Information Technology and Developing Countries:

Potential and Obstacles

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Introduction

Diminishing the digital divide between developed and developing countries is the stated objective of the United Nations (UN) and its agencies:

> There are more computers in the US than in the rest of the World combined. There are as many telephones in Tokyo as in all of Africa. The digital divide can – and will – be bridged.[2]

To bridge this technological gap, two World Bank experts, Talero and Gaudette (1996), recommend that "a major agenda of structural adjustment" should take place in developing countries, otherwise they "risk exclusion from a global economy and severe disadvantage in the competitiveness of their goods and services."[3] This objective is fully supported by the leaders of the Group of Eight (G-8) industrialised nations, who promised at the meeting in July 2000 in Okinawa to create a so-called "Dot.force" – a task force to share information technology (IT) - with less developed countries.

The assumption underlying such declarations and initiatives is that unless developing countries catch up with the computer 'revolution' by acquiring computer hardware and software and by improving telecommunications, their overall growth performance will suffer. Such assumption, however, raises two questions. The first concerns the evidence of the relation between IT and economic performance; the second relates to the transferability of such a relation to developing countries.

By information technology is meant the combined utilisation of electronics, telecommunications, software and decentralised computer workstations, and the integration of information media (voice, text, data, and image) (Malecki 1991; Frisk 1988). Its penetration means the extent of usage. The penetration of IT into developing areas is a large topic of which this paper concerns only a few understandings, and these are

based on the extent that the penetration of IT, including the spread of the Internet, constitute infrastructure-related technologies that provide competitive advantage to certain sectors and communications services across space.

The dual aims of this paper, are, first, to review the literature on the effects of IT on [labour] productivity, taking the US as a point of departure. Second, the aim is to suggest by this background statement the implications of the productivity literature for the benefits of the IT and Internet to economic development. As investment in computers for developing countries is targeted by policy leaders, obstacles to the diffusion of IT as well as the costs of overcoming them will be a research agenda.

Economic Benefits in High Income Countries

During the first part of the 1990s, most studies failed to find a relationship of importance between productivity (the output of the economy per hour of work) and the development of IT, including the Internet; at most they found a marginal impact.[4] Many concurred with Nobel Laureate Robert Solow (1987), who remarked that "you can see the computer age everywhere but in the productivity statistics".[5] The remark was used to highlight 'Solow's paradox' or the 'productivity paradox' of information technology, by which IT and the Internet, although spreading rapidly throughout the US economy, actually failed to improve productivity growth. The productivity paradox is now an obsolete concept,[6] because of revisions of the data as well as the "exploding rates of productivity growth

[2] Annan (2000), p.32.
[3] Talero and Gaudette (1996), section 1: How is information shaping the economy and society?
[4] See for instance Oliner and Sichel (1994).
[5] Sichel (1999), p.18: "until the mid-1990s, the [US] economy's productivity performance was lackluster. After rapid growth in labour productivity in the 1950s and 1960s, output per hour increased at an average pace a bit over 1 percent per year from 1973 to 1995."
[6] Gordon (1999), p.2: "Choosing as break points the cyclical neutral quarter at the cusp of the slowdown (1972:2) and the last quarter before the acceleration began (1995:4), there is clear evidence of a productivity growth recovery. […] annual growth rates of non farm private businesses (hereafter NFPB) output per hour in the three intervals extending between 1950:2, 1972:2, 1995:4 and 1999:1 were respectively 2.63, 1,13, and 2.15 percent. The recovery over the last three years does not bring the US economy back to the pre-1972

registered in 1998 and 1999" in the US.[7] Gordon (2000) qualifies this buoyant assessment by cautioning that the "Solow paradox […] remains intact outside of durable manufacturing."[8] To that, it can be added that IT reduces market segmentation of services dramatically. The sustainability of the impact of IT on productivity growth, nevertheless, remains controversial. For sustainability, the present, "rate of new product and new technology introductions must be greater than in the past".[9]

With this cautionary note, two other major contributors to the discussion of the weight of IT in post-1995 rates of economic growth in the US are mostly sympathetic to its further potential. Reviewed in Bosworth and Triplett (2000),[10] both, along with Bosworth and Triplett themselves, find that a contribution of IT lies in capital inputs: two-thirds of the productivity growth in the US was due to accelerating growth in economic inputs and the rest to multifactor productivity (MFP). In general, it is well understood that there are three channels for productivity growth due to IT: direct productivity gains, capital investment or 'capital deepening' (more capital per worker) and spillover effects. Of these, all authors find for a narrow but visible impact: it is the supply side effects within the IT producing sector, the technological innovations in the production of IT capital, which really matter (Bosworth and Tiplett [2000]). In semi-conductors and computers, there are clear effects of innovation on the productivity of labour through an increase in the capital labour ratio and price declines in IT capital.[11] There is, in fact, considerable agreement that falling computer prices led to an increase in the stock of computing capital, with capital deepening affecting labour productivity through investment, thus accounting for low inflation in the presence of a very tight labour market

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"golden age" but appears to recover roughly two-thirds of the lost ground (with a recovery of 1.02 points equalling 68 percent of the 1.50 point slowdown between 1950-72 and 1972-95)."

[7] Gordon (2000), p.2.

[8] Gordon (2000), p.44.

[9] Triplett (2000), p.326.

[10] Jorgenson and Stiroh (2000) and Oliner and Sichel (2000).

in the 1990s. Of the estimated one percentage point rise in US labour productivity growth in the second half of the 1990s, IT accounted for about _ to _ percentage point.[12] In terms of MFP, the effect is estimated of up to a _ percentage point. There is not much measurement, to be sure, of spillover effects to other industries through the role of intangible capital in the formation of intellectual property.[13] This effect could be of any magnitude. However, Bosworth and Triplett (2000) dominate the thinking, that IT's contribution to economic growth and to labour productivity should be measurable to be embraced, and that this contribution is separable from IT's contribution to multifactor productivity or MFP.

The latter has definably increased after 1995, but not necessarily due to the impact of IT in computer using industries.[14] Bosworth and Gordon concur on this important point: 'computers do not seem to have done much to raise the productivity of the computer-using industries.'[15]

Other economists are more optimistic. They consider in their analysis of the contribution of IT to productivity both difficult to measure factors and a time horizon for analysis. They look at the impact of IT on the work force over the short and, then, medium term, since the application of IT requires a learning adjustment. Daniel Sichel (1999) emphasises that the view of Paul David (1991), regarding the slow appearance of benefits due to long-learning lags, is now appealing, since finally, US productivity growth began significantly to improve after the mid- 1990s. Hornstein (1999) agrees, and he notes that

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[11] Schreyer (1999) finds similar results for OECD countries.
[12] Quoted in IMF (2000), p.73. The studies mentioned are Jorgenson and Stiroh (2000); Oliner and Sichel (forthcoming); Whelan (2000); Council of Economic Advisors (2000); Gordon (2000).
[13] See Gordon (1999b), pp.2-3.
[14] Bosworth and Triplett (2000), p.5. On p.14, the authors make the distinction stronger: "Multifactor productivity (MFP) is the amount of economic growth that *is not* explained by growth in the productive inputs. If all the productive inputs are correctly accounted for and their prices correctly measured, growth in a productive input such as IT capital should not affect multifactor productivity. Whether a technological innovation affects multifactor productivity depends on whether or not a particular innovating activity is or is not fully paid for, and if it is paid for, whether or not it is measured correctly in economic statistics."
[15] Bosworth (2000), p.31.

