticides, increase the nutritional value of food and better withstand drought and salinity. The first green revolution was based on the introduction of intensive production techniques that included new varieties of rice and wheat, and fertilisers, and was supported by determined economic policies. It enabled many countries, especially Asian countries, to meet their growing need for food. The French agronomist, René Dumont, who recently passed away and to whom I would like to pay tribute, was one of its most fervent supporters before becoming a ferocious critic. He was clairvoyant.

Today this revolution is losing steam. Crop production has levelled off for reasons that we cannot entirely explain, and a new green revolution is needed. The next agricultural revolution must link high production rates with ecological viability, and for this reason it must be conceived of as doubly "green". The scientific revolutions in biology–molecular genetics and in IT and genetic research suggest many possibilities for realising it.

The promises held out by biotechnology as a tool for development are based on its capacity to reduce greatly the time needed for hybridisation and for traditional methods of selection. Vaccines against bovine diseases have already become one important product of biotechnological research. Fundamentally, however, this progress cannot rely solely on technology. It must be adapted to the needs of poor populations, and it must concern all agricultural regions, not only those with great potential.

Two French institutions have particular responsibility for co–operative research on agriculture and on tropical diseases. The International Co–operation Centre of Agricultural Research for Development (CIRAD) deals with agricultural questions and veterinary issues. The Development Research Institute (DRI) focuses on research in agriculture and human tropical diseases. These two institutions collaborate with researchers from developing countries in Africa, Latin America, and Asia. CIRAD programmes are currently working on animal breeding with Viet Nam, the Philippines, and Indonesia, on the sustainable management of forestry plantings in Southeast Asia, and on fruit growing in Viet Nam. The DRI has a specialised programme for rice production in Africa and Asia.

The number of forums for sharing knowledge and technology is growing. I am happy to observe that they have often made it possible for political leaders as well as representatives of the private sector and civil society to come together around the same table. Without making an inventory, I would like to examine with you some of the current thinking which I consider important.

The example of the NICTs is significant. Reducing the digital divide is central to discussions at ECOSOC, the OECD, WTO, the EU and the DOT–Force (GEANT, in French), created by the G–8 after the July 2000 Summit of heads of State in Okinawa. I can attest personally that France has been particularly active within this work group.

— More specifically, French co–operation, particularly *via* the French Development Agency, has begun to evaluate the legal, logistic, and economic infrastructure needs to encourage the development of NICTs. The goal is to define, with the beneficiary country, the national strategies that it would like to develop.

— ASEAN has taken a similar approach. The e–ASEAN initiative signed in Singapore last fall seeks to accelerate the economic integration of countries in the region by emphasising the development of communication infrastructures and promoting e–commerce through establishing common legislation and more mutual assistance among member countries for creating and liberalising NICTs.

— Other institutions are considering the legal aspects of the trade and use of these technologies. The World Bank Information for Development Program (Infodev) finances technical assistance programmes and studies to improve market access and the regulation of the technology sector. Since its creation, Infodev has financed four projects in India, a particularly dynamic country in this respect (witness the creation of a “simputer”, for “simple computer”), two other projects in China and several regional projects. UNESCO and the World Intellectual Property Organisation (WIPO) both also work on legal issues, particularly intellectual property rights. UNESCO seeks to go beyond the copyright/public–domain legal debate to develop a more pragmatic, functional approach that would favour universal access to these technologies. The OECD has focused especially on fiscal incentives for developing technologies, making information secure and privacy issues — and therefore on consumer protection. This work is essential to create a framework that is secure and propitious for private initiatives and enables all States to derive the greatest benefit from the NICTs.

— At WTO, 56 countries, including several Asian countries, have signed an agreement on information technologies, including the ITA–1 agreement that seeks to exonerate a certain number of technological products from customs taxes. Negotiations are currently underway to extend this agreement to new products and to eliminate such non–tariff barriers as conformity evaluations, import license procedures and excessive technical norms.

— International thinking is finally addressing the means for using new technologies to make public development aid more effective in the battle against poverty in the priority sectors of education and health. The World Bank’s Global Development Gateway orients its work to putting knowledge on line and to developing distance–education capacity. The point is to use the NICTs to favour access in developing countries to high–level training and, more generally, to share best practices in development.

— The Asian Development Bank has already financed several projects, such as the Grameen Phone Project in Bangladesh that makes cell phones available in rural areas. I believe that the ADB is in the process of defining its strategy and I will be very happy to learn more about your projects in this area.

From this plethora of efforts, we can discern several principles to guide our actions.

— First, it is clear that trade negotiations must help to facilitate the access of poor countries to information technologies, and to enable them to appropriate them effectively. If liberalisation can make it possible to improve the quality and costs of a set of services (telecoms, IT, on–line payment, marketing, distribution), it must be framed by political determination. This policy globalisation has a name: *regulation*. In this respect, I strongly encourage developing Asian countries to participate in the extension of the WTO agreement on information technologies. Another priority must be to create a propitious legal context that protects, for example, against cyber–crimes. The Telecommunications Regulatory Authority in France has regulatory and institutional expertise available on telecommunications that I hope it will share more fully, particularly with Asian countries. Still greater access to these new technologies necessarily requires reducing production costs. We must therefore consider how to make intellectual property rights less rigid. South Africa took a decisive step concerning drugs in the battle against AIDS. The issue of patents has also been raised. The ravages of certain epidemics require that all developing countries have recourse to obligatory licenses for copying patented products in the case of a national emergency. This possibility must remain part of the interpretation of the TRIPS agreements, however, so as to preserve the international patent context.

— Second, we must unite and incite. Unite different initiatives so that they converge. Each institution that addresses these questions must consider how to articulate its thinking and action with those of other institutions, by adhering to a principle of subsidiarity whereby the institution best able to address a specific question is the one that responds to it. In general, it is important to promote regional co–operation that will favour regulatory harmonisation and the sharing of best practices. We also should encourage public–private sector partnerships.

Mechanisms that create incentives must be designed. I find the *Proparco* initiative pertinent. This African Development Bank subsidiary is considering establishing a venture–capital fund for new technologies in West Africa. Several French enterprises in the technology sector could in fact be part of this initiative. It seems to me that this kind of mechanism could also be established in Asia, and that we should help particularly with the NICTs, because enterprises in this field generally require lower capital investments. In this area, we should support the private more than the public sector, which should concentrate on regulatory questions. This is true for Europe, and is probably true in developing countries, particularly in Asia. Donors such as the Asian Development Bank should therefore target their financing towards private projects that will have a true leverage effect for new technologies.

These are the principles that I believe should guide our actions. I hope that your work today will continue to be fruitful. Thank you.

Keynote Speech

Myoung–Ho Shin

Your Excellencies, distinguished participants, ladies and gentlemen, good morning.

It gives me great pleasure to address this seventh OECD–ADB Forum on Asian Perspectives. I would like to thank the OECD Development Centre and the Government of France for their continued support of this annual activity.

Technology, Development and Poverty Reduction

Throughout the history of economic development, technology has been a focal point for efforts to improve economic welfare and reduce poverty. Along with capital, land and labour, technology is inextricably linked with national productivity and industrial competitiveness. The ability to create employment and wealth goes hand in hand with the ability to progress technologically. All the economically advanced countries have used technology to promote socio–economic development.

Per capita income varies across countries not only because of differences in capital stocks but also because of differences in productivity. Long–term differences in productivity depend largely on technological progress, which is a key factor distinguishing a dynamic, growing economy from a stagnant one. In a stagnant economy, technological progress occurs at a glacial pace, per capita income remains more or less constant and poverty persists. At the other end of the spectrum, a dynamic economy is characterised by sustained growth in both per capita income and technological progress. Technology contributes in two mutually reinforcing ways to growth in such an economy:

— *First,* steady technological progress can offset the negative effects of population growth, allowing a continued rise in real incomes; and

— *Second,* rising real incomes contribute to higher educational attainment, which in turn generally leads to smaller families.

Transforming a stagnant economy to a dynamic one poses a formidable challenge for many developing countries.

The impressive technological advances of the past several decades have changed the way people work and attempt to raise their standards of living. Permit me to dwell briefly on a few examples of the economic benefits brought by technological progress through the years.

In agriculture, the Green Revolution brought large economic gains and substantially reduced poverty in the Asia–Pacific region over the past three to four decades. Countries like Bangladesh, the People's Republic of China and India have moved from periodic famines to near self–sufficiency in food production. In the past 30 years, cereal production in Asia has doubled and calorie availability per person increased by over 20 per cent, while real food prices have fallen by 50 per cent. High–yielding varieties of rice and wheat made a critical contribution to this notable achievement.

Besides the Green Revolution, the world has made important advances in biotechnology, with implications for the health sector, while the energy sector, computers and transport and telecommunications, among others, have benefited enormously from the development of lighter and more durable materials. The continuing revolution in information and communication technology is making the most significant impact of all, however. It is creating profound, far–reaching economic and social changes.

As the "knowledge economy" emerges, technology becomes increasingly important. The knowledge economy brings with it a fundamental change in modern economies, characterised by a marked shift away from traditional production patterns toward a new economy dependent on knowledge and professional services. Today, an increasing portion of a nation's comparative advantage depends on the country's collective ability to leverage what its citizens know. The availability of the traditional production factors of land, labour and capital has become less important in the context of globalisation. Today, each of these traditional factors can be obtained in a different part of the world where it is easily available at a good price. Traditional production systems are changing under the impact of increasing automation, outsourcing and relocation. Knowledge, on the other hand, is not constrained by such factors or by national borders. A distinctive feature of the knowledge economy is the fast pace of change. The rapidly expanding knowledge economy makes goods, services and information quickly obsolete. Knowledge–based growth continues to shorten product cycles, drive prices downward and improve product quality through increased competition.

Issues of Technological Progress and Poverty Reduction

Rapid technological changes pose severe challenges to developing countries. These nations need to carefully manage the changes in order to ensure international competitiveness, sustained growth and poverty reduction. In this context, I would like to raise a few issues.

First, it is desirable to prepare a new long–term technology policy within the changing technological context. This policy should be compatible with the overall national development and poverty reduction strategy. While making the most of the opportunities offered by the emerging knowledge economy, the policy should address possible short–term negative impacts on employment through special safety net programmes and intensive vocational training. The long–term technology policy should focus on the major factors that reduce poverty. This will ensure that development resources are not spread thinly across too many areas. The main drivers of poverty reduction should play a leading role in disseminating technology and making it accessible to small–scale enterprises. You will agree that it is undesirable for developing countries with insufficient capital to seek capital–intensive technologies. The new policy must ensure that technological needs and priorities are jointly assessed on an ongoing basis by the government, industry and research institutes. This will help establish a strong link between technology policy, demand, and supply.

Second, within the context of the focused approach of the new policy, it is important to identify and promote technologies that are most relevant to the particular country from the viewpoint of comparative advantage. India's experience in promoting information and communication technology shows clearly that a low–income country can also enjoy international advantages based on its abundant human resources. Similarly, the electronics industries in the Republic of Korea and Taipei,China are excellent examples of the benefits of appropriate technological progress.

Third, the new long–term national technology policy should be underpinned by a human resources development plan. The government should accord top priority to education at both primary and tertiary levels. A strong capability in science and technology cannot be developed without an appropriate human–resource base and a social and economic incentive structure to attract the best students and researchers to science and technology networks. I would like to emphasise the equal importance of primary education in a number of low–income Asia–Pacific countries with low levels of literacy. Low literacy is a severe impediment to both technological development and poverty reduction in these countries.

Fourth, research and development activities should be encouraged at all levels. In low–income developing countries, such activities are generally limited for various reasons. Among the most important are lack of financial resources, low policy and institutional support, inappropriate protection of intellectual property rights and inadequate means of making research products commercially viable. To address these issues, partnerships between the government and the private sector are important.

Fifth, technology transfer should be a matter of priority in developing countries with limited research and development capabilities. Firms must recognise that limiting themselves to technologies available domestically can sometimes give them access only to outdated and inadequate technologies. The choice between domestic development and imports should be based on a careful comparative analysis of long–term costs and benefits. The question often arises whether transferred technology is appropriate for developing countries. In many cases, capital–intensive agricultural and manufacturing technologies imported by developing countries have not contributed to employment, poverty reduction, or an improvement in the balance of payments. Moreover, foreign technologies imported with substantial royalty payments should contribute significantly to generating foreign exchange earnings in order to avoid aggravating the balance of payments situation.

Finally, I would like briefly to discuss information and communication technology (ICT). The expeditious adoption and dissemination of ICT is a pressing task faced by developing countries. The positive role of ICT in raising labour productivity is now well documented in several countries, including the United States. US economic performance since 1995 has been remarkable. From 1995 through 2000, real GDP rose by more than 4 per cent per year, a significant advance from the early 1990s. The rapid growth since the mid–1990s has been driven by a marked increase in labour productivity, which rose by 2 to 3 per cent per annum, twice as high as the average rate during the preceding two to three decades. The country’s large investment in ICT is generally regarded as a major cause of this development.

The ICT gap between developed and developing countries — or the “digital divide” as it is called — is an important development issue now. The problems created by the digital divide include a vicious cycle: lack of ICT leads to slower productivity growth and lower incomes, which in turn impede the use of the latest technologies, including ICT. Children from poor families who cannot afford ICT training are at a disadvantage in the job market. This can become a new factor in perpetuating poverty. It is therefore essential to facilitate the dissemination of ICT in developing countries by creating the necessary infrastructure and promoting education and training in related skills.

In recognition of the urgency to bridge the digital gap, in July 2000 the G–8 countries adopted a Charter on the Global Information Society at their summit meeting in Okinawa, Japan. This was a timely and important international initiative.

Concluding Remarks

Since its establishment in 1966, the ADB has accorded priority to assisting its developing member countries to acquire and upgrade technologies to help reduce poverty and facilitate economic growth. ADB assistance, with an emphasis on especially vulnerable individuals and enterprises, has focused on primary and technical education, vocational training, technology acquisition, research and development and the formulation of national technological development plans. It has covered all the important economic sectors, including agriculture, fisheries, forestry, manufacturing, finance, transport, rural telecommunications, energy and the social sectors. More recent ADB initiatives seek to address ICT issues in its developing member countries. An ADB strategy on ICT will be finalised soon. ADB has made a significant contribution to progress in its developing member countries. ADB reaffirms its commitment to continued close co–operation with these countries in upgrading technologies and eradicating poverty in the Asia–Pacific region.

Ladies and gentlemen, before I close, I would like to express again my deepest gratitude to the Government of France and the OECD Development Centre for their excellent co–operation in holding this forum. I wish you successful discussions on a number of important issues today. The discussions and recommendations of this forum will help developing countries in Asia and the Pacific, as well as in other regions of the world, to pursue technological progress and poverty reduction.

Thank you.

Technology and Development Policy in Poverty Reduction: The Case of Thailand

Suwit Khunkitti

This presentation discussing the issues relating to technology and development policy in poverty reduction will have three parts. I will start with a short profile of the Thai economy, followed by an overview of the poverty situation in Thailand and the impacts of the economic crisis of 1997. I will then discuss the contribution of technology to development and the relationships, both positive and negative, between technology and poverty reduction. I will conclude with an overview of policies of the present government that have direct impact on the approaches to technological development and some of the initiatives already launched to ensure that technological progress will be consistent with the goal of poverty alleviation. Most of the presentation will focus on the agricultural sector, which has the greatest share of the population as well as a higher concentration of poverty incidence.

Profile of the Thai Economy

With average annual growth rates between 7.3 and 7.8 per cent per annum during 1965–95, Thailand's economy was among the fastest growing in Asia. Its agricultural GDP increased by 5.24 per cent per year during the 3rd National Economic and Social Development Plan (1972–76) and by 4.15 per cent annually during the 4th Plan (1977–81). It more or less maintained that performance at 3.69 and 4.58 per cent a year during the 5th (1982–86) and 6th (1987–91) Plans. Average agricultural GDP growth was 2.51 per cent per annum in the Seventh Plan (1992–96)[1]. Over 60 per cent of the total population are employed in this sector. The sector's share in GDP has declined over the last three decades, however, from 25 per cent during the 3rd Plan to just under 15 per cent by the 6th Plan and further to under ten per cent by the end of the 7th Plan[2].

The rapid economic growth resulted in an overall improvement in absolute income and a reduction of the proportion of people below the poverty threshold. In 1962–63 around 57 per cent of Thailand's population was classified as "poor". That measure fell to 32.6 per cent by 1988 and further to 27.2 per cent in 1990, 23.2 per cent in 1992 and 16.3 per cent in 1996. Although the percentage was reduced in all the regions, problems of income distribution persisted, with higher incidence of poverty in the Northeastern Region (23.02 per cent of the regional population in 1996) and the Southern Region (16.7 per cent). Moreover, there is considerable inter–sector income disparity due to differences in labour productivity and adverse terms of trade between the agricultural and the non–agricultural sectors.

The economic crisis that surfaced in the middle of 1997 more or less reversed this positive trend of poverty reduction over several decades. Both urban and rural areas experienced reductions in average per capita income. The percentage of the population classified as "poor" increased by 12.9 per cent between 1996 and 1999, and the numbers classified as "poor" increased by 1.1 million. By the end of 1998, the population classified as "poor" was 7.9 million.

The economic plight of the country drew attention back to the agricultural sector. There were hopes that the sector would be able to continue to produce food supplies to feed the country as well as generate foreign–exchange earnings. Among the preconditions for the sector to be able to fulfil these expectations are the need to intensify land use, increase yields and reduce unit costs as well as import requirements. Note that technological achievement will be instrumental in meeting all these preconditions.

The Contribution of Technology to the Development Process

Technology features as one of the major keys to development. The extent to which it can be instrumental to poverty alleviation depends on three major factors, namely the sources of technology, dissemination of technology and distribution of benefits from its adoption. Given the institutional, political and legal frameworks which condition these three factors, the outcomes of technological development and dissemination cannot always be predicted accurately, nor are they always positive.

Like many developing countries, Thailand's agricultural development framework welcomed the potential benefits of the Green Revolution. Given the sense of urgency to increase output under the *"growth–before–distribution"* paradigm of the new technology, the technology–embodied miracle seeds and the entire input packages were speedily and unquestionably embraced. Reservations over compatibility with resource endowments and mechanisms employed to disseminate the use of such technologies, which feature among the most important considerations today, were more or less absent. Findings from a number of empirical studies have led to similar conclusions that when those considerations are overlooked, externally induced technology has the tendency to intensify initial differences in income distribution and development gaps rather narrow them. Moreover, the delivery of technology and services was not effective in reaching the majority of small–scale farmers. Inadequate access to the formal money markets meant that smaller farmers had to pay higher interest rates for borrowed capital; hence they had higher costs of production relative to larger–scale farmers. These have been the major explanations for the slow advances in diffusion of modern technology.

Given that poverty is spatially concentrated in rural areas and principally among those employed in the agricultural sector, one institution that has a major role in poverty alleviation, particularly with respect to the development and dissemination of technology, is the Ministry of Agriculture and Co–operatives (MOAC). The MOAC captured three key lessons about the role of technology and poverty alleviation from decades of experience as planner, practitioner and stakeholder in agricultural development.