"new technologies diffuse slowly through the economy […] Experts have made this observation for a wide variety of products from diesel locomotives to DRAM chips."[16] On a different note, Sichel (1999) recognises the importance of withholding judgment: "the large gains of the past few years may well turn out to be a transitory response to unusually rapid declines in computer prices and an unusually robust economic environment."[17] Here it can be noted that even the optimists and those willing to consider intangibles are cautious. As Triplett (1999) concluded, it is difficult not to note that the computer may have simply supplanted older technologies for achieving existing outcomes and not led to fundamentally new outcomes.

The factors most responsible for improving economic growth rates are well known. The first objective of this paper is to review how economists have used these factors in growth to explain the impact of IT and the Internet. Theories of growth generally adopt the growth accounting method derived from Solow (1957), and the contribution of IT to the growth rate is mainly assessed in this way. Kiley (1999) incorporates levels of transitional costs for computers in the form of investment adjustment costs, and he finds definite evidence of productivity effects.

However, the accounting method raises particular difficulties that present an important interpretive challenge. Whelan (2000) finds that the US National Income and Product Accounts fail to measure technological obsolescence, and therefore measures of the computer capital stock are inappropriate. His conclusion is that "a marked pick up in the rate of computer capital deepening combined with improved productivity in the computer-producing industry have accounted for almost all of the recent acceleration in aggregate productivity."[18] Quah (1997) also cautions that Gross Domestic Product (GDP), as traditionally divided into agriculture, industry and services, will fail accurately to

[16] Hornstein (1999), p.5.
[17] Sichel (1999), p.22.

measure effects of IT which "straddles, among other things, manufacturing under industry, and transport, storage and communications under services".[19]

Another measurement issue is that the service industry - where IT is having an impact integrating markets - is the least well measured sector in national accounts.[20] That is, as pointed out by Triplett (1999), "even though some sector is measured badly, we cannot know the sign of the error for sure. 'Mismeasurement' does not *always* mean upward bias in the price indexes and downward bias in the output and productivity measures."[21] Still the share of services in the structure of GDP seems to be increasing (Table 1, Appendix 1), and in transition countries, where services are a start-up sector, their expansion from a zero base may account for the simultaneous astonishing growth rate in the expansion of the Internet and IT.[22]

Still another difficult to measure effect is the possible role of IT in assisting growth by contribution to inflation control. Bosworth (2000) explains the critical role of inflation control in the achievement by the US economy in sustaining high growth rates. Naturally, inflation control is not entirely separate from the main contributors to growth: the first being the greater efficiency of labour markets. This efficiency was due to institutional changes, such as the reduction in trade union power and workers sensing the competitive implications of globalization, requiring the modification of organized labour's demands. The second is the favorable external conjuncture reflected in the depressed prices of commodity and other inputs for much of the past decade. IT effects constitute a third factor in the controversial issue of productivity gains. To Bosworth, these gains in

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[18] Whelan (2000), p.26.
[19] Quah (1997), p.50; see also Grossman and Helpman (1997), p. 6, for a critique of the use of GDP as a perfect measure of output growth.
[20] See Griliches (1994).
[21] Triplett (1999), p.319.
[22] A study by the IDC (International Data Corp.) has positioned the Russian Internet market, for example, as on the eve of massive growth, continuing phenomenal growth in usage up to 6.4 per cent of the population. See Leonard (2000).

productivity were realised at least in part through their contribution to the low rate of aggregate inflation.

To define the link between IT and inflation control more precisely, the decline in the price of information processing together with the growth of computing power are what holds down inflation.[23] This is only an indirect influence, but it may be powerful enough to have a strong effect. If this were to be IT's main effect, contribution to the low rate of inflation, it was a major contributor to growth, since inflation control was the sine qua non of recent growth in the US. The evidence has still to be weighed. One word of caution is that,

> [Economists] must be careful in explaining how the benefits of hi-tech products could have held down *measured* inflation without boosting *measured* productivity. Any complaint that official price indexes[24] miss some of the impact of hi-tech innovation (however justified) cannot be part of the explanation of a mysterious deceleration in measured inflation.[25]

Another issue, as discussed by Bosworth and Triplett (2000), is the spread of the use of hedonic prices, which creates international incompatibility in productivity measurement. Statistics are not internationally homogenised, and the use of hedonic prices may artificially increase the rate of price decline of IT capital.

The combined issues of data reliability and measurement prevent anything more than a preliminary assessment of the direct countable effects of IT. As Gordon (1999a)[26] observes, the direct production of computers is far from the only component of hi-tech's contribution to national accounts. Although his own measure puts the computer effect at 1.2 per cent of GDP by official definition, among computer-related potential factors

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[23] Gordon (2000), p.10: the remarkable event which occurred at the end of 1995 was an acceleration of the rate of price change in computer hardware (including peripherals) from an average rate of –14.7 percent during 1987-95 to an average rate of -31.2 percent during 1996-99.

[24] Whelan (2000), p.5 mentions that since 1985 the US National Income and Product Accounts (NIPAs) defines the real output of the computer industry on a 'quality-adjusted' basis, therefore the real investment series for computing equipment are based on quality-adjusted prices, constructed from hedonic regressions that control for the effects on price of observed characteristics such as memory and processor speed.

[25] Gordon (1999a), p.32.

[26] Gordon (1999a), p. 33

lowering cost may be other products, including electronic components in automobiles and supermarket check-out scanners. Where these cost-reducing inputs most hold down prices in the non-computer economy is no doubt in e-commerce, but there too the effect cannot be known for sure in that many of these firms survive despite non-sustainable financial losses.

Regarding spillovers from IT, the key investigations focus on education and the knowledge base. Most studies treat knowledge as a capital good, and they "miss important aspects of the growth process both in high and low-income countries."[27] Danny Quah calls the "weightless economy"[28] one, where knowledge not only matters for economic growth[29] but also for "the increasing importance in national income of *knowledge-products* – computer software, new media, electronic databases and libraries, and internet delivery of goods and services."[…] "the economy is knowledge-intensive, not just because of the quantity of knowledge used in production, but because of the quantity of knowledge-products consumed."[30] But whether, in the longer term, spillover effects will be observed, depends on many interrelated factors. For education to have an effect on the labour market, it is important that the government and private sector initiate structural reforms that would ease labour market segmentation and capital constraints on firm entry as well as general problems of entry in the telecommunications sector.[31]

To summarise, problems of measurement, including how to assess the changes in the knowledge base and pricing, leave the state of the literature somewhat speculative.[32]

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[27] Aghion and al (2000), p.3.
[28] Quah (1997), p.49: "By this I mean that greater value, as a fraction of GDP, resides in economic commodities that have little or no physical manifestation. Another description of such structural change is progressive dematerialisation."
[29] In Quah's analysis, IT or rather ICT is only one element of four of the weightless economy, the other three include intellectual property, electronic libraries and databases and biotechnology, see Quah (1998), p.3.
[30] Quah (1999), Nontechnical Summary, p.1.
[31] IMF (2000), p.78.
[32] Madrick (1999), p.44 notes, "Also the data have been inflated significantly since 1995 by revisions which have reduced consumer prices and therefore raised business output, adding approximately 0.4 percent to

There is no way to say, whether by a narrow or wide approach to understanding GDP growth factors, if US productivity growth will continue at a high rate, or if IT productivity improvements, observed at the end of the 1990s, are sustainable.