First, modern technology will continue to be a major instrument among other poverty alleviation measures. More cautious approaches will have to be exercised in our choices of modern technology. Developing countries will have to learn to be more *selective* and to minimise dependency on imported technology. Greater emphasis should be given to basic research as a means of maintaining and increasing competitiveness in both the domestic and international markets. This also relates to the very pertinent issue of technology gaps between developed and developing countries. Many would agree that the gaps are likely to widen. Moreover, the increasing attention given to environmental issues and intensifying problems of depletion of the natural resource base may give rise to more subtle forms of non–tariff barriers that would further undermine the competitiveness of developing countries. It will be beneficial to discuss the issues of "free and fair" trade to explore the economic and political complexities of how to transform such principles into practice.

Second, there is a need to balance objectives of conservation of biodiversity resources and sustainable use of biodiversity in plant and animals. In trying to achieve production goals, adequate attention must be given to how our natural resource base can be used sustainably. The concept of sustainable production is to maintain the reproductive capacity of the natural resource base, particularly in environmentally sensitive areas. At the same time, it is widely acknowledged that adoption of sustainable production very much depends on economic viability at the farm level.

Third, traditional technologies not only are cost minimising but also are practices more compatible with localised resources and the ecosystem. It is equally important to emphasise the rights of individuals and communities who have access to sources of information to ensure that they will be able to obtain and retain a fair share of benefits from making such information known and profitable in the market economy. This will demand an appropriate supporting legal system on patenting property rights over indigenous and traditional knowledge and practices.

Government Policy to Advocate Advances in Technological Progress as a Means of Fighting Poverty

I come now to the final part of my presentation, where I would like to draw your attention to the current policies and implications of technological development and poverty alleviation. All the measures that I will briefly bring to your attention are fundamentally different from previous development approaches in that they are targeted directly to the farmers as opposed to the rural–*cum*–agricultural sector. This is dictated mainly by the recognition that sector–oriented approaches have had limited impacts in reaching the intended target beneficiaries, these being shortcomings conditioned by the distortion of market mechanisms and social–economic differentiation discussed earlier. Our principle is to reduce the dependency on external development inputs among poverty–stricken rural communities, which will ultimately create self–reliance. It is a major challenge to Thai society because it not only necessitates changes in the entire administrative apparatus, but also involves mobilisation of the masses, until very recently the silent recipients of development services. This is the current direction towards decentralisation and democratisation of Thai society. The process is already taking place with restructuring of the entire top–heavy administrative apparatus to allow for greater speed and improved efficiency in delivery of services.

The prime concern of the government is to improve access to the capital markets, which in turn will improve access to technology. This is to be accomplished through a combination of measures. Debt restructuring is a policy to restructure debt payment of small–scale agricultural producers for a period of three years, during which a system for revision and a comprehensive approach to production restructuring can be put in place. It relates to one of the structural problems of production mentioned earlier, distortion of the money markets and inadequate access to formal sources of credit, which have been among the reasons for slow adoption of modern technologies.

The Thai government places emphasis on creation of opportunities for the poor to access sources of capital through the establishment of the People's Bank and the Village Fund. The approach is to set up a fund of one million Baht per village, which can be used as a revolving fund for investment promotion and employment creation. The fund is expected to be useful for creating small–scale enterprises in rural communities. The principle for small and medium–scale enterprises (SMEs) is systematically to strengthen the performance of existing entrepreneurs. This will create, upgrade and maintain performance of the production supply base so that SMEs become major sources of employment and revenue generation as market networks expand beyond the boundaries of local markets to regional, national and international markets. The People's Bank has also been introduced to create access to the capital market, particularly for small producers, principally to reduce dependency on the informal money markets.

The government is also presently advocating the concept of "One Village, One Product" aimed at encouraging communities to draw upon their traditional and indigenous knowledge for product development. To support this concept, the government will provide inputs such as modern technology and management to link products to the domestic and international markets through networks of distribution chains and the development of information technology.

Finally, I would like to conclude with the observation that everything described above requires two basic inputs. The first is effective reorientation of the research apparatus. The second is the creation of local organisations that can function as partners in the research and technological development process, furnish the appropriate information on research needs and provide the appropriate networks for dissemination, applications and adaptations of research findings. These two inputs will ensure that technological development can be harnessed to the goals of poverty alleviation.

The reorientation of the research apparatus is of crucial importance to ensure that the principle of agricultural research to increase productivity is consistent with the principles of sustainable production, conservation of natural resources, environmental protection and rural poverty reduction. A recent study on restructuring the MOAC identified key measures that may be instrumental for the desired changes. These include:

— The establishment of an apex body at the national level to formulate and facilitate agricultural research policies and priorities;

— The adoption of a new approach at local levels in which researchers work more closely with farmers in identification of their constraints and in testing new and traditional technology to overcome them; and

— Improved vertical and horizontal integration within the research system and with other partners in agricultural development.

The creation of local organisations that can function as partners in the research and technological development process, on the other hand, involves a shift of paradigm from a supply–driven, top–down system of technology generation and transfer to one that is bottom–up and demand–driven. Among the recognised merits is that the shift will open access by the hitherto top–down planning agencies and research apparatus to the farmers' knowledge of their environment and traditional wisdom, for the benefit of planning and evaluation of on–farm trials. The information will serve as the base for framing the research agenda to ensure that the research system can produce technological innovations consistent with needs and adoption capacity of farmers. The key mechanism to link the MOAC with communities to involve them in planning and in the decision–making processes is the Technology Transfer Centres (TTCs). Among the primary functions of the mechanism, a *Tambon*–level organisation to be established nationwide, is to enhance flows of information and technical services from the public sector. It is the general expectation that the TTCs will be instrumental in expanding sources of information and technical services through more effective linkages and networking among the public and private sectors, NGOs and local communities.

Some of the issues I have raised are not unique to Thailand and there are common experiences and views of how we can approach problems of poverty and the contribution of technology development. I hope that the issues raised will serve as starting points for fruitful and valuable discussions.

Notes

1. THAILAND, MINISTRY OF AGRICULTURE AND CO–OPERATIVES (1997), *Action Plan During the Eighth National Economic and Social Development Plan, Revised According to the Cabinet Approval on March 18, 1997*, Office of Agricultural Economics, MOAC, Bangkok, pp. 9 and 11.

2. THAILAND, NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT BOARD (1999), *GDP at Current Market Prices (Original),* Quarterly Gross Domestic Product, Quart. 1/1999, Bangkok.

Technology and Growth: Ireland's Recent Experience

Desmond O'Malley

Introduction

The subject of my address is the central role that the Irish experience of technology and growth has played in transforming the Irish economy in recent years. In the context of today's Forum, I hope it will provide some backdrop for the debates on national growth strategies and technology and on how, by investing in the tools and skills needed to compete in the digital economy, we can improve economic performance and the welfare of our people.

As the globalisation of knowledge, production, trade and the boundaries to technology and computing power continues to astound us, you will forgive me if I draw attention to linking this process with an Irish literary episode. Reading a recent article in the *New York Times* entitled "Software's Next Leap Out of the Box", I am reminded of the writings of one of Ireland's great comic writers, Flan O'Brien, also known as Myles na gCopaleen. He had a bizarre theory about molecular transfer, which he used to explain his bond with his bicycle! This is not unlike the German philosopher, Martin Heidegger, who wrote that a blind man is not conscious of the cane he has as a separate entity, but regards it as an extension of his hand. For contemporary scientists this vision is held up as a powerful guide for future software designers.

Recalling Flan O'Brien's comic genius in describing his relationship with his bicycle, it is perhaps not entirely coincidental that Ireland, a country with a population of only 3.7 million people, is, in absolute terms, the largest exporter of software products in the world — ahead even of the United States. The story of how we got to this stage is not simple, however.

Ireland: Some Basic Facts

First, to set the context, it may be useful to recall some basic statistical facts about the Republic of Ireland:

Population: 3.75 m (2000)

Labour Force: 1.78 m (2000)

Unemployment Rate (2001): 3.6 per cent (2001)

Annual Average Change in GDP 1993–99: 9.0 per cent

Annual Average Change in GNP 1993–99: 8.0 per cent

GDP (1999): IR£69 100 million ($80 200 million)

GNP (1999): IR£59 100 million ($68 600 million)

GNP per head (1999): IR£15 700 ($18 200)

1993–2000: A Period of Exceptional Economic Growth

The process of economic adjustment initiated in the mid–1980s, together with other factors relating to demography and policy initiatives introduced in earlier decades, which bore fruit in the 1990s, led to a period of exceptional economic growth in Ireland in the 1990s:

— The average annual rate of increase in GDP was 9 per cent, and in GNP 8 per cent, over the seven–year period 1993–99 (inclusive);

— The average annual rate of inflation (CPI) was 1.9 per cent from 1993 through 1999. In 2000, however, it increased significantly, under the impact of oil price increases, increased mortgage interest rates, increases in indirect taxation on tobacco introduced in late 1999 for health–promotion reasons, a fall in the value of the euro and a tightening labour market that gave rise to a degree of wage inflation in particular sectors of the economy.

— The debt/GNP ratio fell to below 45 per cent by the end of 2000;

— The population has increased by 240 000 (7 per cent) to 3.75 million since 1990, with net migration into Ireland accounting for over a quarter (64 000) of this increase — a reversal of an age–old trend in which Ireland had been a source of labour supply for countries all over the world;

— The number of people employed has increased by over 60 per cent (over 540 000) since 1993, to some 1.78 million in 2000;

— The unemployment rate has fallen from 15.7 per cent in 1993 to 3.6 per cent this year; and

— GDP per head in Ireland rose to over 111 per cent of the average for the European Union (EU–15) in 1999 — a considerable improvement on the situation when Ireland first joined the EEC in 1973, when GDP per head was about 60 per cent of the EU–15 average. This gain over the past 30 years has been driven by two principal factors:

i) Strong productivity growth (output per head), particularly in an increasingly high–tech industrial sector; and

ii) A falling economic dependency ratio (i.e. the ratio of total population to the number of people employed) as employment and labour participation rates increased and unemployment and the proportion of the population outside the 15–64 year age groups fell.

Ireland's economy has further evolved strongly during the 1990s to reinforce the long–term trend from a natural–resource/agriculture–based, inward–looking, narrowly export–based economy into a high–tech, knowledge–based, export–driven economy. It is one of the most open trading economies in the world. The value of exports and imports combined amounted to over 160 per cent of GDP and over 190 per cent of GNP in 1999.

An Export–Driven Region of A Global Economy

A useful way of looking at Ireland's economy is to view it as a regional economy within the wider European, US and global markets in which it trades. As such, the strength and competitiveness of its export base primarily determine the growth capacity of the economy.

Competitiveness: The Foundation of Ireland's Economic Transformation

Clearly, the fairly remarkable development of the export performance of the Irish economy rests on the competitiveness of its export base. While, ultimately, competitiveness depends on the performance of individual enterprises in specific markets, the national or locational base from which enterprises operate also helps or hinders their competitiveness. Underlying locational determinants of competitiveness include the regulatory environment, the cost, availability and quality of labour, the cost and quality of infrastructure, the comparative burden of taxation, societal attitudes to business and so on. In helping to understand the growth of the Irish economy it is useful to refer to three measures of competitiveness, *viz*:

i) Country rankings as set out in the *World Competitiveness Yearbook* of the International Institute of Management Development (IMD) in Switzerland;

ii) Indices of changes in unit wage costs in manufacturing industry; and

iii) Productivity trends.

World Competitiveness Scoreboard: The IMD *World Competitiveness Scoreboard 2001* ranks Ireland seventh in the world in terms of overall competitiveness for business. Ireland's attractiveness rating is ranked sixth in the world for venture capital and fourth for availability of credit from banks. The country ranks second in GDP growth (9.9 per cent in 2000).

Relative Unit Wage Costs: The competitiveness of the Irish economy, as indicated by relative wage costs in manufacturing industry, has also improved sharply over the past decade and more.

Productivity: One of the most significant features of the growth of Ireland's economy in recent years is the contribution that productivity — defined as GDP per capita — has made. The remarkable increase in productivity has been driven, in turn, by the development of the *high–tech* sectors of the economy and, in particular, the chemicals/pharmaceuticals, electronics, electrical engineering and computer–software sectors. These sectors now account for over 25 per cent of GDP and are the sectors on which the equally remarkable Irish export growth has been based. Today, high–tech exports account for some two–thirds of total exports from Ireland compared with some 40 per cent at the beginning of the 1990s.

Public Policy Agenda Driven by the Needs of the Market–Trading Sector

The trade–dependence of Ireland's economy drives the public policy agenda to a considerable extent. Ireland is highly supportive of an open international framework that promotes, encourages and facilitates trade between countries. For that reason Government policies operate a non–restrictive regulatory framework in respect of capital flows; support an extensive range of trade–facilitating and investment–supporting double–taxation agreements with other countries; and promote a well–developed and competitive financial services industry that is also trade–supporting. Public policy also accords a high priority to the development of an internationally competitive logistics sector — encompassing infrastructure, a high level of services to firms engaged in international trade and the incorporation of service–enhancing and productivity–increasing information technology innovations within the sector.

Foreign Direct Investment (FDI): Key Component of Ireland's Economic Growth

The promotion of export–oriented FDI projects has been at the centre of Irish economic development policies for some 40 years and remains so today. The underlying rationale has been to fast track the development process in a relatively late–industrialising country through the transfer of knowledge (technological, marketing, project financing, managerial) to the private and public sectors in Ireland from globally competitive firms in selected high–growth sectors. The wider public policy agenda has been shaped, to a considerable extent, by the need to meet these objectives.

The reasons for this are clear. A fundamental basis for FDI by any firm relates to the return on investment that it makes in particular locations. The return on FDI for firms that locate in Ireland is, perhaps, the highest in the world. The United States is by far the largest source of FDI in the world and also accounts for the largest share of FDI in Ireland. US Department of Commerce data show consistently that US firms achieve a higher return on investment in Ireland than in any other European country.

A proven high rate of return on investment is a key factor that helps to explain Ireland's success in attracting FDI. It is a function of a complex of interrelated elements. They include a geographically strategic location in Europe at its closest point to the United States, a pro–business regulatory and government policy regime, a flexible and well–educated labour–force and the agglomeration economies associated with a well–established, globally trading, high–tech industry sector. These agglomeration economies include a shared knowledge base, infrastructure, supply linkages, relevant educational curricula and a labour market which has expanded and deepened considerably in the skills in demand to support high–tech industry.

As a location for FDI in the high–tech projects that drive high–income, sustainable economic development, Ireland competes mainly with other European locations rather than with countries in the Far East or other significant destinations for global FDI. Ireland accounts for less than one per cent of the population of Europe, but the share of European–based FDI it attracts is a multiple of its population share. Commissioned research indicates that for FDI projects in software, call/customer–contact centres and shared services Ireland has the highest market share in Europe.

E–Business Investment: A Further Evolution of the Development Process to Serve Global Markets

The development of Ireland as a significant world e–business centre is a further evolution of its development process. For more than 25 years Ireland has been an international centre for investment in the electronics and related industries.

— Today over 300 major electronics companies develop, market and manufacture a wide range of leading–edge products in Ireland. They generate over one–third of total exports and employ over 60 000 people.

— Ireland is the major centre in Europe for software localisation and production. Five of the world's top ten independent software companies have major operations in Ireland. Today Ireland is the largest exporter of software products in the world. Over 40 per cent of all PC package software and 60 per cent of business application software sold in Europe is produced in Ireland.

— Ireland is also the leading European country in attracting call and shared–services centres.

Building on the significant base of activity related to e–business already in place, Ireland is today developing as a major international e–business centre. Already, a range of important investments have taken place in data–hosting projects, e–service provision projects, the manufacture of e–business technology platforms, e–business security services, e–business content projects, e–business trading and procurement projects and e–business system integration projects. These projects have been developed both by the existing base of business projects in Ireland in the fields of electronics, software, call centres and shared–services centres and by new FDI projects from internationally trading firms coming to Ireland for the first time.

Ireland as A World E–Business Centre: The Six Pillars of Success

The attraction of Ireland as a base for e–business projects rests on six main factors:

— An existing base of significant investments in e–business related activities;

— A proven high return on investment for globally–traded businesses, including those engaged in projects related to e–business;

— The availability of people with the high skills and qualifications needed for e–business;

— A high–quality telecommunications infrastructure with competitive prices;

— A highly supportive government and legislative framework for e–business; and

— High–specification R&D programmes supporting e–business.

I would like to expand further on two of these factors: people and infrastructure.

A Young, Educated Workforce. The availability of a plentiful supply of well–educated and skilled young people entering the labour force, both at present and in future years, places Ireland in a strong position for future e–business and technology projects. The proportion of the population less than 25 years of age in Ireland is higher than in any other EU country. The quality of the labour force reflects the high value widely attached to education and to the acquisition of skills and qualifications within Irish society. It reflects also a long–run emphasis in public–sector policies on providing universal (free) access to educational opportunities beyond the primary school level — first at the second level in the mid–1960s and subsequently (in the early 1990s) at the third level. In addition, the significant increase in the educational attainment of the work force over the past 20 years has helped contribute greatly to an increase in average skill levels and productivity.

A High Quality, Competitive Telecommunications Sector. Good telecommunications infrastructure is the basic foundation on which e–business and future industries are built. The first fully digitalised telecommunications system in Europe was installed in Ireland in 1980 through the then State–owned incumbent telecommunications company. In recent years the challenge and opportunities posed by e–business gave rise to new government thinking on the development of the telecom sector and a strategy based on four fundamental and inter–related pillars:

— Increasing and upgrading international broadband connectivity at reduced prices to customers;

— Country–wide rollout of broadband infrastructure and services;

— Increasing the level of competition and deregulation of the telecom sector; and

— Putting in place the legislative framework necessary to facilitate e–business activity.

Countrywide Roll–Out of Broadband Infrastructure Services. To complement the upgrading of international broadband connectivity now in place, the Government is working with telecom companies and infrastructure suppliers active in the Irish market to achieve widespread broadband connectivity to all parts of the country with the aid of a IR£150 million (US$180 million) incentive programme. Every industrial estate in the country will have direct access to top–class broadband infrastructure with the roll–out of 20 000 km. of fibre–optic cable around the country. In addition, satellite–based broadband services are being targeted at remote areas, including offshore islands.

Increasing Competition and Deregulation of the Telecom Sector. A pro–active approach to the deregulation of the telecom sector has been a central feature of the Government's e–business development strategy in recent years. Competition already has ensured that over 15 per cent of the fixed market has transferred from the existing incumbent telecom company to new entrants. Prices have fallen and quality has improved significantly. The mobile market is growing at the third–fastest rate in Europe with a 70 per cent increase in penetration in the year to June 2000. Mobile market penetration is now up to 50 per cent. Mobile phones have already surpassed fixed PSTN lines as the most common means for voice communication. The significant increase in international connectivity being put in place in Ireland is already beginning to impact positively to reduce the cost of international voice and data transfer from Ireland.