Economic Obstacles: Middle and Low Income Countries (MLICs)

Given the fragility of the data and the caution of the benefits-to-productivity estimates, our second objective in this paper is to extend a development perspective to the discussion. Benefits of IT to Low income countries will surely be very limited. Benefits from current investments in IT will be especially difficult to predict. This means that the investments should be closely tracked, so that the nature of outcomes and extent of benefits can continually be adjusted to the long-term development goal.

IT developed from distinct technologies over several decades, and it transformed those technologies by intensifying a geographic concentration. IT allows firms to provide global goods and services, but it favours large urban areas, especially those that service as headquarters of firms and financial capitals, particularly the three major financial centres, London, New York and Tokyo. IT favours cities where there are corporate operations, including also Hong Kong, Singapore, and Seoul, and new investments tend to favour existing concentrations.[33] Regulatory regimes and a large number of other factors slow down diffusion to new locations. One of these factors may be the share of (peasant-based) agriculture which may hold back national demand for IT (see Appendix, Table 1).

Since IT has a substantial spatial dimension, if funds are spent for geographic equalisation, will they actually produce any sustainable result? The obstacles to diffusion confront optimistic views of the potential "revolution" from IT and the Internet both on the demand and supply side.

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reported productivity growth each year. This large adjustment will soon be made to earlier data, making the current performance less strong by comparison."

Demand Factors

External demand on the producing side of the IT sector is quite promising. The share of High Tech products in manufactured exports amounts to 28 percent of in East Asia and Pacific region. The average for South Asia is 4 percent with India reaching 10 percent of manufactured exports. Software, for example, is a profitable export for India. India's software exports will exceed $4 billion in 2000 – about 9 percent of India's total exports. In Latin America and the Caribbean, high tech exports amount to 12 percent of manufactured exports. Costa Rica's economic growth surged to 8.3 percent in 1999 - the highest in Latin America, fuelled by exports from the microchip industry, which now accounts for 38 per cent of all exports. [34]

However, obstacles to the development of IT on the demand side remain. The spread of the Internet across Latin America, Africa and Southeast Asia, where many of the world's most impoverished people live, seems at first glance to defy the notion that low levels of income will inhibit the diffusion of the Internet. Closer inspection leads to different conclusion.

Low per capita income in developing countries holds back households' demand for IT related capital goods and most IT services. The population of low income countries lived on an average of $400 per annum in 1999; in Sub-Saharan Africa the average income per capita is slightly higher at $500--average income in South Africa is $3,140--while that in Mali reach at most $240 (Table 2, Data Appendix). Income in these regions is also subject to high vulnerability, a vulnerability that can be measured by the frequency with which a household falls below the poverty line (a critical level of income or consumption below which poverty is determined).[35] Households in low income countries are vulnerable

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[33] See Moss (1987); Hepworth (1987); Howells (1988); Gillespie and Williams (1988).
[34] Annan (2000), p.32-33
[35] See The World Development Report (2001), p.140.

due to the lack of savings and insurance. Saving rates are much higher in East Asia with 37 percent of GDP in 1999 compared with 20 percent in Latin America and 14 percent in Sub Saharan Africa, Mali only reached 8 percent of GDP (Table 3, Data Appendix). Indicators for private finance (Table 4, Data Appendix) show that high levels of private sector provision of credit coincide with the spread of computers among households (High Income Countries and East Asia and the Pacific). Credit provided by the private sector may be a facilitator in the penetration of IT and the Internet to households and microfinance can play some role in providing capital. Table 3 in the Appendix shows the general structure of demand by region of the world. It distinguishes areas of the world where domestic investment is at levels that support general economic expansion, but it is important to note that in post-Soviet countries, where investment is low, computers have spread among households with significant penetration.

In addition to low levels of income, negative demand-side conditions include patterns of consumption, where subsistence expenditures bulk large in households' budgets, leaving little for education. Education and training are important not only for production but also for IT and Internet to secure a strong demand base.[36] Regarding firms' consumption of IT, their use implies an educated workforce. Where labour is not technologically oriented or educated, skills must be imported and human capital maintained. In the developing world, systems of education are not adequately funded to produce a large highly skilled work force. While in high income countries, public expenditure on education reached 5.4 percent of GDP in 1997, in middle income countries it reached 4.8 percent and only 3.3 percent in low income countries with only 2.2 percent in Mali (Table 2, Data Appendix). India ranks even lower than the average Sub Saharan Africa in level of government expenditures on education with 3.2 percent, marginally

[36] See Quah (1999).

higher in this category than other Asian countries. Public spending on education is also frequently regressive. In Nepal the richest quintile receives four times as much public education spending as the poorest quintile.[37]

Columns for literacy in Table 2 (Data Appendix) show that the skills, including language facility, are missing for much of the population and entrepreneurial orientation required for high Internet usage. The illiteracy rate is especially high among women, reaching 68 percent in Central African Republic compared to 57 percent in India and 16 percent in South Africa.

In the Middle East and North Africa as elsewhere in the developing world, the overwhelming number of users, according to a report for 1999, are elites and access Internet from home (72 per cent), and only 27 per cent of users had only a high school education or less.[38] In Russia, low disposable incomes, particularly outside the leading urban centres such as Moscow and St Petersburg have added to the logistical difficulties, while distrust of both banks and officialdom inhibit the online transfer of sensitive financial information. Since Internet usage is heavily concentrated among young people (40 per cent of users are people aged from 18 to 24), on the demand side, the ageing population will limit the growth in the absolute number of users, which raises doubts about how far or fast electronic commerce will take off.[39] Pioneers such as Guta Bank which, having survived the 1998 crash reasonably well and now focusing on its Internet strategy have launched online financial services, look likely to remain niche players.

Such results seem to confirm that elites in the developing world are rapidly being accultured to the Internet, and a world wide knowledge base will develop through elites,

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[37] The World Development Report (2001), Table 5.1, p.80.
[38] "DITnet Report, survey of 1000 users: "Report Profiles Usage Patterns in Middle East," 9 August 1999, www.nua.ie/surveys.
[39] "Internet Revenues Remain Uncertain: Russian Online by Andrew Jack, Financial Times (UK), 4 October 2000.

but this may have little relevance to the continued predicament of much of the world's population.

Supply Factors

This section discusses the evidence for supply-side constraints on Internet development and then, potential aids to improvement of the supply–side. Supply side bottlenecks include primarily a lack of physical and legal infrastructure. The issue of taxation is also of some concern. Some governments in Africa, for example, impose high import barriers on computers, treating them as luxury goods rather than as part of the infrastructure for economic modernisation. Factors on the supply side include political blockages to liberalising the regulatory environment for the Internet, including the protection of privacy and entrepreneurial activity.

Infrastructure

The spread of IT requires considerable investment infrastructure. The number of telephone lines per 1,000 persons shows that IT and Internet are beyond the reach of 80-90 per cent of the population in parts of Africa and South East Asia.

South Asia, including India, and parts of Africa, have the lowest level of IT infrastructure development in the world, as measured by World Bank Development and other Data Surveys. The most advanced regions include North Asian developed markets, which far outpace the other Asian countries in Internet development. 46 per cent of residents of Singapore were online in August 2000. Behind Singapore, 42 per cent of Koreans connected, 36.4 per cent of the residents in Taiwan, 29.2 per cent of Hong Kong, and 23 per cent of the population of Beijing, Guangzhoi and Shanghai. Computers

themselves are most widespread in Korea, with 64 per cent of Internet users logging on from home.

In Africa, there are 14 million telephone lines, a figure roughly comparable to that of any of the world's major cities where only South Africa can expect to leap barriers to achieve faster growth.[40]. With 11 percent of the world's population, Sub-Saharan Africa has 1 percent of its telephone lines. South Africa has 115 telephone mainlines and 56 mobile telephones per 1,000 people while Mali for example has 3 telephone mainlines and 0 mobile telephones per 1,000 people (Table 2, Data Appendix). Meanwhile, the South African government has the goal of providing 75 per cent of households access to a telephone and to create Internet linkages for universities, households, high schools and public libraries; 'telephone shops' give rural farmers access to cellular phones.[41]

For the Middle East and North Africa, the data in Table 2 show that the main limiting factor in the spread of the Internet is probably low investment by the private sector. In Saudi Arabia, for example, where roughly 120,000 persons are online, development of private sector IT is stymied by the government. Although in terms of most economic indicators, the Middle East has achieved an overall level of development similar, say, to South Africa, computer ownership and Internet usage are far lower than in South Africa, East Asia and Latin America. There were 1.9 million Arab Internet users (of a population of 248 million) in March 2000--this was only 0.7 per cent penetration.[42] The areas within the Middle East that are more rapidly developing in IT are the United Arab Emirates (15 per cent), Qatar (6.1 per cent), Bahrain (6 per cent), Lebanon (5.7 per cent), and Kuwait (5 per cent). The least developed is Yemen, at 0.07 per cent.

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[40] Jerylin Eddings, "Promise, shortcomings of online technology for Africa discussed," www.freedomforum.org/international/1998/11/18afrucaemail,asp.
[41] See Wilson III (1996).
[42] "Internet Use Skyrocketing in the Middle East (Survey by the Research Unit of Internet Arab World magazine)," 9 March 2000, www.nua.ie/surveys.

Internet development in Latin America seems roughly on the same fast trajectory as in the Transition country, Russia, (Table 2, Data Appendix). There are country differences in Latin America, as elsewhere. The most substantial Latin American Internet penetration is in Brazil, with 41 per cent total users, and then Mexico (21 per cent), Argentina (10 per cent), Chile and Columbia (6 per cent each), Venezuela (5 per cent). Users have increased in different countries for different reasons, in large part pricing differences. In Mexico, PC costs are relatively low; in Brazil, telephone access rates are low; and in Chile and Argentina, call charges are lower. Mobile Internet access is having an impact—with Argentina having the highest rate of mobile phone penetration in the region (12 per cent of the population), and in Mexico, wireless lines are expected soon to outnumber the country's 11m fixed lines.[43] Computers are found in less than 3 per cent of the country's households; most people logon to the Internet from the office. Mexico's fragile infrastructure is overwhelmed by explosive growth and insufficient investment, causing serious problems for cellular reception quality and leading to huge gaps in service.

In Russia, with a strong base in an entirely literate population and fairly extensive telephone infrastructure, IT technologies have diffused rapidly since the collapse of Communism. The rate of Internet users has been reported to have increased by 2.5 times to 3 million in 2000.[44] Data from the Yandex search engine, which monitors Russian websites, counts the numbers of servers at nearly 207,000, more than double since the start of 2000. Although usage figures may be high, however, there are still only some 400,000 paying subscribers. About 35 million people would like to have an access to the Internet global web but cannot afford it. It is hardly surprising that few Russian websites have introduced fees and commissions. In Russia, as in Latin America, the gap in infrastructure

[43] Financial Times, Tuesday 19 September 2000, Mexico sees online Wave, Andrea Mandel-Campbell.
[44] Moscow, 3 October 2000, Deputy Minister of Communications and Information Technology Aleksandr Volokitin, Internetcom 2000 show. Andrew Jack in the Financial Times of 4 October reports that Spylog, a

is computers and home telephones. Poor quality phone lines help explain why the time spent online is low compared with other countries. Internet use has added extra stresses to existing capacity. There may be some scope to leapfrog to wireless systems, with the recent experimental introduction by Russia's leading mobile operators of Wireless Application Protocol (WAP) mobile services, and of ISDN-speed GPRS (General Packet Radio Service) in the coming months.

In many regions, there are countries that far outpace others in degrees of infrastructure acquired. Because of a lack of such leading countries, South Asia, Sub Saharan Africa and the Middle East require more start-up infrastructure development than do Latin America and East Asia. It seems to be happening, that due to price declines, the countries are beginning to benefit from the expansion of the IT and the Internet in advanced countries simply because they can purchase cheaper infrastructure than was once required. One example of cost decline is the lack of current need for firms and universities to set up and run their own LAN for the Internet. Firms can lease server space in "Internet Hotels" located in neighbouring regions.[45] In the future it should be possible to create a "virtual LAN" for any institution or individual on the servers of one or more ISP's so there need be no need for in-house servers, in-house server maintenance, and in-house connectors and switches.

Costs may be coming down for generating the infrastructure required for IT and the Internet--Local Area Networks, computers and local telephone lines. [46] However, the Internet is not a free good. Self-sustaining growth of IT – and, according, the benefits of the Internet to economies - depends on the pricing of the Internet as well as the

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web-ranking service, suggests that there are 3.4 m core internet users in Russia, meaning those who have visited a website at least once a week over the two previous months up to September this year.

[45] "Are VLANs on the comeback trail?" in www.cnn.com 27 October 1999 and "Internet v's Private Lines" in www.cnn.com 2 July 2000.

[46] McNight and Bailey (1998), p. 5.

sustainability of the externalities that IT provides--statistical sharing and interoperability, and this also requires commitment and investment.