Conclusion

The evolution in information and communications technologies is, *inter alia*, transforming the way business is conducted. The process of transformation is beginning to accelerate as people and business enterprises begin to understand and recognise the way in which a "new economy" is emerging. This "new economy" is characterised by a number of features, of which the following are among the most important:

— The "new economy" rests firmly on the advances and innovations that have taken place in *information and communications technologies* and that can be encompassed in traditional social and economic activities. These activities can, simply, be undertaken more effectively with the support of the new technologies, or they can be transformed into completely new activities in the process.

— The *price of computer processing power* has been falling at an estimated annual average rate of one–third over the past three decades — a multiple of the rate of fall in the price of previous generic technologies such as steam, electricity and internal combustion engines. This has helped to bring about a situation in which the *pace* at which information and communications technologies is being absorbed into social and economic activities is far higher than was the case with previous economy–transforming technologies.

— The applications of the new technologies are *pervasive* — encompassing most sectors of the economy including manufacturing, agriculture, transportation and the services sector. They hold immense potential to boost *productivity* in the services sector (e.g. in retailing, health services, education services, government services, financial services and so on). Because the services sector accounts for the greater part of economic activity in all developed countries the potential impact on overall productivity is profound.

— The new technologies facilitate greater *transparency*, *competition* and *information availability*, and thereby, greater *efficiency* in markets.

— The new technologies accelerate the process of *globalisation* of production, capital markets, knowledge and entertainment through reductions in the cost and increases in the speed of communication between organisations and people.

— The new technologies accelerate and enhance the process of *innovation* by facilitating, for example, the manipulation and analysis of large banks of information.

These developments pose a particular challenge for governments and call for new methodological approaches to policy formulation — in areas as diverse as education, training, deregulation and competition policy, investment in infrastructure, R&D, taxation and international co–operation. The government in Ireland is acutely aware of these issues. It has gone some distance towards addressing them and I have attempted to sketch briefly the approach adopted in a number of areas. As indicated, some degree of success has attached to the approach adopted, including in the area of e–business promotion and development. Complacency is, however, the ultimate potential enemy of success in the "new economy". Accordingly, Ireland as yet makes no claim to success. It acknowledges only that a journey has begun.

Intellectual Property Protection: What Role in the 20th Century History of Innovation?

John Kay

I have to say I feel I'm here as something of a fraud. I've never regarded myself as an expert on development, but I have always rather fancied myself as an intellectual and, in common with most intellectuals, I rather like the idea of intellectual property. It has a ringing sound about it. It's something for me.

I started to have doubts, however, when I was involved in a dispute in the United Kingdom over copyright in television listings — printed schedules of what will be on television each day. It occurred to me that in terms of intellectual creativity, in a country that had produced the plays of William Shakespeare, the poems of Keats and the novels of Jane Austen, television listings did not rank very highly in terms of their creative contribution. It also occurred to me that even if it were determined that broadcasters had no copyright in television listings, it was unlikely that they would wish to withhold knowledge of what was on their television programmes from the public at large, i.e. the listings would be produced and disseminated anyway. What I found particularly interesting was that neither of these arguments were of any relevance whatsoever to the legal position that governed intellectual property.

I then noticed that, while the broadcasters did have copyright in these particular listings and derived substantial amounts of revenue from them, they obtained that revenue by using their exclusive access to them to maintain a position in distributing and selling magazines called *Radio Times* and *Television Times*. They created commercial monopolies in other areas on the back of their intellectual property rights. So these intellectual property rights did indeed create substantial profits for particular firms. I also noticed, however, that Shakespeare, Keats and Jane Austen had derived no benefit of any kind from intellectual property legislation. Indeed, the conclusion to which I've been gradually coming is that while it's a nice sounding phrase, what is called "intellectual property" is really neither intellectual nor property.

To pursue this further and to give us something to talk about this morning, I asked some of my scientific colleagues what they regarded as the most important contributions to knowledge, the most important innovations of the 20th century. The three they came up with were the following: Einstein's theory of relativity, the invention of computing and the structure of DNA. I then asked the economist's questions about these innovations: who paid for them and who benefited from them?

Well let's ask first who paid for them? Start with Einstein. He invented the theory of relativity whilst employed as a civil servant, a clerk in the Swiss government patent office. He was actually employed there — and this will be relevant later — because he had failed to get a university job in Germany or Switzerland. He did manage to get a job, I'm pleased to say, after inventing the theory of relativity, and he spent the rest of his life as an employee in universities in Germany and the United States. Einstein, after discovering relativity, had a pleasant and comfortable life, although not perhaps the pleasant and comfortable life that one would expect to enjoy as the chief executive of a high–tech company. There was no personal office, no chauffeurs, certainly no corporate jets, but a comfortable enough life all the same, paid for from his university salary and the hospitality of those who valued his intellect and his presence.

Let's go on to computing. Perhaps I should explain what's at issue here. Bill Gates, contrary to common belief, did not invent the computer. But who did? The person with the strongest claim is probably Alan Turing. What Turing invented, back in the 1930s, was the idea of computing. Of course, calculating machines had been around for a very long time. The key insight of AlanTuring was that if you could do a sufficiently long string of calculations sufficiently quickly, you would be able to do things that were almost indistinguishable — some people think *actually* indistinguishable — from the functioning of the human brain.

Turing created this conceptual structure in the 1930s. He was then part of a team who developed the first computer, at Bletchley Park in Britain during the Second World War. It was part of the remarkable Allied success in cracking German codes. Ask again the economist's question: who paid? Turing's initial work was done while he was employed in the University of Cambridge, as a fellow of King's College. For the rest of his short life — Turing was a deeply unhappy man who ultimately committed suicide — he was a civil servant employed by the British Government.

My third major innovation is the unravelling of the structure of DNA. A British post–graduate student, Francis Crick, and an American post–doctoral fellow, James Watson, did this, again in Cambridge, in the 1950s.

In short, universities and governments financed the major scientific advances of the 20th century. Intellectual property did not play much of a role in them. Indeed, not to put too fine a point on it, it played no role, whether in stimulating these inventions or in rewarding the people who made them.

When I've put that argument before, people have said to me, well, what you are talking about is fundamental, basic scientific knowledge, and intellectual property is not about that. Intellectual property is for products rather than about knowledge. Well, maybe that's right. So I reframed the question to my scientific colleagues. What were the most important product innovations of the 20th century? In discussion, they came up with four: computers, antibiotics, television and transistors. So once again I asked the economist's questions. Who paid for these innovations? Who benefited from them? Computers, I've talked about already. So, let's go on and look at the other three.

We'll start with antibiotics. How were antibiotics discovered? Who paid? There is a rather strongly British theme to these particular innovations, and I honestly wondered when setting all this down whether there was actually some bias in my selection. Having been over it carefully and discussed it again with colleagues, I really don't think there is. It truly is the case that the British contribution to major 20th century innovations is disproportionate.

The first antibiotic, penicillin, was discovered by Alexander Fleming, a professor in a London teaching hospital, a quarter of a mile from where I live. Fleming was a somewhat idle person who discovered it by accident. Some of the materials in his laboratory hadn't been cleaned out properly and mould grew on them. That laziness went a bit further because even after penicillin had been discovered, it was ten years before major follow–up work was done. That's deeply significant, because in retrospect we know that the discovery of antibiotics was — perhaps along with the computer — the most significant *commercial* innovation of the 20th century. Notwithstanding that the basic principles had been established very little was invested in developing the concept. If you ask who did, ultimately, fund such development, the answer is that it was the Rockefeller Foundation, an American philanthropic foundation, which sponsored research by Howard Florey and others at Oxford University that created the first administered antibiotics. Further, research funded by Rockefeller and government during the Second World War led to the development of a whole variety of antibiotics, which essentially eliminated infectious diseases as a cause of death in otherwise healthy adults in the West. So the basic funding for the development of this activity came from a charity, and Fleming and Florey again spent their careers as employees of either British hospitals or British universities.

Now let's turn to television. Who paid for television? Well, every encyclopaedia will tell you that yet another Briton, a Scot this time, John Logie Baird, invented television. The truth is that Baird's television did not work very well. Television was essentially invented simultaneously, as sometimes happens with major innovations, by many people in many countries at about the same time.

Take the United States for illustration. There were two major strands of development. For the inventive strand, the person who should probably be credited with inventing American television — what a thing to be credited with — is a gentleman by the name of Philo Farnsworth from Utah. Certainly, it was to Philo Farnsworth that the US patent office finally awarded the major United States patents for television. They awarded them after interminable disputes with the Radio Corporation of America. RCA was by far the largest provider of radio programmes in the United States. It repeatedly claimed to have invented television. The US Patent Office and the US courts found very little merit in this claim. Indeed RCA's chief executive at the time is reported to have said, "Our policy is that we don't pay royalties in this company, we receive them", and that did indeed seem to be their policy. Anyway, they sued everyone else involved in the television business. They lost in the courts, but they did manage to reduce Mr. Farnsworth to penury. He ultimately sold the patents he had been granted in television to RCA for a modest sum.

One aspect of this saga is reproduced often in the modern intellectual property world. The returns from intellectual property rights went not to those who had the greatest capacity for innovation, but to those who had the greatest capacity to pursue legal processes in order to claim intellectual property rights, deserved or otherwise.

The last product innovation I want to take this morning is transistors. Transistors are probably the most important 20th century innovation to have come out of a commercial laboratory. Bell Labs in New Jersey discovered the transistor in 1947. Bell Labs were of course then the research arm of the American Telephone & Telegraph Company (AT&T).

Yet that's a very interesting case because Bell Labs were a very peculiar kind of commercial research laboratory. They were actually prohibited, by antitrust agreement, from conducting research in ways that would benefit the parent company. The result of that was that when the transistor was invented in Bell Labs, what Bell Labs did was to grant licenses to develop this innovation to around 30 companies around the world, for nominal sums. Most of the subsequent development of the transistor occurred in Japan and in spin–off companies established by Bell Labs employees. As a result of being able to take away his employer's intellectual property and build his own company around the innovation that he developed while in the employ of Bell Labs, William Shockley became the *only* inventor on my list who became what my City of London friends would call seriously rich.

The issues in and around intellectual property are a good deal more complicated than normally presented. I think that, in one aspect or another, every one of the cases I have taken illustrates that. Yet the common thread is that as far as major innovation is concerned, intellectual property issues are *not* very important. The creation of intellectual property rights does not seem to have had much to do with the ways in which these 20th century innovations evolved.

An argument — it's quite a subtle argument — says that intellectual property is not very important for big innovations but is important for small innovations. I think that argument is actually wrong, but it would require more time than I have to deal with it. The blunt fact is that most major innovation is actually funded either by the State or philanthropically. That is true of virtually all the innovations that I have described this morning.

Nevertheless, one needs to be very careful about that, because we also know that centralised State control is something that stifles innovation. Centralised State control of the innovation process has in history produced nonsenses like Lysenkoism. It is striking that, despite the rather high quality of most Russian medical services, Russia produced nothing of much significance in the way of new pharmaceutical products in the course of the 20th century.

Indeed, the need for pluralism in this kind of support for innovation is illustrated forcibly by two cases I have cited. Einstein failed to get a university job because he was regarded as a difficult person (as it's quite clear he was). On that account he got poor references from the professors who had taught him in his undergraduate and post–graduate studies. It's unfortunately the case — true of most of the characters on my list — that people who are highly creative innovators are often awkward people to work with and difficult for big organisations, especially tightly run commercial organisations, to cope with. Einstein was able to develop his theory only because he got a job in the Swiss patent office. Like many government jobs, it was not particularly demanding and allowed him to develop the theory of relativity in his spare time. Crick and Watson weren't supposed to be doing research on DNA at all. The money allocated for that kind of work had been sent somewhere else and Crick and Watson were being paid to do quite different kinds of research. In these two cases, only the ability of people to defy the central organisation of research enabled them to produce what they did.

Let me sum up with some final lessons. The rationale often presented for intellectual property regimes — that they are needed in terms of rights and justice for creative individuals — is extremely tenuous. The individuals whom I've described, the most scientifically creative individuals of their century, got very little out of intellectual property regimes. The people who *have* got a lot out of intellectual property regimes are people like Harold Robbins and the songwriters of "White Christmas". In terms of rights and justice for creative people, the current intellectual property structures we have don't achieve a great deal.

That doesn't mean that we shouldn't have intellectual property structures. I think we should, but we should understand that the rationale of intellectual property regimes is as a mechanism of economic regulation. Such mechanisms need to be very carefully designed, because they may stifle innovation as much as they stimulate it. What we need is a judicious balance between incentives and opportunities. The class of intellectual property that our current rules protect is far too narrow. The areas in whichintellectual property legislation matters for economic activity are very limited, and the legislation we have gives far too much protection to those things that it does protect. The result is that intellectual property, in the television–listings case, is largely a matter of finding a basis for the establishment of commercial monopolies.

It's conventional, as you know, for academics to end their papers by saying that more research on the subject is needed, but for what I'm talking about this morning I think that is true. There is an enormous amount of discussion of intellectual property, based — to my mind with very little justification — on assertions and claims about a structure of rights and justice. Alternatively, claims are made about balances between incentives to innovate and incentives to disseminate, which are not justified by reference to any empirical analyses of the relationship between innovation and the exploitation of intellectual property rights.

I don't believe that my ideal world would be one in which there were no intellectual property rights. If forced to choose between the intellectual property regime we have today and none at all, however, I'd be tempted to go for none at all.

Technology Policies and Investment Strategies

Yoginder K. Alagh

Introduction

This paper addresses selected issues on technology, investment and policy strategies for widespread growth of a kind which builds–in poverty reduction, in the sense of significantly reducing food, energy and related income/employment gaps, in low income countries in the Asia–Pacific region. The methodology it follows is bifocal. It takes three case studies of success, the first being agricultural growth in fragile agro–ecological regions, the second artisan–based industrialisation linked with regional and global markets and the third a recent experiment in wiring villages with information technology to source knowledge in the growth process. The technology, income, food, and energy outcomes are described. At the second level, however, our interest lies in how these case studies reveal organisational structures, human and related resource–development strategies, market frameworks, incentive and disincentive mechanisms and macro requirements for widespread replication[1].

The paper takes the approach that that micro and macro policies have to be harmonised for widespread growth of the poverty–reducing kind to take place. This is discussed extensively, but not practised enough. The power of decentralised markets to facilitate such growth on a larger scale has to be enmeshed in strategic policy initiatives to energise it and to resolve the inevitable problems that arise. These broader perspectives are discussed, for example, in Robert Wade's well–cited paper (1992) on East Asia's economic success, which interestingly begins and ends with a quote on strategic intervention from a paper in the ADB's *Asian Development Review* (Alagh, 1989). In a later contribution Stopford (1994) repeated the same quote in order to emphasise that instead of sectoral intervention (picking out winners?) the need now is for a dynamic perspective on labour skills, innovation and developing the market places of the future. The importance of macro policies consistent with poverty–removal strategy is underscored by the contributions of the President of the OECD Development Centre and the Vice President of the ADB to this volume. For broad–based growth of the kind discussed in this paper, we would add policies for the development of markets, financing, information and communication infrastructure. The paper by Bussolo and O'Connor in this volume also underlines that institutional issues are central in integrating technology with poverty–removal strategies.

Sustainable Livelihood for the Marginalised

Consistent agricultural growth over a period leads to declines in rural poverty in the areas where such growth takes place. The so–called Green Revolution areas are a case in point. Agricultural growth of over 3.5 per cent annually for two decades or so invariably led to critical elimination of hunger and significant declines in poverty levels. Yet such growth took place in areas with good soils and assured rainfall or irrigation. FAO studies showed that the elasticities of cropping intensively and of land productivity with respect to irrigation were around 0.3 and above 0.5, respectively, so assured water supply was land–augmenting (see FAO, 1993). Hayami (1981) showed that this kind of growth raised the demand for labour, employment went up and poverty levels declined. The model of atomistic peasant agriculture worked here. The benefits of state–supported agricultural research could reach the farmer if land rights were established. Input and output disposal markets worked because irrigation technology and market support were very much a part of this strategy. Yet it worked only in selected areas.

Policy in India, for example, worked around it (see Alagh, 1988, 1989 and 1991*b*, and Planning Commission, 1989). In the early 1980s some critics called this the favoured–crop, favoured–region model. Another critic described the planning of this strategy as limited and linear thinking. The problem arose in areas where the initial favourable conditions did not exist. These areas were bypassed in the growth process. In India, in the first phase of the Green Revolution, growth was negative in a fifth of the districts, and in another two–fifths it could not keep up with population growth. In Sahelian Africa, many countries in the rest of Africa and some countries in Latin America, the situation was worse and continued so. The prime issue for institutional development and policy is to reverse this process. With all the advances made in understanding the organisation of agriculture, technology and resource management, the persistence of mass poverty and hunger presents a striking contrast with claims of universal progress.

An interesting aspect of these problems is their relationship with environmental problems. These are "fragile eco–regions". They are the arid and semi–arid regions described in the FAO–UNESCO *Agro–Economic Zoning Atlas* (FAO, 1978/81, 1982). They are the hill slopes with declining tree cover and rainfall causing soil erosion. They are the coastal areas with disappearing mangroves. They are the saline lands and the problematic soils. As in the plateaux and arid regions in India, communities had through time established a balance in these areas between carrying capacity and human need. There was poverty, but there were also time–honoured practices of sustaining the fragile resource base with activities, technologies and customs evolved through centuries of experimentation and adaptation. In the last century, dramatic reductions in mortality and resource demands from outside have rudely shaken the carrying–capacity balance of such areas.

Very little organised work is available on successful models under these conditions. In the late 1980s, an attempt was made in India to build up a set of best–practice cases that had worked. I summarised them in work done for starting an agro–climatic policy exercise in India and in a book written for WIDER (Alagh, 1991*a*). The cases had some common characteristics. The economic rates of return to investment were high — over 18 per cent on the investment made. Substantial food and energy deficits of the rural communities studied were met (Table 1). The technology consisted of land and water development followed by the introduction of appropriate "cropping" sequences. On the hill slopes it involved watershed development, contour building, gully plugging and work along the ridge contours. In coastal areas, it was aquifer management; in saline waterlogged soils, soil amendments and drainage. Vegetation cover was a part of the strategy. Appropriate tree cover for consolidating soil and either tree crops or the "recommended" crops followed the land and water development strategy. Generally a two–crop sequence or tree cover, either of which helped further to consolidate the soil, substituted for a low–yielding cereal.

From the replicability angle there were some interesting features. Leadership at the community level was important in all these cases. Generally the leadership group had some science background. The leaders were from NGOs or social–work organisations, retired army personnel, civil servants and in one case a farmer. The technology for land and water development was generally available in the institutions of the region, although some local adaptations were made, in the saline waterlogged soil–reclamation project, for example. In each case the major work was at the community level. Individual landholders had to co–operate for well–defined purposes. In fragile agro–ecological regimes, limited co–operation is a precondition for land and water development strategies to succeed. If one farmer stays out, the contour bounds of the others will be washed out in the next monsoon. The atomistic model alone cannot work here. The success stories inevitably involved a period of basic education and group consciousness.