More optimism should come from quick benefits to be obtained from bandwidth widening. There is a growing acceptance that many of the most useful functions that an isolated computer can perform - email with attachments, voice mail or even video mail, banking, file viewing, document editing, calendaring - can be performed by a so called 'thin client' server, providing remote access. The ICP (Internet Content Provider) or the final customer could then rent software or access it free of charge. Thin clients need minimal processing power, simple or no local information storage (a zip disk might do), and they may utilise a television for the representation of information, which makes them cheap. Such thin client servers are only being introduced in the U.S and Canada on a mass basis as part of ISP access packages. This 'thin' segment is growing fast in the developed North American market suggesting that even with the market for ICP functionality hardly developed and in the face of a high rate of PC penetration, thin clients can meet most of the desire for functionality by consumers. With time such clients could be developed for and sold to developing or underdeveloped countries, massively expanding the set of consumers with access to the Internet. Moreover, the cost of the broadband facilities necessary to achieve this outcome is lowest where population density high – as in the majority of developing countries.

Competition and Regulation

One basic social commitment that seems required is to firm access and ease of entry, implying laws protecting openness and privacy. Wallsten (1999) studied the effect of competition on access to telecommunications services. Taking a sample of 30 African and Latin American countries, he found a positive correlation between competition and per

capita figures in mainlines, pay phones and connection capacity. The opening of the telecommunication state services to private participation is driven not only by the revenues generated through the sales of stocks but more by the desire to have a more innovative sector with reduced possibility of charging high prices. More than 90 developing countries opened their telecommunications sector to private participation in 1990-98. The main beneficiaries include Argentina, Brazil, Hungary, Indonesia, Malaysia, Mexico and Thailand. Private participation is also making progress in Sub Saharan Africa. [47] As Abbott and Brady (1999) mentioned in the wake of privatisation, regulatory reform and competition followed and the leaders in deregulation in the telecommunications sector include Chile (1982), and Guatemala (1996).[48] Latin America seems among the most advanced countries of the lower middle income group in preparedness for the potential revolution.

It is argued that wide economic reform, going beyond specific policies to embrace institutions, is required from MLIC governments to create a business-friendly environment and attract more investors into domestic telecommunication and Internet sectors so that PCs as well as Internet can spread. Serious existing barriers, such as for instance lack of transparency, mean that the scope for business-to-business services, such as commodity exchanges, may be limited - or at least that it will not be the ISPs which benefit. Businesses are suffering from corruption and inefficient distribution channels. Serious corporate governance violations take place as for example in Russia where the Ministry of Communication confiscated channels in the GSM 900 frequency band previously used by MTS and Vimpelcom. The motivation behind such a decision was to give business to Sonic Duo – a company which in May 2000 was awarded a license without tender to

[47] "The transactions involved investment commitments of US$214 Billion. Two thirds of that amount has been invested in expanding and modernising networks; the other third has gone to governments, as divestiture revenues or license fees." See Izaguirre (1999), p.1.
[48] Abbott and Brady (1999), p.66.

become the third Moscow GSM operator, and whose Russian partner (Central Telegraph) is widely linked to senior officials in the telecommunications bureaucracy. However the Communication Minister had to revoke the decision prompted by investor and public concern and the implementation of the confiscation was suspended.[49] Such example shows that foreign investors often struggle with red tape and bribery, as well as a legal system that is exposed to political pressure and vested interests from local established businesses.

Intellectual property rights are vital to the applicability of computers and software to problems of development in much of the world. They are also only controversial contributors to productivity. In that sense, it is not clear that restricting property rights of the Internet, such that ownership of information can provide incentives for economic development, actually promotes or constrains economic growth. Certainly distributional aspects of growth are powerfully and negatively affected by intellectual property rights, and thus economists have not come to a consensus on whether they pose an obstacle or benefit to Internet as a factor in innovative activity and growth.

The very diversity of languages in the developing world may be a strength for the distribution of intellectual property on the Internet. Currently, many North American textbooks are available in India in a black and white form for a substantially lower price. A US$50 textbook may be available in India for US$5. The assumption is that no one in the U.S. would be willing to forgo the benefits of superior typesetting and colour and suffer the shipping costs from India just to read an Indian version of the book. Further, publishers can localise the content. The Indian version of an Economics textbook may have Indian and not American examples, so rendering it less appealing to an American audience, or the text could be translated into Hindi making it valueless for all but a few American students. So it could go with software. Since replication costs little more than

[49] Granville Christopher and Alexei Zabotkine (2000), pp.13-14.

the price of the CD's Windows Whistler could be priced at US$150 for the English version and US$10 for the Hindi version. Reverse and reengineering a Hindi version or Windows Whistler to endow it with English would be prohibitively expensive, many English speakers would be unwilling to give up the service that may be packaged with it and any distributor of reengineered software would have to advertise to sell effectively so ensuring he is easily found and prosecuted by Microsoft.

Political barriers

The largest bottleneck to benefits from IT are no doubt the regulation of Internet use in countries where political controls are imposed. In some countries, the undermining of privacy and insecurity of the Internet is used as coercive state method against opposition, which may explain the extent of state disregard of international regulations. International laws and norms recognise privacy as a fundamental human right. Article 12 of the Universal Declaration of Human Rights, Article 17 of the International Covenant on Civil and Political Rights, and other international agreements and national laws, protect privacy.

The U.S. Department of State, in its 1996 Country Reports on Human Rights Practices, reported widespread illegal or uncontrolled use of wiretaps by both government and private groups in over 90 countries. In Honduras and Paraguay, the state-owned telecommunications companies were active participants in helping the security services monitor human rights advocates. These problems are not limited to developing countries.

The government of China limits Internet and technology companies' through restraints on foreign investment, upon which they depend, and by the requirement that the Chinese government own 51 per cent of any Chinese IT company.[50] This Chinese development (2 October 2000) is particularly important as a suggestion of how the supply

[50] "Increased Regulation for Chinese Internet Use," http://www.nua.ie/surveys.

side can be restricted by government action. China introduced sweeping new regulations that limit international investment in the Internet sector, required strict surveillance against "subversive" content, and threatened to close down any unlicensed firms. The regulations hold companies responsible for blocking vast categories of illegal content on their Web sites and chatrooms. The regulations ban any content that subverts state power, supports cults, "harms the reputation" of China or hurts reunification efforts with Taiwan. Internet content and service providers are required to keep records of the content that appears on their Web sites and the users who dial up servers for 60 days, and provide the records to police on demand. Internet service providers, the firms that connect people to the Internet, must "record the times users log on to the Internet, users' account numbers, Internet addresses or domain names and the phone numbers users dial in from."[51]

In Russia, as in China, a constraint is the intrusion of government into Internet exchange. The situation is characterised not by blanket prohibitions but intrusive controls on the part of security agencies. Heightened control reflects the legacy of state repression under the Soviet system. In the context of contemporary Russia's systemic corruption, control threatens not only the privacy and rights of the individual citizen, but also the integrity and development of e-commerce. A specialist information service reported that it will be soon necessary to obtain a State licence in order to publish even the simplest Internet site. The FSB (the successor to the KGB) is implementing a system called "Sorm 2". This includes black boxes that must be installed by Russian ISP's allowing interception