The economics of these efforts led to interesting questions. While these projects had high internal rates of return on the investments made, they ran financial losses. Generally markets were weak in fragile regions, output prices were lower than border prices and input prices higher. In the initial phases land productivity levels also are lower and improve as the effort proceeds and the organic composition of the soil improves. Sometimes low–value productivity crops are needed to improve soil composition. While generating employment or improving access to food and energy, such activities need initial subsidies. Ignacy Sachs (1991) suggested that these be funded as "front–up costs" in his summary paper for the Hague Conference[2].) In his paper Sachs asked for "…a welcome shift from crop oriented policies to production systems oriented ones, with special emphasis for the needs of small farmers." He pointed out that "Alagh [1991*a*] gives many examples of watershed development projects with a short payback period. The techniques for such projects are well known and their impact at the level of the community would be very favourable. Yet they need public funding for the "front–up" costs. Alagh argues in favour of an agro–climatic planning in terms of alternative agricultural and farming systems, in order to overcome the shortcomings of a favoured crop–region approach."

Table 1. **Selected Characteristics of Watershed Development Projects in India**

Name	Land/Water Development Cost Rs/hectare	Current Input Rs./hectare	Annual Return (Amounts are in Rs/hectare)	Remarks
Naigaon	11 364	2 809.56	912	
Sukhomajri	22 221		7 979	Benefits include those to village and government, agriculture, dairying, fisheries and fodder. IRR was 19 per cent.
Samithed	1 500	n.a.	n.a.	Returns are in terms of plantations, rise in water table and fodder on 312 acres of land; 78 000 saplings.
Ralegaon Sidhi	9 689	n.a.	n.a.	Drinking water available within 100–150 metres of each household.
Tejpura	4 246	816.8[a]	3 764	Doubling of *bajra* and *jowar* yields: 70 crossbred cattle are given green fodder.
Mittemari	2 030	n.a.	n.a.	Incremental income of Rs. 2 540 per household as compared to control village.
Sikandurpur and Kotpurva	11 220	10 825	255 days of grain requirement for a family plus 400 days of fodder for pair of animals	Saline Land Reclamation Project
Sikandurpur and Kotpurva	11 220	10 825	255 days of grain requirement for a family plus 400 days of fodder for pair of animals	Ussar Reclamation Project

a. Additional.

Source: Alagh (1991*a*).

This was integrated in Agenda 21 and the Rio Conference. The effort by community–level agencies is now such that in countries like India the approach is no longer at a pilot level but is the beginning of a movement. The literature on case studies I initiated has been flatteringly duplicated, and the table I presented of eight cases (Table 1) has been replicated for over fifty efforts (Chopra and Kadekodi, 1993). More important, the largest NGO supported by the EC in the land and water field (Sadguru in Panchmahals) and another group supported by a German programme (WOTER in Ahmednagar) put 124 316 acres under tree cover, as verified by independent evaluations. This is just a little less than the tree cover lost in India in the years 1990–95. (For a World Bank assessment, see Lele *et al.*, 2000.) The EC–supported group, the advisory committee of which I chair, has recently completed a training programme for Sahelian tribal leaders supported by NORAD and the Agha Khan Foundation.

The requirements, however, are not in hundreds of thousands but millions of hectares. Government support for such programmes in India has just about kept constant. International support has gone down. This was a period of “economic reform”. Why do we find it difficult to help those who help themselves even in the core areas of local and global concern? As preparations for the Kyoto meetings showed, we are well behind the Rio targets in the interrelated areas of land, water and energy.

While the institutional issue has been the focus here, the technology questions are also present, particularly in the recent phase of biotechnology possibilities. As discussed earlier, in fragile agro–ecological regions, tree crops can be important in diversification away from low–productivity cereals. An interesting experiment in India has been the creation of a very large tissue culture facility for tree crops. Claimed to be the largest in the world, this facility has been created in the private sector by the Tata Energy Research Institute (TERI), with a grant from the Indian Department of Biotechnology of the Ministry of Science and Technology. TERI is grappling with a delivery mechanism for farmers in different agro–climatic regimes. A possibility under experiment is the creation of biotechnology parks for small entrepreneurs, who will be the vendors.

Technology for widespread agricultural growth is leading to interesting organisational innovations. Another “mission”–oriented project in this context has been the Hybrid paddy project, conceived as a goal for Indian agricultural scientists when the Indian seed market was liberalised in the late 1980s. The project was planned as a consortium of public and corporate entities as follows:

A. Private, including MNCs

1. Hybrid Rice International Co.
2. Mahyco Seed Co.
3. SPIC PHI Biogene Co.
4. Hindustan Lever Ltd.
5. Vikki’s Agrotech Ltd.

B. Public

1. DRR/KVK Gadipally
2. Department of Agriculture, Tamil Nadu and EID Parry Co.
3. Karnataka State Seed Development Corporation
4. A.P. State Seed Development Corporation
5. Department of Agriculture, West Bengal and Pallashree Seed Co.

Local, National and Global Rules

The problem of imposing a hard budget constraint at the local level and helping those who help themselves is a difficult one to address. Another way of setting the problem is as one of harnessing the great vitality of decentralised markets in replicating widespread rural growth within the core areas of local and global concern. Some of the lessons that result are as follows.

— Financial institutions must design structures such that community collateral is possible for viable projects. Self–help financing groups are only one such structure. Land and water development groups, local infrastructure projects in the road or communication sectors (Alagh, 1999*a*), bringing products developed in R&D institutions into production, training for production with improved techniques and market development schemes developed by local and community groups would be other examples (ADB, 2000).

— Lending through a weather or project cycle would be necessary. The Indian National Agricultural Bank started a scheme of this kind in 1991 as part of an agro–economic regionalisation strategy started by the author, gave it up in 1993 and is starting it again now (see Reserve Bank of India, 2000, for details).

— It is reasonably certain that problems are going to arise in development experiments that are off the beaten track. The question then arises whether there is somebody in the policy decision–making structure who will sort out the problem. A solution is to develop policy "champions" for sorting out administrative, financial and procedural issues at local, regional and national levels, when such problems arise with these kinds of development strategies. ADB (2000) reports in a detailed study of farmer–managed irrigation systems that the failure cases were those where such support did not exist. Failure here is defined as performance levels in water delivery lower than those of government agencies. These kinds of problems arise partly because the existing legal and administrative systems and financial rules are structured for formal organisations in the public or private corporate sector. So are global financial institutions. The newer kinds of institutions with strategic mixtures of organisational styles — co–ops and corporates, NGOs and government, NGOs and co–ops — do not have a level playing field (see Alagh, 2000*a*, for an attempt to develop a new legislative framework for co–operatives to incorporate as corporate entities). For example, a loss–making, subsidised electricity system can underprice a renewables group and drive it out of the market. The long–term problem is reform in the sense that subsidies and protection given to established groups have to be withdrawn. In the short run the protection given to each group must be the same.

— The structure of incentive and disincentive systems for this kind of growth should begin with a taxonomy of complementarities of policy rules at different levels of policy making — like no level can spend more resources than it has access to. Yet resources, which are short or binding constraints at national or global levels, are elastic at local levels, although their mobilisation requires policy changes at higher levels. For example, it is easy to buy a tax–free New York City bond, but very little attention has been paid to markets for local bodies' bond paper in developing countries and the fiscal reform that has to precede them (see Vaidya, 1999, for a description of an exceptional effort in Ahmedabad and the difficulties faced.)

The last three problems essentially signify that the reform process has to be fairly deep–rooted for widespread land– and water–based poverty–reducing growth processes to take place. The kind of growth discussed meshes well with higher output, income, employment and trade. Improved management of water leads to crop diversification. In the typical sequence, a poor–yielding, mono–inferior cereal is succeeded by a high–yield cereal and a commercial crop or tree crops. In the Indian case, exchange–rate reform led to higher growth of agricultural exports before the East Asian crisis cut down demand in the fastest–expanding markets (Alagh, 1995). Recent evidence shows that the districts that are sources of non–traditional exports have gone through a phase of land and water development sequences (Alagh, 1999*b*).

Artisan–Based Development

Serious research during the last decade and a half has shown fairly conclusively that the tremendous opportunities available with the new technology require groups and systems able to manage its interdisciplinary nature, because applications cut across areas like biotechnology, communications and computerisation. If the preconditions are available the technology spreads very fast, through both space and sectors of the economy and society. If the physical and human infrastructure is not there, however, vast areas will be left out, including some in the developed world. There is also the need for quick response. As Ricardo Petrella of the EC's FAST Group pointed out, each generation of innovations builds on the corpses of earlier ones (Petrella and Granrut, 1992). State and parastatal agencies find it difficult to perform in this framework.

Major think tanks working on the character of the Neo–Fordist technological revolution, like the FAST Group of the EC, the flexible industrial specialisation networks and others have emphasised the strong compatibilities with networking and decentralisation. As the Science and Technology Minister of India, I convened for UNESCO a Prepcom meeting at Bangalore for the World Science Conference at Budapest. The Bangalore Declaration strongly reiterated that the spread of technology was an institutional and not just a technology issue. Small, flexible groups responding to needs are effective. The need for partnerships of community initiatives to back those who work is again obvious.

The Industrial Districts literature in the OECD countries gives many examples of this kind of growth. The original Piore–Sable case of fashion garments in Emiglia Romana was flatteringly replicated for leather goods in Lyons, furniture in Denmark and sports goods and gold jewellery in Valencia. The literature on standardisation and lean production also falls in this category (Sengenberger and Pyke, 1992; Pyke, 1992).

These kinds of developments were not supposed to have much relevance in poor countries, but recent work shows that artisan–based responses to national and global markets can be powerful sources of growth. In any case, they are not insignificant in exports from poor countries. As much as a third of India's engineering exports are attributed to them. A recent case study of a small town of Trichengodu in a dry and backward region of India showed how satellite dish antennas and garments for global markets and truck bodies for the domestic regional market became a powerful source of growth, almost doubling industrial employment and generating a $250 million increase in output. A large part of India's diamond cutting comes from the town of Surat, which had less than half a million in population when the expansion started now has around three million (Table 2). India is the largest exporter of diamonds in the world.

Table 2. **Demographic Characteristics of Surat City**

Year	Population (million)	Workers (million)	Growth (annual, in per cent)	
			Population	Workers
1971	0.47	0.15		
1981	0.91	0.32	6.84	7.80
1991	1.52	0.52	5.20	5.10
2001	2.81		6.61	

Source: Misra and Misra (1998).

The success studies here involve training and improvement of inherited, community–based artisan skills. The organisational pattern is generally based on fierce competition between small firms, with considerable mobility between self–employment and wage labour. The communities (castes in India) also engaged in training and skill enhancement, access to larger markets through traditional networks and technology enhancement, for both production and markets/communication. A Surat diamond–cutters study (Kashyap and Tiwari, 1985) found the following:

— An organisational structure of distribution, processing and markets based strongly on trust, with the roughs (*passas*, as they are called) and polished diamonds changing hands without any written documentation;

— Constant upgrading of technology on the production side, with hand polishing giving way to semi–automatic tools;

— Intense competition and mobility in the lowest polishing formations;

— Community (caste) based training efforts of a decentralised nature in each *Taluka* (sub–district town) centre in Gujarat.

Similar characteristics have been recorded in the Thrichengodu case (Box 1) (Houllier *et al.*, 1994) and the gold thread industry (Desai, 1995).

Box 1. **Tiruchengodu: A Profile**

Turuchengodu is located in the Salem District of Tamil Nadu in South India. It is a dry, rain–shadow, backward region. Population growth from 1971 to 1991 was 71 per cent, as against an average of 37 per cent for its size–class of towns. Its low sex ratio shows a highly male–selective immigration pattern. The number of electricity connections per thousand of population for industrial and commercial purposes was much higher than for the district capital of Salem. It has strong inherited artisan skills, caste–level training and education centres. The major industries are textile garments, truck bodies (for which it is now India's second–largest centre), satellite dish antennas and truck/rig operation (5 000 truck/rig units work in dry regions of central, western and south India). Garments and satellite dish antennas are produced mainly for export.

Source: Houllier *et al.* (1994).

Kashyap and Tiwari (1992, 1998) found that a strong centralised promotion policy with product identification, financing, protection and technology support does not work. The proper strategy is to help those who help themselves, with support of local efforts to access market information, working finance, standards setting, skill enhancement and family welfare and worker health measures. The employment and poverty–reduction results of such strategies are dramatic. In Gujarat's case, poverty levels went down from around 38 per cent in 1972 to 18 per cent in 1997. High immigration into Surat has been noted (Box 1). Much the same kinds of approaches are necessary in diverse fields like education, health, urban problems and the larger debate on industrial restructuring policies. (See Lance Taylor's description of these structures in his *Rocky Road to Reform*)

Information Technology

While the leading role of information technology in India's trade and local growth has been documented, the same role in rural growth has not. We can discuss preliminary impressions of two such cases in a dry region of India. They refer to two co–operatives, one at Warna and the other at Pravara, both in the rain–shadow region of Maharashtra in Western India.

The Pravara Sugar Co–operative is the first one in India. It diversified from efficient production of cane and white sugar into bagasse–based electricity, high value–added chemicals and alcohol. In the 1980s, with a shortage of water, it encouraged diversification into dairying, horticulture and ice cream. It went into perhaps the first case of drip technology in line crops. By the early 1990s it was spending around Rs. 500 million annually on education and health, with a wide range of institutions, and in 1993 a group of eminent co–operators and educationists brought out a Rural Education

Policy Draft, which operationalised a strategy for using knowledge as a source of growth in rural areas. It envisaged a borrowing strategy for the best skills available for training at a global level and ultimately generation of local world class knowledge.

By 2001, the internet was completely integrated in the regional educational and infrastructure bodies like the co–operative bank. There was also a strong local training and service industry in this rural area, with a major contribution from women entrepreneurs. This part of the sector is financed either privately or with cross subsidies from basically profit–making entities. Farmers from the 55 villages of the co–operative have access to the internet in the local language in the production/service sectors. In this century Pravara begins the more difficult process — internet–based human–resource development at the village level itself. The technology package developed needs heavy investment in each village. The model insists on a one–third contribution by user charges or village contributions. The process is still working itself out.

The main characteristics of this project have been made operational in a project document (Roy and Alagh, 2001). This document notes that technology has "made presentation of data in the local language possible and updating of information has become simpler. Moreover, with minimum training, local youth can learn to operate the computers and help the end users.…[I]n village meetings, the farmers have informed that they do watch TV programmes aimed at agriculture, but lamented over their inability to communicate with the experts at the other end for clarifications of doubts…It is hoped that the target population will use it extensively to acquire necessary information, improve their all round efficiency and productivity and ultimately improve their quality of life." The project documents the target population in numbers, through space and by level and nature of activity. The objectives are:

— Set up village kiosks/centres;

— Generate awareness about information technology;

— Train village youth to handle village kiosk centres;

— Develop appropriate information material based on local needs — education, agriculture, markets, employment, health, weather, etc.;

— Establish a multi–point video conference facility on the intranet; and

— Promote e–commerce in the area.

A pre–feasibility technical study has been conducted, and first–phase hardware and systems are in position. Since questions of rural infrastructure availability are important and such experiments are few, the project deserves a brief description. Nandini Roy at the Shirdi Sai Rural Institute (SSRI), of which the author is the President, designed it. After some preparatory work, SSRI had discussions with public and private providers of IT services, including the Indian Space Research Organisation and the National Informatics Centre (NIC). NIC hardware and systems were used to provide connectivity initially to 11 rural institutions in the region. For the village–level system, intense discussion showed that a telephone–modem network was not possible. The existing 64 kbps VSAT at SSRI was upgraded to 256 kbps for village connectivity, both for video conferencing and browsing. NIC gave blanket permission for bandwidth and radio frequency use. The village level connectivity involves high–bandwidth point–to–multipoint connectivity by wireless wide–area network (RF technology). The 60 villages have been divided into three clusters. Each village will be connected to its hub centre through an omni–directional antenna. The project will cover around 65 kms. The connectivity is seamless. There is a separate software, system materials and content development program. SSRI has started the project with resources it has raised and is raising funds for the rest. It proposes an independent evaluation unit for renewal through real time. A phased budget is available.

In a period in which the region and the co–operative sugar sector were not doing too well, the Pravara co–operative has maintained a strong economic performance. It has always fought for reform. Abolition of controls, co–operatives free from bureaucratic control and now corporatisation of producer associations have all been advocated and lobbied for.

The WARNA case is similar, but its information technology experiment is different. It began in 1998, with a strong impetus from Delhi, after the setting up of a National Task Force on Information Technology. The central facilities, the infrastructure groups, the training institutions and entities at the village level were set up simultaneously. The costs have been high. The process is still working itself out. It is too early to compare and evaluate. A good strategy would be to provide seed funds for components and study the outcomes, to see if more general programmes can be worked out.

Pravara has also submitted for recognition at Delhi a project to set up a degree–granting Information Technology Institute, with initial funding but ultimately self–financing. It would technically support the HRD/ Production/ Infrastructure institutions and also study and re–engineer the village systems on a real–time basis. Pravara is lobbying hard to get the proposal approved.

Post Script

The emphasis on institutional change for widespread growth and application of technology in this paper does not mean that large, mission–oriented projects are not important in the growth process, particularly in large third–world countries. Tissue cultures in tree crops and hybrid paddy rice are cases in point. Hybrid paddy in the People’s Republic of China and India has yield levels of around seven to eight tonnes per hectare and is the precursor to genetically modified super rice. Indian agricultural science has released around 400 varieties to date; this is the basis of India’s agricultural performance. The use of the space industry as a product in the village IT projects is clear. A recent study sponsored by the French Institutes in India has shown the critical role of nuclear power if the carbon emission problem is to be kept in check (see Schwank *et al.* (2000) and foreword by Alagh in Audinet, 2000 and Alagh, 2000*b*). The Indian programme of completing the nuclear fuel cycle based on the country’s abundant thorium reserves has to be seen in this light. The experimental fast–breeder reactor, Kamini, currently generating energy with thorium, is now being upgraded to a 500 MW facility.

Notes

1. Although this paper was written independently, it is interesting that the theoretical paper written for the Forum (Bussolo and O'Connor, the first chapter in this volume) discusses the same agenda, namely the green revolution technology and beyond into biotechnology, non–agricultural rural growth and use of information technology for poverty removal. Poverty and technology is a difficult area, but perhaps there is a beginning of a research tradition to follow.

2. Maurice Strong has described the conferences at Founex in 1971 and the Hague in 1991 as the "two seminal meetings on environment and development".

Bibliography

ALAGH, Y. (1988), "Guidelines for Agroclimatic Planning: A Draft for Discussion", *Journal of Land Development*.

ALAGH, Y. (1989), "The NIE's and the Developing Asia–Pacific Region", *Asian Development Review,* Vol. 7 (2).

ALAGH, Y. (1991*a*), *Indian Development Planning and Policy,* WIDER Studies in Development Economics, Vikas, Helsinki and Delhi.

ALAGH, Y. (1991*b*), *Sustainable Development, From Concept to Action: Techniques for Planners,* UNCED, N.Y.

ALAGH, Y. (1995), "India's Agricultural Trade with the ESCAP Region", UN, ESCAP, *Agricultural Trade in the ESCAP Region,* UN, New York.

ALAGH, Y. (1999*a*), "Participatory Institutions and Rural Roads", UN, ESCAP, *Transport and Communications Bulletin for Asia and the Pacific*, No. 69, UN, New York.

ALAGH, Y. (1999*b*), "India's Agricultural Trade", *Indian Economic Journal,* First Dantwala Memorial Lecture.

ALAGH, Y. (2000*a*), *Report of the High Level Committee on Legislation for Corporatisation of Cooperatives,* Ministry of Company Affairs, New Delhi.

ALAGH, Y. (2000*b*), *Sustainable Development: India 2020*, UNU/IAS, Tokyo.

ALEXANDRATOS, N. (ed.) (1995), *World Agriculture Towards 2010, An FAO Study,* Wiley, Chichister.

ASIAN DEVELOPMENT BANK (ADB) (2000), *Rural Asia: Beyond the Green Revolution,* Manila, ADB, and *Rural Asia: Companion Volumes (I–III),* Oxford University Press, Oxford.

AUDINET, P. (ed.) (2000), *India's Energy: Essays on Sustainable Development*, Manohar, Delhi.

CHOPRA, K. AND G. KADEKODI (1993), "Watershed Development", *Economic and Political Weekly*, June 26.

DESAI, R.D. (1995), *The Household Sector; A Study of the Zari Industry,* Har Anand, New Delhi.

FAO (1978/81, 1982), *Agro–Economic Zoning Atlas*, FAO–UNESCO, Rome.

FAO (1993), *Agriculture Towards 2010*, FAO, Rome. For the final published version, see N. ALEXANDRATOS (ed.) above.

GOVERNMENT OF INDIA, PLANNING COMMISSION (1989), *AgroClimatic Planning: An Overview,* New Delhi.

HAYAMI, Y. (1981), *Understanding Village Community and the Direction of Agricultural Change in Asia*, IEG. Occasional Paper, New Series, No. 1, Delhi.

HOULLIER, F., V. BENER AND L. KENNEDY (eds.) (1994), *Industrial Decentralisation and Urban Development in India,* Institute Francais de Pondicherry, Pondy Paper in Social Sciences, 23, Pondicherry.

KASHYAP, S.P. AND R.S. TIWARI (1985), *Shaping of Diamonds in Surat: An Enquiry into Some of its Passas (Facets),* SPIESR Monograph No. 12, Ahmedabad.

KASHYAP, S.P. AND R.S. TIWARI (1992), "Growth of Small–size Enterprises in India: It's Nature and Contents", *World Development,* Vol.16, No. 7.

KASHYAP, S.P. AND R. S. TIWARI (1998), "Recent Development in the Small Enterprises Sector in India", Discussion Paper No. 48, ILO, International Institute of Labour Studies, Geneva.

LELE, U., N. KUMAR, Y.K. ALAGH, N. SAXENA AND K. MITRA (2000), *Forestry in India: An Evaluation*, World Bank, Washington, D.C.

MISRA, R.P. AND K. MISRA (eds.) (1998), *Million Cities of India: Growth Dynamics, Internal Structure, Quality of Life and Planning Perspectives,* Pondview Books.

PETRELLA, R. AND C. GRANRUT (1992), *La Mondialisation de l'Economie*, FAST, European Commission, Document No. MO 75–5/34, Brussels.

PYKE, F. (1992), *Regional Development in an Era of Globalisation,* ILO, International Institute of Labour Studies, Geneva.

RESERVE BANK OF INDIA (2000), *Report of the Expert Committee on Agricultural Credit* (Kapur Committee), Delhi.

ROY, N. AND Y.K. ALAGH (2001), *Community Information Centres for the Rural Poor*, Pravara, SSRI.

SACHS, I. (1991), "Background Paper for the Hague Declaration**",** reprinted in *Nature* and by RIS.

SCHWANK, O., T. VON STOKER AND N. NORTH (2000), "Long Term Carbon Emission Targets", *in* P. AUDINET (ed.), *India's Energy: Essays on Sustainable Development*, Manohar, Delhi.

SENGENBERGER, W. AND F. PYKE (eds.) (1992), *Industrial Districts and Local Regeneration,* ILO, International Institute of Labour Studies, Geneva.

STOPFORD, J.M. (1994) "The Impact of the Global Political Economy on Corporate Strategy", Carnegie Bosch Institute, Working Paper No. 94–7, Pittsburgh.

TAYLOR, L. (ed.) (1993), *The Rocky Road to Reform*, MIT Press, Cambridge, Mass.

VAIDYA, C. (1999), *Private Sector Participation in Financing and Management of Urban Water Supply and Sanitation Projects***,** USAID FIRE Project, reprinted in 31st Annual IWWA Technical Volume, Delhi.

WADE, R. (1992), "East Asia's Economic Success", *World Politics*, Vol. 44.

Enabling People to Make Technologies Work for Them

Lahiru Perera

Introduction

In the first years of the 21st century, technology lies at the heart of contested public policy issues and debates. New technologies, specially those in the life sciences and information processing field, are raising profound moral and ethical questions about the differential impacts of technical change and the kind of society or development we want. There is a talk of a paradigm shift in social and economic organisation because of technology development. The rate of change in technology is faster than in the past, adding to the imperative of addressing the policy issues.

The issues raised in these debates are not new. Over the last four decades of the 20th century they were raised, and efforts were made to provide answers, by a range of thinkers and organisations that loosely formed the Appropriate Technology movement. With global environmental degradation and North–South divides in technology becoming a major part of the public policy debate and technology development being seen once again by some as the solution to the world's problems, there is cause to re–examine the relevance of Appropriate Technology to the 21st century. My presentation will emphasise some actions required to achieve the policy objectives of "making new technologies work for human development".

Technology and Poverty Reduction

There have been significant achievements in reducing poverty. Between 1990 and 1998 the proportion of people living in poverty in developing countries decreased from 29 per cent to 24 per cent, although the actual number of people in poverty declined by only 77 million (DFID, 2000). Life expectancy in developing countries has increased over the past three decades from 46 to 64 years. Rates of infant mortality have halved. The proportion of children enrolled in primary school has increased by more than 80 per cent. Adult literacy rose from 55 per cent in 1980 to 70 per cent in 1995, although there are 24 million more illiterate adults than in 1980. Access to safe drinking water and basic sanitation has doubled (DFID, 2000).

Technology, or rather technology change, has had a major role in facilitating these achievements and will continue to be a key factor in enabling the International Development Targets to be reached. Despite the achievements to date, the challenge for international development remains the elimination of poverty and inequality.

— Two billion people still do not have access to modern, efficient forms of energy supply.

— 1.5 billion people still live in inadequate shelter.

— One billion people still have no access to safe water, and 2.4 billion have no sanitation.

— 800 million people continue to face regular hunger and long–term malnutrition.

— Hundreds of millions of people lack secure employment.

— 1.2 billion live on the equivalent of less than $1 a day.

The gaps are widening both between and within countries. While improvements in technology can provide the means for producing more with less, in many respects the capacity to manage processes of technical change to this end defines the divide between industrialised and developing countries (Barnett, 1995).

Three–quarters of the poor in developing countries live in rural areas and depend on agricultural production for all or part of their livelihood. Poverty, too, is not only a matter of incomes. It also means being excluded from social and political processes and from access to services to meet basic needs such as education and health[1]. It is experienced differently by different people. Women, the majority of the world's poor — around 70 per cent — suffer additional disadvantage and discrimination and have a different experience of poverty from men. Some social groups, including people from minority ethnic communities, disabled people, displaced people and people living in unrecognised settlements also experience particular disadvantage.

Technology plays an important role in addressing these non–income dimensions of poverty. It contributes to the quality of life of poor women and men through improved access to clean water and sanitation, through health services and through education. Technologies for transportation and communication help reduce isolation and vulnerability as well as open up new livelihood opportunities.

Enabling People to Make Technologies Work for Them

ITDG (the Intermediate Technology Development Group) believes that important among the capabilities that determine "the range of things people can do or be in life" are technological capabilities:

— To analyse problems and obstacles for technological achievement;

— To identify and evaluate potential technological solutions;

— To select, adapt and apply new technologies; and

— To evaluate effects of new technologies.

Some people proceed from a conventional view of the process of technology development and diffusion, wherein research in the "laboratory" is followed by adaptive development and then diffusion through the market. This view reflects the process in industrialised countries where most expenditure on research and development takes place, but it bears little relation to the technological change experienced by the majority of poor women and men in developing countries.

Our approach is founded on Schumacher's dictum, "Find out what people are doing and help them to do it better." That means starting with people and enabling them to achieve sustainable livelihoods by building their own technical and organisational capacities, achieving technology choice and adapting and improving technologies.

Building the Technological Capabilities of the Poor

Building technical capacities of "countries" will have an impact only if the capacities of poor women and men are built to manage technical change. Poor people must be enabled to make technology choices. Most poor people in developing countries do not have access to formal employment. They must forge their livelihoods in the private, informal sector, working in the fields, homes and small workshops and making vital decisions about the best use of their limited assets in order to survive on the tightest of margins. They do not invest lightly in new techniques.

Poor people will invest in technology choices that are accessible, affordable and appropriate for them. Building poor people's capacity to make choices means not just bringing new technologies to their doorstep, but addressing their organisational, management and marketing skills, opening new channels for information and knowledge and making credit and markets more accessible. What mechanisms, actors and institutions can mediate effectively between the global and local levels — bringing technology choice, knowledge and skills to poor women and men and enabling them to operate above the local level to help determine the choices and the policy frameworks made higher up?

Creating Innovative Partnerships and New Incentives for Research and Development

The UNDP's *Human Development Report 2001* (*HDR 2001*) proposes taking advantage of the "network age" to establish virtual, international research communities, pursuing research driven by the needs of the poor in developing countries. The intertwining of public, university and private efforts is at the heart of new approaches to technology. Would this approach work for research and development in more traditional technologies? To what extent can they be accountable to the ultimate users? We propose that the key output of North–South and South–South partnerships for technology research and development, whether in new technology fields or more traditional ones, should not be "*faux* collaboration" or "more R&D". Global public investment should be focussed upon creating R&D capacity in developing countries while ensuring that this new capacity is focussed on the needs of the poor. This capacity is a pre–requisite to intermediate the new technologies.

Protecting and Respecting Social and Traditional Knowledge

Discussions on fair implementation of the TRIPs agreements and difficulties that developing countries face in implementing IPR regimes in compliance with international agreements are not new. It is necessary to revisit and change international treaties with respect to genetic resources and local or indigenous knowledge and environmental practices, in order to recognise social and traditional wisdom and better protect the rights of poor women and men and their communities.

Expanding Investments in Technologies for Development

There is an enormous gap between the resources devoted to technological R&D for markets in the industrialised world and those that address the needs of the poor in developing countries. The reliance on market mechanisms in public policy over the last two decades could be said to have contributed both to the neglect of pro–poor R&D and to have reduced overall public funding. Over a decade ago a study by ITDG for the DAC found that there was little explicit consideration of technology in the decision making of bilateral donors. Nothing in recent years suggests that this has changed. To ensure that the voices of the poor are heard in setting the R&D agenda, mechanisms are necessary to facilitate communication and feedback between low–income, marginalised technology users and technology developers. This may well entail the development of appropriate intermediary institutions. It certainly requires consideration of the user–developer in national technology R&D systems and policies. Means are also needed to ensure that support is provided to technology adaptation and development by low–income producers themselves, recognising that technology development is primarily a continuous process of incremental changes and that technology users often make these changes. National policy and donor support, should seek to establish the frameworks that facilitate this user–led technology development and take advantage of the "network age" to enable ready exchange of information about technologies.

Providing Regional and Global Institutional Support

The *HDR 2001* report recognises that "Technology–related problems are often the result of poor policies, inadequate regulation and lack of transparency and the need of the government's recognising that technology policy affects a host of development issues including health, education and job creation." Establishing the appropriate national, regional and international policy and regulatory frameworks, however, is more complex than perhaps suggested by the focus on fair application of global rules and new initiatives. Just as technology policy affects many sectors, other policies affect technology development. National as well as global rules need to be applied fairly and across the full range of public policy. National policy, particularly in respect of "appropriate" macroeconomic policy, is constrained by global frameworks and the influence of regional and international actors.

Summary

Technology is clearly a critical factor in poverty reduction. Seen holistically, in the complexity of a dynamic social, economic, cultural and political context, the effective management of technology change is a question of capabilities. The poor must be enabled or empowered to access improved technologies and to make their own technical choices through the development of their capabilities. This would enable them to respond to changing needs and the opportunities as they arise, leading to the sustainable development of their livelihoods. In order to achieve this, the importance of an appropriate policy framework for the management of technology change by the resource–poor should be recognised. Emphasis should be given to the following actions.

Building the Technological Capabilities of People

— Start with poor people's capabilities, not with technologies;

— Together with poor women and men, subject new technological options to field testing to see whether they are affordable, accessible and appropriate;

— Stimulate and support intermediary organisations.

Creating Innovative Partnerships and New Incentives for R&D

— The international partnerships for technological R&D recommended by the *HDR 2001* should have as an output the creation of greater developing–country capacity for R&D;

— Public support and partnership should be extended to low–income and marginalised technology users to undertake incremental R&D.

Protecting Social and Traditional Knowledge

— Genetic resources for food and agriculture should be kept in the public domain and protected from private expropriation through international agreements such as the International Undertaking on Plant Genetic Resources for Food and Agriculture (IUPGRFA);

— Intellectual property–rights regimes should be developed to incorporate socially generated knowledge, traditional knowledge and common property resources.

Expanding Investment in Technologies for Development

— Additional resources should be provided through ODA;

— Bilateral and multilateral donors should adopt procedures that ensure that all technological options are considered by all projects and programmes;

— Technology users should be enabled to communicate with and influence technology developers in publicly funded R&D systems.

Providing Regional and Global Institutional Support

— Capacity building is required to enable civil society organisations and NGOs to raise awareness of technology policy issues;

— An active campaign is required to raise the profile of technology in international development policy processes;

— Complementary recommendations about how to implement national strategies that enable poor people to achieve technology choice should be developed.

Note

1. Amartya Sen has argued that poverty must be seen as the deprivation of basic capabilities rather than merely as low incomes, thus expanding the concept of poverty beyond income to include education and health. Similarly, vulnerability, voicelessness and powerlessness, are key dimensions of capability. Sen himself (1999) has identified the inability resulting from social norms or lack of basic civil rights to influence decisions that affect one's life as a legitimate dimension of the capability concept of poverty.

Poverty Alleviation in the People's Republic of China's Rural Areas: Problems, Strategy, Policy and the Role of Science and Technology

Liu Yanhua

Anti–Poverty Movement and Evolution of Policy in the People's Republic of China

The largest country in the world, the People's Republic of China (PRC) did not raise the issue of poverty in rural areas and carry out an anti–poverty plan until the late 1970s. Poverty became a very important issue when the gap between urban and rural areas grew larger and the living situation in many rural areas worsened. The 20–year history of the anti–poverty campaign can be divided into three phases.

Phase One (1978–1985): Poverty Alleviation through Systemic Reform in Rural Areas

Before 1978, those in the PRC living below the poverty line determined by the Chinese government exceeded 250 million and accounted for 33 per cent of the total rural population. Although this serious poverty situation had many causes, the major one was the restraint on output from the land stemming from low enthusiasm for production in the People's communes. Thus, reform in the system was seen as the main measure for poverty reduction.

The reform had two parts. First, the land–ownership structure — the collective cultivation system in the People's communes — was replaced by the contract responsibility system, which linked each household's income to its output. This change so kindled the peasants' enthusiasm that it released productivity and output increased. Second, with the liberalisation of agricultural market prices, the system of markets for agricultural products was rebuilt. Township enterprises boomed because of the huge amounts of capital invested by industrial and trading enterprises. With these changes, the land received full exploitation and rational use. The national economy developed quickly. The increases in agricultural prices (by 15 per cent to 35 per cent for the main farm products), restructured agricultural industry towards high added–value output. Rural labourers were employed or got jobs in the non–agricultural sector. The population in poverty benefited from these changes, and many peasants living under the poverty line shed their poverty and backwardness. The poor population with difficulty in food and clothing fell in that period from 250 million to 125 million, or by 17.86 million annually. The incidence of poverty dropped from 31 per cent to 14.8 per cent.

Phase Two (1986–1993): A Well–Planned, Well–Organised, Large–Scale Campaign

By the mid–1980s, most rural areas had obtained economic development rapidly with their own regional advantages. Nevertheless, due to social, economic, historical, natural, geographic and other restrictions, the gap between the less–developed areas and other parts of the PRC, especially the well–developed coastal areas, had expanded. The problem of uneven development in rural areas began to surface. Along with gradually increasing per capita income in Chinese rural areas, a large portion of the population had low incomes. Many of these people could hardly support themselves. They usually lacked food to eat, clothing to wear and homes to live in.

According to a survey, the rural population in poverty in 1985, with annual income per capita less than 200 yuan (around 50 per cent of the average income level at the time) was 125 million. It accounted for 14.8 per cent of the total rural population. Nearly 40 million (4.4 per cent of the total) had annual incomes per capita of less than 50 yuan. The poverty population concentrated in certain areas, mostly in the economically less–developed middle and western parts of the PRC. Moreover, many of these areas were the old revolutionary base areas and minority, remote and frontier areas.

Whether the situation of the poverty areas could be changed within a short period, and the poor given enough to eat and wear had a very important bearing on the PRC's reform and opening, steady politics, the unity of nationalities, social stability and long–term co–ordination of national economic growth. Therefore, the Chinese government formulated a series of important decisions regarding the problem of poverty in rural areas.

— In 1984, the central government issued *A Notification on Changing the Situation of Poverty Areas in A Short Period*, demanding great attention from governments at all levels, effective measures and positive attitudes. It required that governments at various levels should devote heavy efforts to solve the poverty problem in over a dozen areas, to strengthen internal vigour in economic development.

— In 1986, the task of helping the old revolutionary base, minority nationality, remote and frontier areas to get rid of poverty and backwardness was proposed as an important issue in the Fourth Session of the Sixth National People's Congress and incorporated in the Seventh Five–Year Plan (1986–1990).

— In June 1986, the Chinese government established the Leading Group for Economic development in poverty areas under the leadership of the State Council. It was renewed in 1993 as the Leading Group for Economic Development and Poverty Alleviation (LGEDPA) at State Council. The Leading Group was responsible for organising, leading, co–ordinating, supervising and examining the economic development of poverty areas.

The Chinese government launched the work with a well–organised and large–scale plan for helping the poor and economic development. It moved the anti–poverty effort into a new historical period.

Phase Three (1994–2000): Tackling the Key Issues Confronted by Poverty Regions

Between 1986 and 1993, the poverty population in rural areas was cut from 125 million to 80 million, down 3.2 per cent annually, as against the 9.4 per cent annual drop between 1979 and 1985. Although rural areas were growing economically, the gap between the east and the west grew larger and the poverty population became more concentrated in the middle and western parts of the PRC. By 1994, nearly 82 per cent of the 592 poverty provinces determined by the state were in the west, and their poor populations made up 91.1 per cent of the total.