[51] From http://www.cnn.com/2000/ASIANOW/east/10/02/china.int.reut/. James Kynge reports in the Financial Times, "China puts limits on internet", 3 October 2000, p.12, that the vague content and user restrictions if enforced would undoubtedly hamper the development of IT in China. More than $1bn in foreign capital is believed to have been invested in Chinese dotcoms by venture capitalists and many of the world's largest media companies over the past two years. Internet content providers, the regulations say, must win the approval of the Ministry of Information Industry (MII) before they receive foreign capital, co-operate with foreign businesses or seek stock listings within China or abroad. Many Chinese dotcoms, often majority owned by foreigners have not received the permission for their infusion of foreign capital. It may be that the MII which has long warned that foreign investment in Internet content providers is illegal until China joins the WTO. Beijing has promised to allow 49 per cent foreign ownership in internet content providers on entry into the WTO rising to 50 percent two years later.

of any subscriber's correspondence. In addition, each ISP must allow for a fibre optic cable to be run from the black box to the local office of the FSB. The only Russian ISP that has ignored the interdict lost its licence. It only recently regained its licence through the courts and appeals to the rights guaranteed by the Russian Constitution. New efforts are being made to circumvent the courts ruling. [52]

To some extent, that government controls over the spread of IT and Internet should be the primary factor in the failure of IT to spread rapidly in the Middle East, by contrast with South Africa and Latin America, means that the lifting of controls will produce certain benefits. In Syria, for example, in May 2000, the government announced a plan, overturning previous policy, to provide Internet access to every household. Between 1998 and 1999, only private firms and the public sector were online, and only 2000 internet accounts were in use, but the number of users has increased since the regime opened the way in the repeal of government intervention.[53] Growth to 10,000 out of 17.5 million, of course, still represents a small percentage of the populace.[54]

It is important that the wider agenda include common and unrestrained access to the Internet. That is, firms can prohibit person-to-person communication whether for personal purposes or for production and consumption of information, for financial services, and for the distribution of information and other commodities. The freely available encryption techniques in advanced countries, developed to protect information being transferred between allied parties, are based on encryption keys, which, selected at random, are of sufficient length to be almost impregnable. Most countries do not restrict the domestic use of encryption by their citizens. Of the handful of countries around the world that do, few are democracies and most have strong authoritarian governments. The countries include Belarus, China, Israel, Kazakhstan, Pakistan, Russia, Singapore, Tunisia,

[52] From http://www.zdnet.co.uk/news/2000/38/ns-18101.html.
[53] "Syria Announces plans for Universal Access," 2 May 2000, www.nua.ie/surveys.

Vietnam, and Venezuela. For the rest of the world, the Internet has significantly changed even the effectiveness of export controls. Strong, unbreakable encryption programs can now be delivered in seconds to anywhere in the world from anywhere with a network connection. It has been increasingly difficult for countries to limit dissemination, and once a program is released, it is nearly impossible to stop its re-dissemination, especially if it is in one of the many countries around the world with no export controls. In the United States, export controls are used as a justification to limit the availability of encryption on domestic Internet sites and thus serve as indirect domestic controls on encryption.[55]

Concluding Remarks

The digital divide is the exclusion of a large part of the world's population by age, income and area of residence. To benefit from IT an economy requires more than sophisticated telecommunications infrastructure. Fundamental development issues of basic literacy and secondary technical education are pre-conditions for successful technology transfer. Attempts by governments of some developing countries to censor or to limit the Internet either by excess taxation and/or limited access provision can seriously hamper long-run growth prospects.[56] It is therefore essential for there to be free transmission of information across countries and a respect for basic civil liberties.[57] The West could do much to help MLIC by promoting the distribution of easily accessible and easily useable encryption and stenographic techniques. The gains to civil society and the economy from the diffusion of these techniques would be significant. The use of such techniques shows a considerable power in the Internet rapidly to shape institutions and provide a stimulus to growth.

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[54] "Internet still censored in Saudi Arabia," AP, 29 September 2000, reported by www.nua.ie/surveys.
[55] From Cryptography and Liberty, An International Survey of Encryption Policy; Electronic Privacy Information Centre (www.epic.org), 1999, Washington, DC
[56] Quah (1999), gives the example of 14th century China where technology and knowledge were the exclusive domain of the Chinese government and stagnated.
[57] Rodriguez and Wilson III (2000), pp.28-30.

The way to assure positive effects is for international organisations such as the UN closely to track discrete project outcomes, showing how much investment the public and private sectors will need before MLIC benefit from the productivity impact seen in the developed world. Optimal policies should be based on large empirical surveys as well as detailed smaller estimates. Rather than anticipating direct benefits only on a per-computer basis in the computer using-industries, policy makers should restore their prior focus on integrated development, telecommunications infrastructure, and education as the foundation for gradual technology transfer.

Governance targets for integrated development also apply. Privacy laws, taxation and openness are important for the development of Internet, as some regional patterns, above, show. Apart from locating in urban concentrations and spreading outward from corporate headquarters, it is countries with such laws that have witnessed, despite demand and supply barriers, the fastest spread of IT and the Internet. Co-signers of international agreements will be able to benefit early from the spread of Internet and all of the functionality it implies, although even some wealthy co-signatories have institutions that seem to inhibit the growth of accessibility. A good example is Britain, where broadband access, until very recently, was almost unknown. About as wealthy Sweden has an environment where consumers have many more options.[58]

There are institutional and political failures, in other words, that will limit the capacity of developing countries to benefit in the same measure as developed countries, even once they actually acquire computers in optimal numbers. Because of the lack of empirical evidence, it cannot be confirmed that the obstacles identified above are binding

[58] A good example is www.bredbandsfabrikken.no, a very recent expansion of a Swedish company into Norway. This company has laid fiber optic cable to 300,000 apartments in Sweden for 2000 SEK per hookup and a monthly fee of 200 SEK (US$23). Individual houses are excluded. Subscribers get 10 Mbps each way broadband access packaged with access to analog and digital TV and IP telephony (allowing free local and international calls). The best on offer from British Telecom at the moment is to put you on the waiting list for a DSL line.

constraints for developing countries in deriving some benefits from investment in computers and the Internet. However, both tangible and intangible factors give grounds for caution. The impact of IT on education, for example, is no doubt, positive. Because these are not immediate effects, however, it is difficult to estimate how much investment and how long it will take to reap these benefits.[59] Other examples include a country the size of Russia, where the Internet could provide a powerful tool to not only overcome distance, but also help companies to slim down excessive Soviet-style over-regulation and become more cost-efficient. Only the potential is clear. The value of the potential investment in developing economies and societies has yet to be tested.

[59] "A positive interpretation of the finding that education is positively correlated with growth is found in Lucas (1988), where only the unbounded accumulation of human capital, not its current stock, is meant to sustain growth" Aghion and Alii (2000), p.27.