With the deepening of reform and economic growth in rural areas and the gradually diminishing poor population, the types of poverty and the reasons for it changed greatly. First, poverty incidence resulting from the agricultural system fell. Second, the poor population concentrated more in the south–west part of the PRC (lacking soil), the loess plateau in the north–west (with a serious water shortage), the Qinba poverty mountain area (less land, poor transportation and serious soil erosion) and the Qingzang Highland area (a cold zone). These geographical features of poverty became more and more evident. The main causes of poverty were serious natural conditions, weak capital endowments and the backwardness of social growth.

These changes prompted a change in the form of helping the poor. Development–oriented projects replaced the earlier combination of system reform, economic growth and project development. Thus, in areas poor mainly as a result of geographical features, the work on reducing poverty and backwardness would be conducted only through specific projects, with no mistaking what they aimed at. This meant that, before the development problems of less–developed regional economies had been settled, the central task was to provide the poor with enough to eat and wear. In 1994, the Chinese government launched and implemented the State Eight–Seven Plan for tackling the key problems in poor areas. It aimed, within the following seven years and with help from all walks of life, to enable the 80 million poor in rural areas to dress warmly and eat their fill. The Plan redefined 592 poverty provinces as the focal points; they accounted for over 72 per cent of the total poverty population in the country. It was the first programmatic document with specific targets, objectives, measures and a time limit. With its implementation, the speed of reducing the population in poverty accelerated greatly.

To sum up so far, after 20 years' work against poverty, more than 200 million poor people in rural areas now had enough to eat and wear, which made their long–term dream come true. This was a record never seen in either Chinese or world history. With the world's population living in poverty increasing by nearly 10 million annually, it was exceptional that the PRC performed so well.

Evaluation of the PRC's Anti–Poverty Strategy and Measures

During the 20 years of reform and opening the economy, the important campaign against poverty and for economic development in Chinese poverty areas was gradually specified and strengthened. Since the early 1990s, on the basis of past experience, the anti–poverty plan has seen important adjustments and reforms, mainly in three areas.

— A shift from decentralised relief for the poor to economic development, with the necessary support from the state combined with the natural–resource advantages of the poverty areas, led to development–oriented, productive efforts. This gradually formed the self–accumulation and self–development abilities of these areas and the poor.

— Work on helping the poor changed. The distribution of funds moved from "average" distribution based on poverty populations to allocations based on projects' economic results. This meant shifting from reliance mainly on the governmental administrative system to using economic organisations and broadening inputs from funds alone to combinations of funds, technology, materials, training and necessary services.

— More funds and materials were invested to support productively oriented projects that could provide poor families with chances to take part in economic growth. Controlling population growth played an important role, as did improving the quality and self–development ability of the poverty population. Government and society were encouraged to participate in the anti–poverty task. The impact of science and technology on the anti–poverty campaign was strengthened, and the functions and results of science and technology in economic growth in rural poverty areas expanded.

The anti–poverty strategy in the PRC, gradually regulated and perfected, clearly showed three major changes. First, it moved from a relief–style anti–poverty plan to a development–oriented one. Second, it switched from supporting industry development to supporting agriculture development. Third, the emphasis changed from helping poverty areas to helping poor families. With great efforts, each change strode forward towards the goals of the anti–poverty campaign itself. Among the problems to be solved were:

— *A Contradiction between Enriching the Poor or Enriching the Counties*. Our anti–poverty task focused originally on poor counties. The central government and governments at all levels distributed anti–poverty funds to each county under the poverty line according to the "Principle of Equity", and most poverty provinces used and distributed these funds in the light of the "Principle of Efficiency ". As the governors of the anti–poverty funds, the regional governments tended to invest them, with no strict supervisory system, in projects that could bring economic achievements to the governments quickly so as to relieve their money difficulties. Therefore, especially by promoting economic development in the poverty provinces with revenues, the anti–poverty funds resulted in few achievements and deviated from the reasonable goal, designed by the central government, of shaking off poverty and backwardness.

— *Targeting the Initiation of Projects on the Poor Family*. In allocating funds for helping the poor, the original intent was not to distribute the money directly to poor families, but to help with the establishment of economic entities — enterprises and businesses. Such enterprises would employ local labourers from poor families to develop production with direct loans from anti–poverty funds. It proved tempting for the enterprises to promote economic growth through enterprise expansion, so that only part of the economic gains went to some people living under the poverty line. Between 1986 and 1990, nearly 80 per cent of total funds for helping the poor went into such enterprises. Given the features of the planned economy, however, the so–called "commodity economy" policies, carried out without flexibility in poverty regions, were doomed to failure. The facts proved that poor people rarely could be helped out of poverty by enterprise. Those inaccessible areas were poor in natural resources, and eight or nine out of ten enterprises with seriously adverse environments, especially industrial enterprises, turned out to be weak or went bankrupt. As a result, the enterprises did not enjoy full development, and large sums of money for helping the poor were wasted.

Lack of Poverty Evaluation and Supervision. A very serious shortcoming in anti–poverty practice in the PRC was the absence of an independent and objective supervisory system. This was considered the major reason for deviations from the targets. The main problems of poverty supervision included:

— Lack of a set of scientific and standard measures for poverty–line determination, which was usually conducted greatly at will.

— The poverty line usually remained unchanged for several years with no consideration of inflation. Only the national poverty line existed. There were no provincial, city and county poverty lines. The price differences between different locations were not considered reasonably.

— The national and regional poverty rates and the inadequate figures on the poverty population could hardly be estimated accurately. In order to ask for more funds, governments at all levels submitted poverty populations higher than the real figures. Many discrepancies existed between the useless information on the distribution of the poverty population and the poverty ratios estimated by each organisational channel.

— Thus, the poverty population was incorrectly determined and hard to distinguish. The difference between poverty families and those not in poverty could hardly be seen from the poverty statistics known by the provincial governments. As the system for determining what should be aimed at as the object of the plan of helping the poor was incomplete, the desire to help the poor by giving support directly to the poor family tended to fail.

— The Plan lacked a system of effective indices and calculation measures for evaluating usable results.

— The effort had no independence. Governments at various levels interfered heavily in the anti–poverty work, which yielded much false information and false statistics.

— No organ existed with specific responsibility for the anti–poverty campaign. The statistics showing poverty situations proved poor in continuity and reliability.

Poverty Alleviation through Science and Technology

The process of helping the poor through science and technology brought many advanced technologies and ideas, measures and ways of modern management to the poverty regions. They were used together with traditional productivity factors in poverty areas. This caused gradual reform in the means of production, expansion of labour objectives and improvements in labour quality. As the functioning of the productive system changed and strengthened step by step, regional technological advances and economic development were promoted. Measure to help the poor through science and technology turned out to be a major channel for speeding the work on poverty reduction.

Features of Helping the Poor by Science and Technology

Helping the poor by science and technology was a very important strategic measure. It was proposed in 1998, based on actual situations of scientific and technological backwardness and serious shortages of technological professionals, by the Ministry of Science and Technology and the Chinese Association of Science. It generated active participation among Chinese technological professionals. It had the following features:

— *A Stress on Self–Development*. The normal relief actions have been denied in the practice of helping the poor through science and technology. It has instead regarded markets as guidelines and science and technology as precursors. It has carried out such steps as reasonably exploiting natural resources in poverty areas, changing resource advantages into economic ones, developing the commodity economy, focusing on economic results, starting the market and improving the competitive ability of poor peasants to accomplish sound self–development.

— *Introducing Technology and Starting Markets*. The PRC's scientific and research personnel had long worked according to plan, rendering their achievements *gratis*. Since the beginning of reform and economic opening, and with the commercialisation of technological achievements, technology has entered markets to obtain growth through market competition. The importation of advanced practical technology strengthened the sense of technology and commerce in poverty areas. With technology as a motive force, the productivity and the exploitation and usage ratios of natural resources increased. As a result, competitive ability has gradually improved.

— *Introducing the Competitive System*. Competition should govern the investment of funds and project implementation. To introduce it, the earlier practice of distributing money and materials on the basis of departmental and administrative measures was changed. Distribution now depended on the science and technology content of projects and their technological value added. The economic entities and scientific and technological research departments in charge of helping the poor received support internally and externally. The objective was to develop an "economy of talented people" to promote integration of technology.

— *Paying More Attention to Introducing Advanced, Perfected and Useable Technology*. Helping the poor by science and technology had always given priority to the introduction of technology. Technologies have inherent characteristics, however, especially involving their regional adaptability and applicability. When advanced technology is introduced in poverty areas, two requirements have been stressed — that imported technology should be the most up–to–date in its field, and that the technologies introduced should be suitable for poor areas and easy to understand and use.

— *Combination of Anti–Poverty and Anti–Ignorance Policies*. Helping the poor through science and technology not only helped the peasants to have enough to eat and wear and to get increased incomes, but also combined anti–poverty and anti–ignorance efforts through a three–in–one combination involving agriculture, scientific research and education. On the one hand, this involved inputs from scientific and managerial personnel, establishing and completing networks for science and technology demonstration and organising various kinds of training. On the other hand, it gave heavy publicity to scientific and technological knowledge, expanded the spirit of science, improved the quality of peasants' know–how and built the new generation of peasants. The national network for spreading scientific and technological knowledge has now been established in rural areas.

— *Joint Efforts to Implement the Anti–Poverty Campaign*. Helping the poor had always focused on the integration of all factors. With the implementation of joint efforts, the work infiltrated into every level of the social anti–poverty task. This appeared mainly in two aspects. The first was the agglomeration of all scientific and technological factors and plans. This gave full play to scientific and technological personnel, the plan for helping the poor through science and technology, the Spark and Torch Plans, the plan for social development and the plan for demonstration of major research achievements. The second was the strengthening of the work on co–operation with scientific and technological departments and institutes, some relevant departments and social forces, including the three–in–one combination mentioned above, to support the development of poverty areas. Joint efforts combined the functions of scientific research personnel tightly with local economies.

Main Models for Helping the Poor through Science and Technology

Sending in Scientific and Technological Professionals. Because separations and constraints in the system resulted from many conditions, the introduction of science and technology to poor regions had proved difficult despite its inherent strengths. Under such circumstances, the implementation of science and technology transfer to rural poverty areas and using it to enhance actual productivity could be done only by combining it with external strengths through a well–organised and well–designed plan. Dispatching groups of scientific and technological personnel with advanced knowledge to poverty regions was adopted as a model for helping the poor by making use of external forces.

Since 1986, the Ministry of Science and Technology has sent fifteen groups in succession to help the poor in poverty areas. They totalled 360 persons, of whom 67 were bureau leaders and 150 were section chiefs. The groups were designed to mobilise and organise scientific and technological personnel from research institutes and education departments under the leadership of government. Their tasks involved going to poverty regions and providing the local people with science and technology for shaking off poverty. The main ones included:

— Giving publicity to policy on helping the poor;

— Conducting surveys and research to help each province work out plans for economic development, help the poor through science and technology and play the role of advisers to local governments and the Party committee;

— Selecting and testing exploration projects, choosing the correct openings, carrying out the plan on scientific and technological breakthroughs, the Spark Plan and scientific and technological testing demonstration projects, and co–operating with local organs or departments to exploit, develop and promote various kinds of practical technologies; and

— Providing training courses to talented local people, to train those capable of becoming better off through science and technology to implement the anti–poverty campaign.

Scientific and Technological Support for Leading Industries. This model was carefully designed to exploit or improve certain products or industries, extend technology to peasants, accomplish scale economies and develop key products or leading industries. The goal was to promote regional development as a whole, finally shake off poverty and get rich. It worked on the basis of local natural resources and social and economic conditions. It was organised and co–ordinated by the local governments. It built on assessed advantages of the major industries and their ability to promote activity continuously, achieve steady and co–ordinated economic growth and absorb science and technology as precursor through the introduction of useable scientific and technological achievements.

The model was established on the basis of economic development and growth theory. Technology transfer to poverty areas requires certain necessary conditions. Under the circumstances of inadequate human resources, financial capacity and materials supply, solving many technological problems depends on creating comparatively favourable conditions for technology transfer. Combinations of technology and production must be selected correctly to make full use of the limited human, capital and material resources. Industrial structures in poverty areas mainly involve single–product economies. They often lack leading industries with adequate scales of production and strong competitive ability. They remain focused on local production and marketing with very low commodity ratios. With scientific and technological development, promoting local economic growth by fostering leading industries is an effective measure. The Ministry of Science and Technology used the model successfully in the Dabie Mountain area and later in the Jinggang Mountain area and the Shaanbei Mountain area.

The Dragon–Head Industry as Driver. This model mainly means pushing towards an increase in economic results as the final goal through a series of activities — for technology promotion and demonstration, making use of indigenous advantages, and sending advanced, usable technology and equipment to the peasants. The results sought are stable production and quality raw materials, quality finished products for domestic and foreign markets, a greater presence in the commodity markets, good sales results and value from exports. The leading enterprises integrate their businesses and make active use of the advantages of information, talented people and funds, etc, to improve labour quality. Specifically, this involves providing training courses, speeding up the whole process of modernising agriculture, trying to promote usable technology and practical high technology and introducing the most advanced technology and equipment to increase the technological content of output. In actual practice, by taking the local leading industry or key products as the centre of activity and economic results as the linked goal, enterprises usually realise integration in three ways — in production, materials procurement and sales.

Providing Services through Scientific and Technological Contracts. This model is implemented through establishing and perfecting socialised science and technology contract entities. They cover specific subjects, are of diverse types and have a flexible system. They organise series of services in the periods before, during and after production. They carry out the combined functions of inputting technology, information, funds and materials and promoting the integration of technology and production.

The features of this model appear mainly in its structure and organisation for integrating government and civil organisations. The functions of government mainly include establishing the demonstration system for agricultural science and technology and creating specialised departments and branch offices for administrative regions. Civil organs — mainly various kinds of research institutes and specialised associations and organisations — provide scientific and technological consulting services. State promotion and market forces have been used together in practice. The state and governments at all levels promote the growth and development of scientific and technological markets through technological contracts, technology transfer, selling technology for shareholders' equity and technological consulting, etc. They transfer advanced science and technology to rural areas on a large scale. Services are styled to integrate technology development, production and business, sending technology and knowledge to poverty areas and establishing new physical carriers of scientific and technological information.

Helping the Poor in the Early 21st Century in the PRC

The initiative of the Eighth Seven–Year Plan of "Storming Heavily Fortified Points on Helping the Poor" basically defined the task of providing the poverty population in rural areas with enough to eat and wear. The Chinese government accomplished it during the 20th century, a great historical achievement. Enabling the poor to dress warmly and eat their fill is only a start, however. To eliminate poverty in the PRC still remains the most serious problem and the most important challenge for the 21st century.

Development Trends in the Early 21st Century

The poverty population currently is distributed mainly over mountainous areas, deserts, highlands, loess plateaux, reservoir areas and regions with high local disease rates and poor natural resources. These areas share remote locations, poor transport conditions, weak ecologies, slow economic growth, backward education, difficult drinking–water supplies and adverse living and production conditions. Compared with earlier work, helping the poor in these areas has proved much more difficult, with the cost likely to be up to several dozen times as high.

According to information published by the office for helping the poor under the leadership of the State Council, nearly half of the remaining rural poverty population lives in provinces not classed as in poverty. According to present regulations and rules, however, funds to help the poor may not be invested in these provinces. The poor there cannot benefit from the anti–poverty funds invested by the central government, which slows the task of shaking off their poverty and backwardness. Moreover, because living and production conditions have not changed completely, the poverty population now fed and clothed as a result of past efforts has no strong ability to withstand natural disasters. When disaster occurs, these people tend to become poor again.

The current poverty line, 500 yuan per year in per capita net income, has remained unchanged for 90 years. It is a standard only for mere existence. Calculated on the comparative standard of the World Bank, $1 per day in 1995 (purchasing power parity), the poverty population would increase to 106 million, with the poverty ratio at 11.5 per cent.

In addition, a new–style problem of poverty has emerged suddenly in the PRC in the course of implementing market–oriented production and changing the economic structure. This new part of the poverty population includes people affected by changes in the agricultural structure, the new urban poor and laid–off workers from state–owned enterprises. The most important task in the early period of this century is to help this part of the poverty population.

Generally speaking, the overall features of poverty in our country in the 21st century are as follows. First, the co–existence of absolute and comparative poverty, and the increase of the comparative–poverty population will become the key focus of anti–poverty work. Second, urban and rural poverty mingle and influence each other, and the problem of urban poverty will worsen. Third, regional poverty and class poverty co–exist. The regional poverty caused by natural–resource deficiencies will take a favourable turn, while local differences resulting from unbalanced economic development become more evident. Because of an unreasonable distribution policy and the lack of a re–distributive control and regulative system, the income gap between individuals is expanding. Class poverty will become more serious, and the issue of poverty among such minority social groups as women, children, the aged and the disabled will attract more attention. Finally, the question of poverty among minority nationalities will exist in a special way for a long period. All these problems will make the design of our country's strategy and policy for helping the poor more complex.

Planning A New Strategy for Helping the Poor

Because changes in the traditional anti–poverty strategy are necessary, planning the new strategy is the most difficult immediate task. At present, the State Council, together with international organisations such as the UNDP, the World Bank and the Asian Development Bank, has been working on the framework of a strategy. The issues have not yet reached final resolution. In my opinion, although the work on building a new strategy for helping the poor has proved very difficult and complex, we must draw lessons from the experience of the past 15 years and hold firmly to some basic principles.

First, the new strategy must shift from provisional to systemic policy. Since 1986, the work on helping the poor in the PRC has depended basically on provisional policies and measures. Although it achieved some apparent results within a short period, it had no continuity. In this century, many abuses would arise if provisional policies and measures were implemented just as before.

Second, the new strategy must combine anti–poverty policy with state macroeconomic policy. In the past, they have diverged. The relationships between economic gains, structural change and the negative impact of the poverty population were not considered. The development target in the new strategy should be expanded, making it an organic part of general national economic policy, which should include not only growth but also reducing income disparities and human poverty as well as regional and sex differences in economic well being.

Third, the new strategy must be co–ordinated with other welfare plans to establish a social security system satisfying the essential needs of the population in absolute poverty. In the past, good co–ordination was lacking among anti–poverty strategists and social departments, civil administrative organs and departments in charge of social relief. The new strategy should establish and perfect a large–scale, highly efficient overall security–network system.

Fourth, the new strategy must favour an anti–poverty system with a focus on transferring resources for helping the poor to the poverty family or the poverty population. It should guarantee equal opportunity of access to credit resources earmarked for people in poverty.

Fifth, implementing the new strategy must create an environment able to strengthen the human rights of the people living under the poverty line, especially of people or minority groups in weak situations. Taking the participation of the poverty population and exploitation of the ability of the poor as the key tools, the provision of capital infrastructures and social services can guarantee that the poor enjoy equal chances to take part in economic development.

Anti–Poverty Measures in the PRC during the 21st Century

In the PRC, helping the poor is a long–term strategic task. It involves not only the requirements of the poverty population, but also the needs of those not in poverty for employment and economic activity. It embraces fostering domestic markets and a prosperous economy, the need for co–ordinated national economic development and the need for social civilisation and sound growth. To combine the strategic plan for our national economy with social growth, and to focus on the characteristic general requirements of the work on helping the poor, the following measures should be implemented in Chinese anti–poverty strategy in the 21st century.

— *Implement the Plan on Helping the Poor in Special Poverty Areas*. Taking the poverty population from the revolutionary base areas, districts inhabited by minority nationalities, pastoral areas, border areas and other special poverty areas as the working targets for attention, concentrate human, material and capital resources on them. Develop a master plan and implement it over a period of years, over a large area with specific treatments for each group.

— *Give Full Play to Resource Advantages, Grow Leading Industries and Develop the Economies of Poverty Regions*. With market demand both at home and abroad as a guide, make full use of rich bio–natural resources, light environmental pollution and special geographic conditions in poverty areas by introducing advanced and applicable science and technology. Develop leading industries and special industries in line with local conditions, to promote rapid economic growth in poverty areas and increase the peasants' income. In some poverty regions with comparatively better conditions, actively invite and attract domestic and foreign businesses to participate, guiding enterprises to invest in agricultural processing with local raw materials to increase the incomes of the local poverty population.

— *Improve the Ability of the Poverty Population to Help Itself, Devote Attention to Investment in Human Resources and the Supply of Production Factors in Poverty Areas*. Aside from the natural ecological environment, the shortage of funds is not the most serious reason for economic restriction in poverty regions. The low quality of the population in these areas is the most serious. In the final analysis, economic differences between regions result from differences in the degree to which people use technology. Therefore, first strengthen literacy and the universal elementary education of the poverty population. Provide various kinds of education, such as adult, vocational and technical education, science and technology publicity, professional training, technical consulting services and so on, combined with cultural education. Make most young people master one or two practical technologies. Second, attach importance to aids for modern production, such as introduction of better seed strains, farm chemicals, chemical fertiliser, agricultural machines and scientific management. Exploit the demonstration role played by scientific professionals and key local families, to speed the increase in quality of science and technology used by the poverty population. Third, establish and perfect grass–roots health–care networks to improve health conditions in poverty areas, prevent and reduce local diseases, reduce the death rate in poverty families and extend life expectancy.

— *Provide Necessary Capital Facilities for Poverty Areas*. The government's anti–poverty plan considers capital construction to be a key factor, which could play a direct or indirect role in increasing productivity in poverty areas and reducing the poverty population. Work on some types of capital construction in poverty regions needs more efforts. Examples include roads, water supply, irrigation, power supply, post and telecommunications and other infrastructure, especially for grain security, market facilitation and drinking water.

— *Strengthen Environmental Measures in Poverty Areas*. Promote farming systems and technological measures favourable to ecological development in poverty areas so as to form sound economic and ecological conditions. In combination with the strategic plan on western development, strengthen the current necessary infrastructure construction and control over the State land in poverty areas. Increase unit output, tap the potentialities and realise the change from output–oriented, external expansion to internal development with the focus on improving product quality. According to the overall plan, the focus on comprehensive control and treatment and the principle of integrating entire poor areas, promote integrated action for small valleys, including mountains, water, fields, woods and roads. The objectives should be to strengthen soil erosion treatment and accomplish continuous growth in poverty areas.

— *Speed the Establishment of a New Multi–Dimensional Fund Collection System for Helping the Poor, with Government as Catalyst and Extensive Participation by the Whole Society*. The establishment of an effective new system of funds collection is not only the basic security of the work on helping the poor, but also its real need. It has four aspects. First, the central government must conduct the functions of public administration, formulate an investment security system, perfect the whole social security system, strengthen support for anti–poverty investment and increase utilisation ratios. Second, all departments and regions should invest more money and plan and carry out more projects in poverty areas. Third, because the present ways of helping the poor rely mainly on economic relief or engineering construction, certain expenditure should be transferred from the relevant anti–poverty funds to attract more talented people, purchase technology and enhance anti–poverty achievements. Fourth, implement effective measures to encourage and guide organisations, enterprises and individuals both at home and abroad to help the poverty areas grow economically, with donated funds and investment.

Technology, Investment and Development: Some Reflections from Portugal

José Braz

Introduction

These are contemplative times. Recessions (or even just economic slowdowns) are usually times for reflection, for questioning the "new realities" and other follies of the preceding boom. My purpose here today is to share some reflections based on experience in government and in the technology private sector over the past decade. For the benefit of those whose attention span is limited to the first three minutes, let me start by laying out the main ideas:

— Clarity of objectives is fundamental. (Not every country needs a Silicon Valley to derive benefits from the use of technology.)

— Information may travel at speed of light, but change is still at a snail's pace. (It's not as easy as it looks.)

— Just DO it — don't just SAY it! (Good intentions, speeches and committees are not enough.)

— New–economy success needs old–economy virtues (investment in education, increasing productivity, good governance, sound macro policies).

Do We All Need a National NOKIA?

The answer, clearly, is no, but it often appears as if every government wants to throw money at subsidising the emergence of a national Silicon Valley. A country does not need a car or bus or locomotive factory to have good transportation services — just good roads and good drivers. It is crucial for all countries, but especially for resource–constrained developing countries, to be clear about what levels and types of technology are most useful for their development.

This is seldom the case. Perhaps because the digital revolution is so new and so powerful, it is natural that no government wants to be accused of not keeping up with technological progress. At the same time, because the new technology is complex and evolves rapidly, political decision–makers can hardly be expected to be fully up–to–date. As a result, government ICT (information and communications technology) initiatives often give the impression that anything to do with the internet is, *ipso facto*, a good thing and should be promoted with tax deductions, subsidies or special incentives. At every level of government, an enormous amount of scarce resources is wasted on creating and maintaining websites and portals that have virtually no useful purpose, except perhaps to employ expensive consultants.

The relation between technological expertise and wealth creation (or poverty reduction) is far from linear. The old Soviet Union was first in placing a human in space and getting him back safely, but this technological excellence did nothing to reduce the country's widespread poverty. An interesting, more recent example is that of the state of Karnataka in India, home to the city of Bangalore, which claims to have more engineering colleges (21) than any other city in the world and has a long tradition of excellence in engineering and, more recently, information technology. It is generally considered one of the world's leading centres of ITC excellence — a Silicon Oasis in a very poor country. Despite that, the state of Karnataka has more poverty (i.e. lower GDP per capita) than its neighbours to north and south, Maharashtra and Kerala. Its literacy rate, at 67 per cent, is not significantly different from the Indian average of 65 per cent, notwithstanding that 30 000 engineers graduate from the state's 82 engineering colleges each year (*The Economist*, 2001). Many probably emigrate — it is said that 36 per cent of NASA's engineers are Indian, as are 34 per cent of Microsoft's. Karnataka's focus on ITC excellence is certainly impressive, but not necessarily the most effective way to combat poverty.

The appropriate IT strategy for each country has to take into account that country's initial conditions — the skills of its workers, the literacy of its population, the purchasing power of its consumers and the composition of its output. For most developing countries with relatively unsophisticated productive sectors, it probably makes more sense to invest in basic education, including adult education, than to develop fancy, and expensive, programmes of getting the public sector wired to the internet, with each government department having its own website, for example.

Yes, Minister!

The speed at which technology evolves can create two types of erroneous policy responses — the phobia of obsolescence and the illusion of rapid change. The first error is to rush into introducing the latest technology (even if inappropriate) so as not to be left behind; the second is to imagine that change can be effected rapidly. Let me give two examples of this latter type of error from my own experience, one from the public sector, the other from the private. In the early 1990s, the Portuguese Treasury tried to streamline the network of treasury offices throughout the country. It wanted to reduce the cost of running a payments system that made sense when it had been introduced at the beginning of the century but was largely redundant when ATMs, checking accounts and post office branches were available in even the smallest towns. The project was keenly supported at cabinet level and even at the top level of the Finance Ministry's civil service. Yet, in the finest "Yes, Minister" tradition, small practical problems kept delaying the implementation of the changes long enough for a Cabinet reshuffle to bring in a new Finance Ministry team that was more pragmatic and shelved the project. As a result, Portugal continues to have an expensive system of treasury branches with 21st century technology and salaries and 19th century staffing levels.

The private–sector example has to do with attempts to introduce sophisticated risk–management software in financial institutions. Generally, top management is keen to introduce computer systems that measure value–at–risk (VAR) to help monitor the risk levels at which traders operate and to improve capital efficiency. Traders, however, prefer greater freedom in decision–making and would rather not allow top management to monitor them so closely. As a result, practical problems of database synchronisation or staff reassignment frequently are exaggerated sufficiently to delay or even impede the introduction of systems that would lead to greater efficiency and cost savings.

In both cases, the lesson to be learnt is that no matter how sophisticated or rapid the systems made possible by technological evolution, the end–user is normally a human being, fearful of the consequences of change and with a strong preference to maintain the *status quo*. It is prudent to be realistic about how long things can take to change and to identify at the outset what obstacles need to be overcome.

Just DO It — Don't Just SAY It!

In Caesar's time, wives had not only to *be* virtuous, but also to *appear* to be virtuous. Nowadays, politicians seem to be mainly concerned with appearing to be virtuous, especially in complex areas like technology or slow–moving ones like poverty reduction, in which the results of not being virtuous usually materialise only in someone else's mandate. In politics, what appears, is! The result is that every government makes the right noises — declarations of the priority of technological excellence or of poverty reduction, creation of special task forces or even agencies to promote innovation and special incentives to encourage "industries of the future" (as if anyone can predict what they will be). With few exceptions, all this activity is a monumental fraud — a public relations exercise to show that the government is concerned with issues that are current and that public opinion deems important even though it realises that achieving results is not within its power.

Portugal is a good example of this tendency to make the right noises and fail in the substance. The last Portuguese presidency of the EU, in the first semester of 2000, gave special importance to issues of innovation, competitiveness and employment. The tone was set by a Presidency Document in January on *Employment, Economic Reforms and Social Cohesion — Toward a Europe of Innovation and Knowledge*. In March, a special meeting of the European Council in Lisbon and a Ministerial Conference in Noordwijk focused on “Knowledge and Innovation for European Competitiveness”. They set targets for improvements in R&D, the use of ICT and the importance of benchmarking, all with a view to catching up with and then overtaking the United States as the world leader in technological innovation. In June, the Feira Summit achieved a promise of possible, distant harmonisation of taxation, meant to contribute to European cohesion. Again, the Summit conclusions were replete with references to innovation, reforms, flexibility, pragmatism, dynamism, entrepreneurship, employment and growth. All the right sounds had been made and politicians could go on holiday with a clear conscience.

When they returned, the rude reality of having to get a budget approved made the government look for support wherever it was most forthcoming, which happened to be on the left and came with severe strings attached. A social security “reform” entrenched the *status quo* and made it impossible even for parliament to make significant changes without the explicit approval of the unions. A tax “reform” paved the way for the lifting of bank secrecy, sharply raised effective taxation on small enterprises and introduced capital gains taxation on equity transactions. As a result, the Portuguese Stock Exchange is the worst performing of all European exchanges this year, with the price index having fallen by almost 20 per cent since the beginning of 2001. Less than a year after the commitments to dynamism and growth, the Portuguese economy is in considerably worse shape — not only cyclically but also structurally — than it was before the fine speeches and the summits.

“New–Economy” Success Needs “Old–Economy” Virtues

Portugal is a good case study of what needs to be done to make the economy more competitive and so raise average incomes. By most measures of competitiveness used in benchmarking exercises, Portugal is at or near the bottom of the list. Comparative data reproduced in the graphical annex to this paper show Portugal to be somewhat or very much at a disadvantage relative to the EU average, the United States and Japan when measured by indicators of:

— Enterprise investment;

— R&D spending in education;

— Number of researchers in industry;

— Attitudes to new technology;

— Quality of ICT infrastructure;

— Cost of internet access;

— Levels of higher education; and

— Labour legislation inflexibility.

Even more disquieting than these static indicators, however, is the evolution of public spending in Portugal over the past decade. Between 1991 and 2000, all other countries in the EU significantly lowered their ratios of public spending to GDP — by four percentage points on average in the EU and by 13 percentage points in Ireland. During the same period, Portugal increased the weight of its public sector in the economy by no less than seven percentage points, to over 50 per cent of GDP in 2001 (see Mateus, 2000, for a fuller account). The increase in public spending has been predominantly in larger transfer payments and in bloating the civil service even further. In a relatively short period, Portugal has reached Nordic levels of public spending, while retaining Third–World quality of public services.

The solution to this problematic situation is easy to prescribe but difficult to implement. Improving competitiveness and productivity calls for:

— Lower public current spending and more investment in improving education and training;

— Reducing effective tax rates to promote new productive investment;

— Making labour legislation more flexible to promote employment;

— Increasing competition in utilities and ICT services, to reduce costs and improve quality; and

— Improving the functioning of the judiciary and of the official bureaucracy.

In most of these areas, technology could give an invaluable assist in the form of more efficient procedures and greater productivity. Yet that would require tough political decisions to close down redundant divisions or departments and retrain or lay off personnel, something which politicians have great difficulty in doing.

The painful bursting of the Nasdaq bubble over the past year has shown that "new–economy" firms could not forever ignore "old–economy" management principles. Similarly, in the management of national economies there is no escaping the need to adhere to the "old–economy" virtues of prudent fiscal management, good governance, investor–friendly legislation and tax structures and a well trained labour force. In Portugal over the past decade, a favourable external environment has been squandered while populist policies have made the country less competitive, in spite of all the lip service paid to the frothy buzzwords of the internet age.

Bibliography

BRAZ, J. (ed.) (2000), *Por um Sistema Fiscal Competitivo*, CIP (Confederation of Portuguese Industry), Lisbon.

MATEUS, A. (2000), "A Competitividade Fiscal no contexto da União Europeia", *in* J. BRAZ (ed.) (2000), *Por um Sistema Fiscal Competitivo*, CIP (Confederation of Portuguese Industry), Lisbon.

The Economist, 2 June 2001, "A Survey of India's Economy".

UNICE (Union of European Confederations of Industry and of Employers) (1999), *Fostering Entrepreneurship in Europe — The UNICE Benchmarking Report 1999*, UNICE, Brussels.

UNICE (2000), *Stimulating Creativity and Innovation in Europe — The UNICE Benchmarking Report 2000*, UNICE, Brussels.

Appendix

The following figures, taken from the UNICE *Benchmarking Reports* of 1999 and 2000, compare selected variables for Portugal, the European Union (EU), the United States (US) and Japan.

Figure 1. **Average 1992-97 Enterprise Investment Per Capita**
(€)

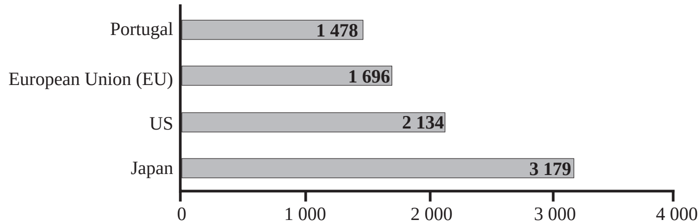


Figure 2. **Average 1997 Per Capita R&D Spending on Post-secondary Education**
(€)

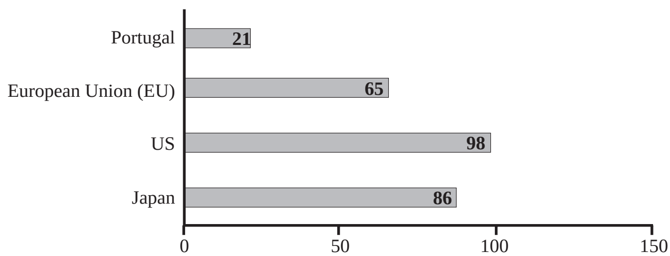


Figure 3. **Number of Researchers in Industry, per 10 000 Workers, 1996**

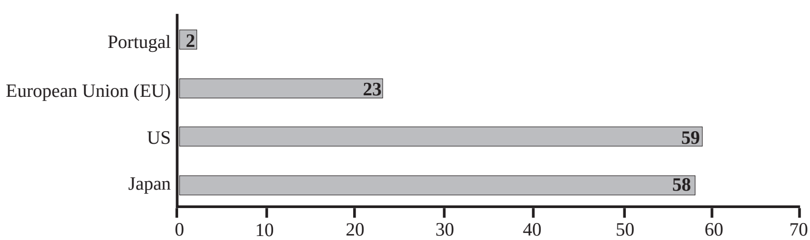


Figure 4. **Negative Attitude to New Technologies**
(Percentage of adults polled, 1996)

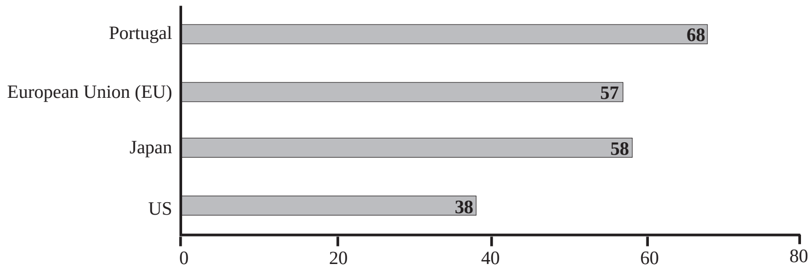


Figure 5. **Quality of ICT Infrastructure**
(Index base year 1998)

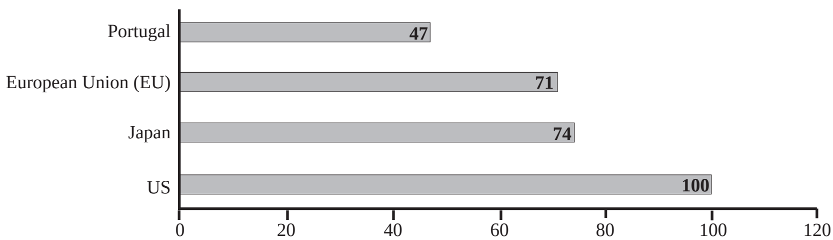


Figure 6. **Cost of 40 Hours of Peak-Hour Internet Access**
($, with VAT, October 1999)

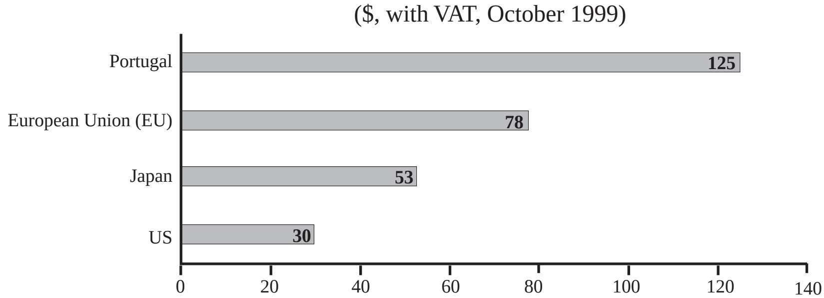


Figure 7. **Percentage of Population (25 to 64 years old) with Post-Secondary Education, 1998**

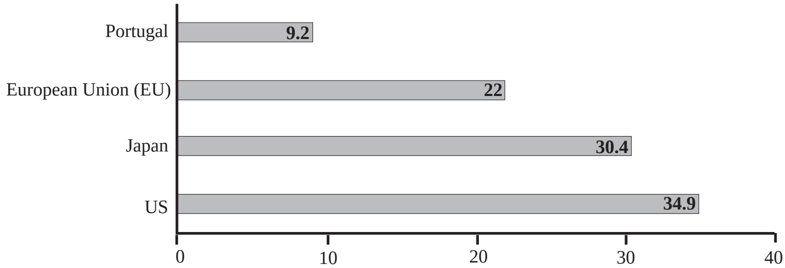
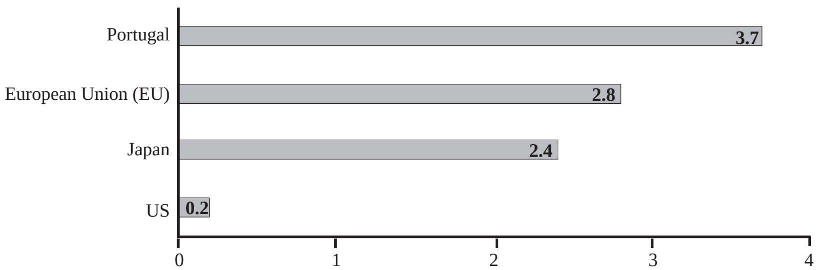


Figure 8. **Inflexibility of Labour Legislation, on a Scale of 0 to 4, 1999**



Note: This measure is originally from OECD (1999), *Employment Outlook,* OECD, Paris.