APPENDIX 1 – DATA

Table 1 – Structure of Output

	GDP		*Agriculture*		*Industry*		*Manuf.*		*Services*	
			Value added		value added		value added		value added	
	$ millions		% of GDP		% of GDP		% of GDP		% of GDP	
	1980	1998	1980	1998	1980	1998	1980	1998	1980	1998
Low income	811,234	1,880,673	31	23	38	39	27	27	30	38
Excl. China & India	451,833	463,829	29	26	32	33	13	19	39	41
Middle income	2,322,822	4,312,567	12	9	42	33	24	22	46	58
Lower middle income	..	1,477,327	15	11	41	34	..	22	44	54
Upper middle income	1,164,279	2,838,231	11	8	42	32	26	22	47	60
Low & middle income	3,137,067	6,193,861	18	13	41	35	25	23	42	52
East Asia & Pacific	503,584	1,693,340	24	15	42	45	30	32	33	41
Europe & Central Asia	..	1,003,000	..	12	..	33	..	..	..	55
Latin America & Carib.	787,863	2,028,359	10	8	40	29	28	21	50	64
Middle East & N. Africa	409,860	583,374	10	14	53	43	9	14	37	43
South Asia	237,289	565,131	37	28	24	25	16	16	39	47
Sub-Saharan Africa	271,814	333,865	18	17	38	29	16	15	44	54
High income	7,936,135	22,543,577	3	2	37	30	25	21	59	65
Europe EMU	..	6,457,663	..	2	..	..	..	21	..	58

Source: World Development Report (2000), p.188.

Table 2 – Literacy and IT

	Adult illiteracy rate, % of people		Total Pop	GDP	GNP	Public	Televisions	Telephones	Pers computers	Internet Hosts	High Tech
			Millions	US$ millions	per capita	Expenditure	per 1,000 hab	per 1,000 hab	per 1,000 hab	Per 10,000	exports % of mfg.exports
	15 and above	1998	1999	1999	US$, 1999	On Education	1998	1998	1998	Jan-00	1998
	Male	Female				(%GNP)1997					
igh Income			891	23,662,676	25,730	5.4	661	567	311.2	777.22	33
ow and Middle ıcome											
urope and Central sia	2	5	475	1,093,237	2,150	5.1	353	200	34.6	18.87	8
f which											
ussia	0	1	147	375,345	2,270	3.5	420	197	40.6	14.69	12
Sub-Saharan Africa	32	49	642	332,744	500	4.1	52	14	7.5	2.73	
f which											
entral African epublic	43	68	4	1,053	290		5	3		0.02	0
ongo	14	29	3	2,273	670	6.1	12	8		0.01	
Iali	54	69	11	2,714	240	2.2	12	3	0.7	0.01	
outh Africa	15	16	42	131,127	3160	7.9	125	115	47.4	39.17	9
liddle East and N. frica	26	48	291	580,253	2,060	5.2	135	81	9.9	0.55	1
atin America/Caribbean	11	13	509	2,055,025	3,840	3.6	255	123	33.9	22.33	12
f which											
Iexico	7	11	97	474,951	4,400	4.9	261	104	47	40.88	19
ast Asia and acific	8	22	1,837	1,888,729		2.9	228	70	14.1	2.69	28
outh Asia	35	59	1,329	595,915		3.1	61	19	2.9	0.22	4
f which											
ıdia	33	57	998	459,765	450	3.2	69	22	2.7	0.23	10

Source: The World Development Report (2001), Table 1, p.274, Table 2, p.277, Table 6,p.285,Table 12,p. 297, Table 19, p.311.

Table 3 – Structure of Demand

Countries	% of GDP, 1999				
	Private consumption	*General government consumption*	*Gross domestic investment*	*Gross domestic Savings*	*Exports of goods and services*
High Income	62	12	21	22	22
Low and Middle Income	63	12	24	25	26
East Asia and Pacific	53	10	33	37	39
Europe and Central Asia	64	12	20	23	38
Russia	57	14	14	29	48
Latin America and the Caribbean	68	13	21	20	16
Mexico	70	7	24	23	31
Middle East and North Africa	60	21	22	19	25
South Asia	71	10	22	19	12
Of which India	69	11	24	20	11
Sub-Saharan Africa	69	16	17	14	27
Mali	80	12	20	8	22
South Africa	63	19	16	18	25

Source: The World Development Report (2001), Table 13, p.299.

Table 4 – Private Sector Finance

	Private investment as	*Stock market*	*Listed domestic*	*Domestic credit*
	% of gross domestic Fixed investment	Capitalisation Millions of US$	Companies	Provided by the banking sector % of GDP
	1997	1999	1999	1999
High Income	79.2	33,603,476	24,748	139
Low and Middle Income	66.9	2,427,331	24,892	72.2
East Asia and Pacific	56.9	955,379	3,754	112.5
Europe and Central Asia		265,207	9,000	33.5
Russia		72,205	207	35
Latin America and the Caribbean	79.8	584,985	1,938	27.6
Mexico	81.4	154,044	188	29.1
Middle East and North Africa		151,562	1,863	72.2
South Asia	68.9	194,475	7,199	44.1
India	70.1	184,605	5,863	44.9
Sub-Saharan Africa		275,723	1,138	43.2
Mali				16.1
South Africa	72.7	262,478	668	73.4

Source: The World Development Report (2001), Table 16, p. 304.

REFERENCES

Abbott, Alden and Brady Gordon (1999) "The Liberalisation of the Telecommunications Sector: A Rent Seeking Perspective", European Journal of Law and Economics, 8: 63-77.

Aghion, Philippe, Cecilia Garcia-Penalosa and Peter Howitt (2000). "Knowledge and Development: A Schumpeterian Approach", Paper presented at the ABCDE Conference jointly organised by the World Bank and the Conseil D'Analyse Economique in Paris on 27 June.

Annan, Kofi A. (2000). "We The People, The Role of the United Nations in the 21st century," United Nations, Department of Public Information, New York.

Barro, Robert J. (1998) "Determinants of Economic Growth, A Cross Country Empirical Study", The MIT Press, Cambridge, Massachussets, London, England.

Bosworth, Barry P (2000). "The US Economy in the 1990s: Good Luck or Good Policies?" in Essays on the World Economy and its Financial System, Tokyo Club, ed. by B.Granville, published by RIIA distributed by Brookings, October 2000, pp.23 - 35.

Bosworth, Barry P. and Jack E . Triplett (2000). "What's New About the New Economy? IT, Economic Growth and Productivity", Paper presented in Munich, Tokyo Club, 18-19 October.

Braga Carlos A. (1996), "The Impact of the Internationalization of Services on Developing Countries", http//www.worldbank.org/fandd/english/0396/articles/070396.htm

Chen, Shaohua and Martin Ravallion (2000). "How Did the world's Poorest Fare in the 1990s" Policy Research Working Paper, World Bank, Washington, D.C.

Council of Economic Advisors (2000). *Economic Report of the President*, Washington, D.C., US Government Printing Office.

Coate, Stephen and Simon P. Anderson (2000). "Market Provision of Public Goods: The Case of Broadcasting", NBER W.P. 7513, January.

Coates, David and Ken Warwick (1999). "The Knowledge Driven Economy: Analysis and Background", in The Economics of the Knowledge Driven Economy, Papers presented at a conference jointly organised by the Department of Trade and Industry and the Centre for Economic Policy Research, 27 January, London, UK.