Information Technology and Development Co–operation: A View from the DOT Force

Gilles Brégant

The French Ministry of the Economy, Finance, and Industry created the Mission for a Digital Economy in March 2001, with three objectives:

— *First,* to promote a forward–looking consideration of the issues surrounding the new information and communication technologies (NICT) economy, such as electronic trade, secure exchanges, electronic signature, taxation and public markets, as well as the spread of the internet and the digital divide;

— *Second,* to ensure a permanent discussion between the ministry's services and the economic actors, enterprises and professional associations; and

— *Third,* to present the ministry's positions to international authorities dealing with new technologies, using the best public and private experts.

The Seventh International Forum on Asian Perspectives could not better correspond to this definition of assembling the best public and private experts, and I would like to thank the Asian Development Bank and the OECD Development Centre for the honour of inviting me to speak to you on this occasion.

All of us are concerned with the issue of technological progress and investment strategies. With the recent creation of the internet, this subject concerns all countries and our mission works on these themes, particularly within a national context. Because the internet raises similar questions everywhere, our mission has been involved for the last several months in the work of the G–8 on this issue and, more specifically, in the work of the Digital Opportunity Task Force (DOT Force), known in French as the GEANT group. I would like, therefore, to develop this topic with you. As many of you know, this unusual structure was created after the Okinawa Charter, when Japan presided at the G–8 meeting, to develop several themes that the Charter had already clearly presented.

— *First,* the DOT Force was to facilitate discussions among economic development actors from developed countries, international organisations and developing nations alike. The goal of these discussions was to encourage the creation of regulatory frameworks, improve connectivity and reduce its costs, and advance in training and the creation of economic activities.

— *Second,* it was to help co–ordinate the work of different entities in development aid for new technologies.

— *Third,* it was to promote an understanding at the highest political level of the development issues that information technologies represent.

— *Fourth,* it was to better assess the contributions of enterprises and all actors of good will to reducing the digital divide.

— *Last,* it was to present its conclusions before the G–8 Summit in Genoa, in July, which our newspapers have been discussing very actively.

The DOT Force is indeed an original institution. It brings together 17 governments (the eight G–8 countries, the European Commission, eight developing countries, including India and Indonesia, who are here with us at this conference), seven international organisations including the OECD, eleven private–sector representatives and eight NGO representatives, one from each G–8 country. These 42 official delegations rapidly received contributions from local and regional communities, from other enterprises and associations, and even from individual experts. This diverse structure brings together many different and complementary experiences and has functioned quite effectively. This in itself is a first important lesson for organising international working groups on these issues. It may well be that the unusual composition of this group led it to go further than simply making an analysis of the situation, to define a set of actions by targeting from the outset practical solutions to the problems addressed to it. The group sought to work by consensus on the major directions to recommend. Three points of consensus became clear.

— *First, the NICTs offer real opportunities for reducing inequalities and beginning to create local wealth*. The DOT Force members were not utopian. They did not seek to transmit the enthusiasm of the first internet promoters. The NICTs are not a panacea and their effects are not automatic, but if they are adapted to local uses, they can help to share crucial knowledge, for example about weather conditions, health, market prices or the availability of scarce resources. Sharing knowledge makes it possible to improve production methods and facilitates greater access to mutually beneficial services. Having a community *appropriate* crucial information that affects its own development is the beginning of a virtuous cycle.

— *Second, technologies cannot resolve all problems*. The governments of all developed countries are working to reduce today's digital divide, which is the product of a combination of factors — the state of infrastructures, access costs, regulatory arrangements, the absence of local content and the difficulty of turning information flows into productive economic activities. For these reasons, the digital divide will grow exceptionally quickly if we are not careful. It is therefore important to create a clear framework from the outset so that parameters do not diverge and these technologies always benefit the greatest number.

— *Third, we must put an end to the either–or debates,* i.e. either development aid or financing for information technologies. These technologies are in fact part of any approach to development aid. In today's world, they underpin improvements in agriculture, industrial production, health care, education, and soon in community living. Leaders of developing countries daily confront questions more serious than IT equipment, but it is nonetheless important that they integrate the new technologies into their decisions as an aid or even as a lever for resolving certain problems. Many developed countries are already operating this way, dispatching IT expertise to every branch of their administrations. Since 1997, every ministry in France has had a representative of the new technologies, and the Prime Minister himself is responsible for co–ordinating them. International organisations are similarly organised, as they incorporate new technologies increasingly into their development aid programmes.

Having posed these principles, the group then proceeded to analyse four specific areas, identifying the state of the art, the obstacles to avoid, and the possible initiatives. The first was the national legal and regulatory context and the issue of international governance of the internet. The second concerned infrastructure and access. The third covered the development of human capital and the fourth the development of applications and services. Each area raised a different set of problems. The work showed that IT should, above all, be *disseminated* as a stimulus within communities so that they can play their role fully, depending on the specifics of each country and culture. To make this possible, the group proposed nine directions for action.

1. Establish strategic programmes (e–Strategies) for developing an information society. Each government must define its specific priorities and strategic programme. The regulatory and institutional framework should be made coherent as soon as possible to enable public and private actors to play their roles. The DOT Force also proposes the creation of a virtual resource centre to facilitate the exchange of solutions. France, where the regulatory plan was quickly established, would be ready to share its experience in this area with both governments and independent regulatory agencies.

2. Improve connectivity, create widespread access and lower costs. Here, it is important to allow the different available technologies to compete and to encourage the creation of public access points. France is committed to this idea, and we already have an aid fund for creating such access points.

*3. Improve human development, create and share knowledge***.** The issue here is to encourage the dissemination of IT in schools and universities, without forgetting to include girls and boys alike, for they will all play a crucial future role in accepting these technologies into their daily lives. Enterprises in developed countries should encourage the temporary loan of some of their experts to launch these education programmes more quickly.

4. *Promote the emergence of an entrepreneurial spirit, which is key to sustainable development.* The internet lends itself well to the creation of enterprises by opening new areas of possibility, as many countries have seen — and continue to see despite the end of an era of exuberance. Enterprises can be created anywhere, so long as financing is available and all the requisite conditions exist for new, profitable companies to emerge. The experience of private enterprises in terms of incubation time should be put in the service of development, and public and private capital should be invested in these initiatives.

5. *Make it possible for all countries to participate in the international debates on the internet and IT***.** The DOT Force suggests that all countries be involved in questions concerning internet governance and that they have access to the necessary expertise in order to take positions in these debates.

6. *Support the initiatives of developing countries for IT access.* Public and private support should go especially to large–scale national and regional projects designed to provide higher–speed communications access or rural development.

7. *Support the use of IT for health, particularly in the fight against pandemics such as AIDS, and infectious diseases.* The world–wide dissemination of information made possible by the internet is one of the first benefits to be expected.

8. *Support the creation of local content and applications*. This supposes that communities have access to low–cost or free (open–source) tools to develop programmes and applications in local languages that are immediately useful. It is also possible to imagine that administrations could promote the spread of the internet, once a sufficient number of public access points exists, which is also a vector for familiarising the public with these technologies.

9. *Determine the priorities of the G–8 and of the different development aid programmes, and improve the co–ordination of multilateral initiatives in line with e–Strategies*. This means creating transversal co–ordination for more effective action.

The Mission for a Digital Economy and the head of the Treasury have already proposed incorporating these nine directions into their thinking about the strategies of French development agencies. Indeed, the breadth and objectivity of these initial concrete results for using the internet for development already provide some clear indications for defining public policy.

Given the initial objectives of the DOT Force — to facilitate discussion, co–ordinate action, create awareness, bring together all concerned actors and finish in less than a year — we can be satisfied with the work accomplished thus far and particularly with the dynamism that this structure has created. We have also seen that where organisation lends itself to such an endeavour, governments, enterprises and NGOs can all work together productively on important international issues. Having been personally involved in this work, I can assure you that it was also particularly harmonious. I would like to express my wish that these proposals soon lead to concrete actions, and that it will be possible in the near future and, who knows, perhaps within the context of this forum, to monitor the concrete effects for development and for the reduction of poverty.

Seventh International Forum on Asian Perspectives

PROGRAMME

Experts' Seminar

Monday, 18 June 2001

Introductory Remarks: Myoung–Ho Shin, Vice–President, Asian Development Bank
Jorge Braga de Macedo, President, OECD Development Centre
Suwit Khunkitti, Deputy Prime Minister, Thailand

Session I:

Chair: Arvind Panagariya, Chief Economist and Director of the Economics and Development Resource Center, Asian Development Bank

A. Technology Diffusion and Poverty Reduction: History and Prospects

Presentation on Technology and Poverty: Mapping the Connections

Maurizio Bussolo and David O'Connor, OECD Development Centre

Discussants: Michael Lipton, Department of Economics, Sussex University, United Kingdom

Yoginder K. Alagh, Vice Chairman, Sadar Patel Institute of Economics and Social Research, India

B. Biotechnology, Intellectual Property, and the Poor

Presentation on Diffusion and Distribution: The Distributive Impact of Intellectual Property Rights on Global Agriculture

Timo Goeschl — Department of Land Economy, University of Cambridge
Timothy Swanson — Department of Economics and Faculty of Law, University College London, United Kingdom

Presentation on Poverty, Food Security, and Agricultural Biotechnology: Challenges and Opportunities

Nihal Amerasinghe — Director, Agriculture and Social Sectors Department (East), Asian Development Bank

Discussants: Liu Yanhua, Director General, Department of Rural and Social Development, Ministry of Science and Technology, People's Republic of China

Carliene Brenner, Biotechnology Consultant, France

Jenifer Piesse, Department of Management, Birkbeck College, University of London, United Kingdom

Session II:

Chair: Ulrich Hiemenz, Director, OECD Development Centre

A. Information and Communications Technologies: Their Contribution to Poverty Reduction in Asia

Presentation on Information and Communication Technology in Developing Countries of Asia

Brahm Prakash — Assistant Cheif Economist, Economic Analysis and Research Division, Economics and Development Resource Center, Asian Development Bank

Discussants: Peter Ballantyne, International Institute for Communication and Development, the Netherlands

Sanghoon Ahn, OECD Economics Department

B. Technology Financing towards Poverty Reduction in Asia

Presentation on Financing Information Technology Diffusion in Low–income Asian Developing Countries

Yun–Hwan Kim — Senior Economist, Economic Analysis and Research Division, Economics and Development Resource Center, Asian Development Bank

Discussants: Arnaud Ventura, Director General, PlanetFinance, France

Lahiru Perera, South Asian Regional Director, Intermediate Technology Development Group, Sri Lanka

Concluding Remarks: Arvind Panagariya and Ulrich Hiemenz

Co–chairs of the Forum: Myoung–Ho Shin, Vice–President, Asian Development Bank

Jorge Braga de Macedo, President, OECD Development Centre

Public Conference

Tuesday, 19 June 2001

Inaugural address: François Huwart, Secretary of State for Foreign Trade, Ministry of Economy, Finance and Industry, France

Welcoming Remarks: Jorge Braga de Macedo, President, OECD Development Centre

Keynote Address: Myoung–Ho Shin, Vice–President, Asian Development Bank

Session I: Technology Development Policy for Poverty Reduction

Chair: Jorge Braga de Macedo, President, OECD Development Centre
Suwit Khunkitti, Deputy Prime Minister, Thailand

Desmond O'Malley, Member of Parliament,
former Minister of Justice and Minister of Industry and Commerce

Lahiru Perera, South Asian Regional Director,
Intermediate Technology Development Group, Sri Lanka

John Kay, Economist, United Kingdom

Session II:Technology Progress and Investment Strategy in Low–income Countries

Chair: Yoginder K. Alagh, Vice Chairman, Sadar Patel Institute of Economics and Social Research, India

Liu Yanhua, Director General, Department of Rural and Social Development, Ministry of Science and Technology, People's Republic of China

José Braz, Managing Partner, TEcFinance, Lda., Portugal

Henri Guillaume, President of the Mission for a Digital Economy, Ministry of Economy, Finance and Industry, France

Seventh International Forum on Asian Perspectives

List of Authors and Participants

High–level Panel 19 June 2001

Co–chairs of the Forum

Jorge Braga de Macedo
President, OECD Development Centre

Myoung–Ho Shin
Vice President, Asian Development Bank

Yoginder K. Alagh	Vice Chairman and Professor, Sardar Patel Institute of Economics and Social Research, India
José Braz	Managing Partner, TEcFinance, Lda., Portugal
Gilles Bregant	« Technologies de l'information et de la société de l'information » à la DIGITIP, Ministère de l'Économie, des Finances et de l'Industrie, France
François Huwart	Secrétaire d'Etat au Commerce extérieur, ministère de l'Economie, des Finances et de l'Industrie, France
John Kay	Economist, United Kingdom
Suwit Khunkitti	Deputy Prime Minister and former Minister of Science, Technology and Environment, Thailand
Desmond O'Malley	Member of Parliament, former Minister of Justice and Minister of Industry and Commerce and Personal representative of Mary Harney, Deputy Prime Minister of Ireland
Arvind Panagariya	Director and Chief Economist, Economics and Development Resource Center, Asian Development Bank, Philippines
Lahiru Perera	South Asia Director, Intermediate Technology Development Group (ITDG), Schumache Centre for Technology and Development, Sri Lanka
Liu Yanhua	Director General, Department of Rural and Social Development, Ministry of Science and Technology, People's Republic of China

Authors, Experts and Discussants / Experts' Seminar

18 June 2001

Sanghoon Ahn	Economist, OECD Economics Department, Resource Allocation Division, France
Yoginder K. Alagh	Vice Chairman and Professor, Sardar Patel Institute of Economics and Social Research, India
Sergio Alessandrini	ISLA, Universita Commerciale Luigi Bocconi, Italy
Nihal Amerasinghe	Director, Agriculture and Social Sectors Department (East), Asian Development Bank, Philippines
Bernadette Andreosso–O'Callaghan	Director, Euro–Asia Research Centre, University of Limerick, Ireland
Peter Ballantyne	Manager Knowledge Sharing, International Institute for Communication and Development (IICD), Netherlands
Carliene Brenner	Biotechnology Advisor, France
Maurizio Bussolo	Researcher, Income Distribution, OECD Development Centre, France
Wan–wen Chu	Deputy Director, ISSP, Academia Sinica, Chinese Taipei
Daniel Cohen	Special Advisor, OECD Development Centre, France
Cowan Coventry	Chief Executive, Intermediate Technology Development Group Ltd., The Schumacher Centre for Technology & Development, United Kingdom
Stéphane Ducable	Director of International, Government and Regulatory Affairs, Alcatel, France
Dag Ehrenpreis	Senior Advisor for Poverty Reduction, OECD Development Co–operation Directorate, France
Paul Falzon	Director of the UNESCO Development Banks Division of the Bureau of Extrabudgetary Funding, UNESCO, France

Michel Fouquin	Directeur adjoint, CEPII, France
Ulrich Hiemenz	Director for Co–ordination, OECD Development Centre, France
Suwit Khunkitti	Deputy Prime Minister and former Minister of Science, Technology and Environment, Thailand
Yun–Hwan Kim	Senior Economist, Economic Analysis and Research Division (EDAN), Asian Development Bank, Philippines
William Lazonick	Visiting Scholar and Co–director, Project on Corporate Governance, Innovation and Economic Performance, INSEAD, France
Michael Lipton	Research Professor of Economics, Sussex University, United Kingdom
Françoise Nicolas	Économiste, IFRI — Institut Français des relations internationales, France
David O'Connor	Researcher, New Technologies and Developing Country Entrepreneurs, OECD Development Centre, France
Arvind Panagariya	Director and Chief Economist, Economics and Development Resource Center, Asian Development Bank, Philippines
Lahiru Perera	South Asia Director, Intermediate Technology Development Group (ITDG), Schumacher Centre for Technology & Development, Sri Lanka
Jenifer Piesse	Reader, Department of Management, Birkbeck College, University of London, United Kingdom
Tony Polatajko	Enterprise Development Adviser, Department for International Development (DFID), United Kingdom
Brahm Prakash	Assistant Chief Economist, Economic Analysis and Research Division (EDAN), Asian Development Bank, Philippines
Ravi Rao	Deputy Director of Science and Technology Division, Commonwealth Secretariat, United Kingdom

Pascal Renaud	Conseiller de nouvelles technologies, informations et communications, Institut de recherche pour le développement (IRD), France
Timothy Swanson	Professor, Department of Economics and Faculty of Law, University College London, United Kingdom
Zeynet Varoglu	Assistant Programme Specialist, Higher Education Division, Access, Mobility and Quality Assurance, UNESCO, France
Graham Vickery	Principal Administrator (Information economy, Electronic commerce), OECD Directorate for Science, Technology and Industry, France
Liu Yanhua	Director General, Ministry of Science and Technology, People's Republic of China
Ralf Zeppernick	Senior Economist, Federal Ministry of Economics and Technology (BMWi), Germany

Additional participants to those listed above

Asian Development Bank

Mr. Jeoung–Keun Lee	Senior Advisor, Office of the Vice–President (West)
Mr. Robert Salamon	Chief, Office of External Relations

OECD Development Centre

Caroline Blond	Trainee
Georg Caspary	Stagiaire
Gilles Cavaillès	Trainee
Catherine Duport	Head of Support Services
Colm Foy	Head of Communication
Ida McDonnell	Researcher
Henri–Bernard Solignac Lecomte	Economist/Analyst of Civil Society

Forum Secretariat

Myriam Andrieux
Marsha Beaudoin
Laurie Chamberlain
Claude Gaine
Christine Johnson
Sandrine Sabatier
Mayrose Tucci
Terri Wells

OECD PUBLICATIONS, 2, rue André-Pascal, 75775 PARIS CEDEX 16
PRINTED IN FRANCE
(41 2002 05 1 P) ISBN 92-64-19821-0 – No. 52567 2002