David, Paul (1991). "Computer and Dynamo: The Modern Productivity Paradox in a Not-Too-Distant Mirror," in Technology and Productivity: The Challenge for Economic Policy. Paris: Organisation for Economic Cooperation and Development, pp.315-47.

Frisk, T (1998). "The future state of information technology: a technological assessment, in H. Schutte (ed), Strategic issues in information technology, Maidenhead: Pergamon Infotech, pp. 15-26.

Gillespie, A. and H. Williams (1988). Telecommunications and the reconstruction of regional comparative advantage," in Environment and Planning A 20: 1311-20.

Gordon, Robert (1999a). "Foundations of the Goldilocks Economy: Supply Shocks and the Time-Varying NAIRU," February 3, Revision of the paper presented at Brookings Panel on Economic Activity, Washington, D.C., September 4, 1998.

(1999b). "Has the New Economy Rendered the Productivity Slowdown Obsolete?" paper presented at the CBO panel of economic advisors (Washington, DC: Congressional Budget Office), revised, June 14.

(2000). "Does the 'New Economy' Measure up to the Great Inventions of the Past?" May 1 draft of a paper for the Journal of Economic Perspectives, http://faculty_web.at.nwu.edu/economics/gordon/351.html

Granville Christopher and Alexei Zabotkine (2000) "Russia Quarterly Outlook – 4Q000" United Financial Group, 26 September.

Greenspan, Alan (2000). Speech given at the Federal Reserve Bank of Chicago, May 6.

Griliches, Zvi (1994). "Productivity, R&D, and the Data Constraint", American Economic Review 84, 1 (March), pp.1-23.

Grossman, Gene M. and Ethanan Helpman (1997). Innovation and Growth in the Global Economy, The MIT Press, Cambridge, Massachussetts, London, England.

Hepworth, M (1987). "Information technology as spatial systems," in Progress in Human Geography 11: 157-80.

Hornstein, Andreas. (1999). "Growth Accounting with Technological Revolutions", Federal Reserve Bank of Richmond, Economic Quarterly, Volume 85/3, Summer.

Howells, J. (1988). Economic, technological and location trends in European services, Avebury: Aldershot.

International Monetary Fund. (2000). "World Economic Outlook", September, Washington, D.C.

Izaguirre, Ada Karina (1999). "Private Participation in Telecommunications: Recent Trends." Viewpoint 204. World Bank, Finance, Private Sector, and Infrastructure Network, Washington, DC.

Jorgenson, Dale and Kevin Stiroh (2000). "Raising the Speed Limit: US Economic Growth in the Information Age," Brookings Paper on Economic Activity, Washington, D.C.

Kiley, M. T. (1999). "Computers and Growth with Costs of Adjustment: Will the Future Look like the Past?" Federal Reserve Board.

Leonard, Carol (2000). "The New Economy, Emerging Transition Markets and the Service Sector," paper presented at the Royal Institute for International Affairs, 14 November 2000.

Levy, Frank (1999). "The New Dollars and Dreams: American Incomes and Economic Change," Russell Stage Foundation.

Lucas, Robert E. (1988). "On the Mechanics of Economic Development." Journal of Monetary Economics, 22:1, pp.3-42.

Madrick, Jeff (1999). "How New is the New Economy", The New York Review of Books, September 23, pp. 42 – 50.

Malecki, Edward J (1991,1996). Technology and Economic Development, Essex, England: Longman.

McNight, Lee W. and Joseph P. Bailey. (1998). An Introduction to Internet economics," in McKnight, L. W. and J. P. Bailey, Eds. Internet Economics. Cambridge, MA: MIT Press, pp. 3-27.

McKnight, L. W. and J. P. Bailey, Eds. (1998). Internet Economics. Cambridge, MA: MIT Press.

Moss, M. L. (1987). "Telecommunications, world cities, and urban policy," Urban Studies, 24: 534-546.

Niininen, Petri (1998). "Computers and Economic Growth in Finland", The United Nations University, WIDER, Working Papers No. 148, August.

Oliner, Stephen D. and Daniel E. Sichel (1994). "Computers and Output Growth Revisited: How Big is the Puzzle?" Brookings Papers on Economic Activity*:* 2, Brookings Institution, pp.273 –317.

Oliner Stephen D. and Daniel Sichel (forthcoming) "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?" Journal of Economic Perspectives.

Quah, Danny T. (1996). "The Invisible Hand and the Weightless Economy", Centre for Economic Performance, Occasional Paper No 12, April.

. (1997). "Increasingly weightless economies," Bank of England Quarterly Bulletin, February, pp.49 - 56.

(1998). "Growth and Wealth Creation in the Weightless Knowledge-Based Economy", Speech to the Belgian Enterprise Foundation, 7 October, http://econ.lse.ac.uk/~dquah/.

(1999). "The Weightless Economy in Economic Development", LSE Economics Department, Centre for Economic Performance, Discussion Paper No.417, March.

Rodriguez, Francisco and Ernest J. Wilson III (2000). "Are Poor Countries Losing the Information Revolution?" *INFO*DEV Working Paper, May.

Schreyer, Paul (1999). "The Contribution of Information and Communication Technology to Output Growth." Statistical Working Party (99) 4, OECD, Paris, November.

Sichel, Daniel E. (1999). "Computers and Aggregate Economic Growth: An Update", Business Economics, 34, No.2:18 - 24.

Solow, Robert (1957). "Technical Change and the Aggregate Production Function, Review of Economics and Statistics 39: 312-320.

(1987). "We'd Better Watch Out", New York Times Book Review, July 12, p.36.

Talero, Eduardo and Philip Gaudette (1996). "Harnessing Information for Development, A Proposal for a World Bank Group Strategy", World Bank Discussion Paper, Number 313, The World Bank, Finance and Private Sector Development Vice Presidency, Industry and Energy Department, Telecommunications and Informatics Division, March, http://www.worldbank.org/html/fpd/harnessing/

Triplett, Jack E. (1999). "The Solow Productivity Paradox: What do Computers do to Productivity?" Canadian Journal of Economics, 32, No.2:309 – 334.

Wallsten, Scott J. (1999). "An Empirical Analysis of Competition, Privatisation, and Regulation in Africa and Latin America." Policy Research Working Paper 2136. World Bank, Washington, D.C.

Whelan, Karl (2000). "Computers, Obsolescence, and Productivity," Board of Governors for the Federal Reserve Working Paper 2000-6, Washington, Federal Reserve Board, May.

Wilson III, Ernest J. (1996). "The Information Revolution Comes to Africa", CSIS Africa Notes, No 185, June.

(1998). "Wiring the African Economy", Centre for International Development and Conflict Management (CIDCM), Working Research Paper Series, August, http//www.bsos.umd.edu/cidcm/papers/ewilson/wiring.htm.

World Bank (2000). "Entering the 21st century", World Development Report 1999/2000, Published by the World Bank, Oxford University Press.

World Bank (2001). "Attacking Poverty", World Development Report 2000/2001, Published by the World Bank, Oxford University Press.