Broadband as a platform for economic, social and cultural development: Lessons from Asia

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Abstract

Far from "playing catch-up", Asian economies have been setting the pace in the development of broadband networks, both on fixed and mobile networks. The Republic of Korea was an early leader in fixed broadband, while Japan has been setting the pace in mobile broadband. Singapore is one of the world leaders in urban fibre deployment while Hong Kong is a pioneer in the provision of Internet Protocol Television (IPTV). Among the developing countries of the region, China will soon have the largest installed base of broadband users while India has recognized the critical importance of broadband for its bourgeoning software outsourcing industry.

Among Asian economies, there has been keen competition and a close interest in global comparisons of broadband performance, such as penetration rates, speeds and prices. There has also been considerable government support for broadband promotion. The implicit assumption is that broadband can drive growth in the rest of the economy and the development of an Information Society. But can it and, if so, how? How does broadband create jobs, how can it spur innovation and how does it reduce costs for businesses? In a similar vein, does broadband simply imply faster video downloads and longer hours spent gaming or can it be a platform for broader-based social and cultural development? Furthermore, can broadband help with wider problems of society, such as climate change, rising fuel prices or food insecurity? This paper will look at the lessons that can be learned from the Asian broadband superstars in terms of the changes that broadband can bring, both positive and negative, and how they might be passed on to the developing world.

1. Why Broadband?

The study of long-term trends in economic, social and cultural development has long been fascinated by the emergence of new "drivers" that will provide for a sustained upturn in the global economy. The study of so-called "Kondratieff long waves" has identified previous drivers, or general purpose technology (GPT) enablers, such as steam power, oil, the motor vehicle, plastics etc, which have sustained long-term waves of innovation and growth. More recently, the development of information and communication technologies (ICTs), which can be dated to the development of microprocessors (semiconductor chips) in the late 1960s, has given rise to a new period of sustained development that has been termed the Information Society.

If we assume that the average life-cycle of such long waves is 40-60 years, and that with technological progress this is speeding up over time, then the world is now overdue for another significant technological driver of economic progress. There are many such candidates – ranging from mobile phones and the internet in the ICT sector to nanotechnology or bioengineering – and it is unlikely that a single technology would be capable of supporting a sustained rise in global GDP. But a good case can be made to argue that the next large-scale drive will come from the ICT sector and that it will encompass the three major strands of that sector – telecommunications, computing and broadcasting. The leading candidate of the moment is Broadband.

1.1 What is broadband?

Conventional definitions of broadband focus on what it is *not* rather than what it *is*. For instance, broadband is NOT narrowband, in that there is general consensus on the low-end cut-off speed for broadband as offering a transmission capacity equal to or above 256 kbit/s. But there is no upper limit placed on what broadband can become, and the evidence points to the fact that broadband speeds, and its performance/price ratio, are tending to double every 12-15 months. This trajectory makes it tempting to make comparisons with semiconductor chips for which, following Moore's Law, performance/price has been doubling on average every 18-24 months since the late 1960s.

Similarly, broadband can be defined as NOT being a "scarce" service, by contrast with the telephone which is used on average for less than 30 minutes per day, and which is priced per minute, per mile and per megabyte. Rather, broadband is an "always-on" service, which is distance-independent and which, for the most part, is available without limitations on capacity use. Again, by stating what broadband is *not*, there remains much to discover about what it can become, particularly as the main users of broadband in future will not necessarily be humans but rather machines and objects that are interconnected and controlled in a ubiquitous network.

Finally, a third way of looking at broadband would be to say that it is NEITHER fixed nor mobile but rather it can be BOTH. In other words, in a Next Generation Network (NGN) environment, the term broadband will refer to the quality of the access environment, and the possibilities this allows, rather than whether a particular user is connected to a fixed-line or wireless environment at any particular time. Similarly, broadband is not limited to a telecommunications environment, but can be used to support broadcast audio and video and to provide access to so-called "cloud computing".

In summary, although existing definitions focus on what broadband is *not*, there are no real limitations on what it can *become,* and therefore it is better to avoid rigid definitions. There are lessons to be learned by taking an analogy with the application of microprocessors. In the 1970s, they were used in machine tools and in hand-built personal computers, such as the Altair or the Apple 1. In the 1980s, PCs were mass produced for the first time and microprocessors started appearing in other devices like washing machines or elevators. By the 1990s, the process of miniaturization and rising speeds saw them appear in mobile phones and cars while in the 2000s the most prolific form of microprocessors is in RFID chips and smart cards. In other words, the

simultaneous processes of increasing power, shrinking size and falling price has allowed microprocessors to be embedded in all sorts of devices and used in many more applications than were ever envisaged when they were first developed.

Can we also expect broadband to follow a similar trajectory? At present, the relatively high price of broadband means that it is generally restricted to those applications for which humans are willing to pay a premium price, like entertainment or business. But in the future, as broadband capability becomes embedded in a wider range of devices, and as machines and objects rather than humans become the main users, then broadband will give birth to a wide range of devices and applications, as yet unimagined. Again, with reference to the development of microprocessors, the improvements in performance/price can continue at a regular level over a long period but it is only once some kind of threshold is passed that this incremental progress becomes revolutionary. Atkinson and Castro (2008), in their newly released report on *Digital Quality of Life*[1], argue that the inflection point that triggered the ICT revolution did not come until the mid-1990s, some thirty years after Moore's Law was first coined. The price of chips and of memory storage had fallen so far by the mid-1990s that it became viable to interlink websites on the internet, or to manufacture digital mobile phones that could be carried in the palm of a hand. If we date the birth of broadband to the late 1990s, and if it follows a similar path to the microprocessor, then by the late 2020s we can expect to be benefitting from speeds measured in terms of Gigabits per second for prices lower than US$20 per month. At that point, a revised definition of broadband will be long overdue!

1.2 Where is broadband?

Broadband has been one of the fastest growing ICT services ever seen in terms of its diffusion worldwide. The first country to deploy fixed-line broadband on a commercial scale was the Republic of Korea in the late 1990s. By the year **2000**, some 36 economies had launched broadband service (see Figure 1, Top Chart), of which two economies had a penetration of fixed-line broadband subscribers per 100 inhabitants greater than 5: Republic of Korea (8.2) and Hong Kong, China (6.67).

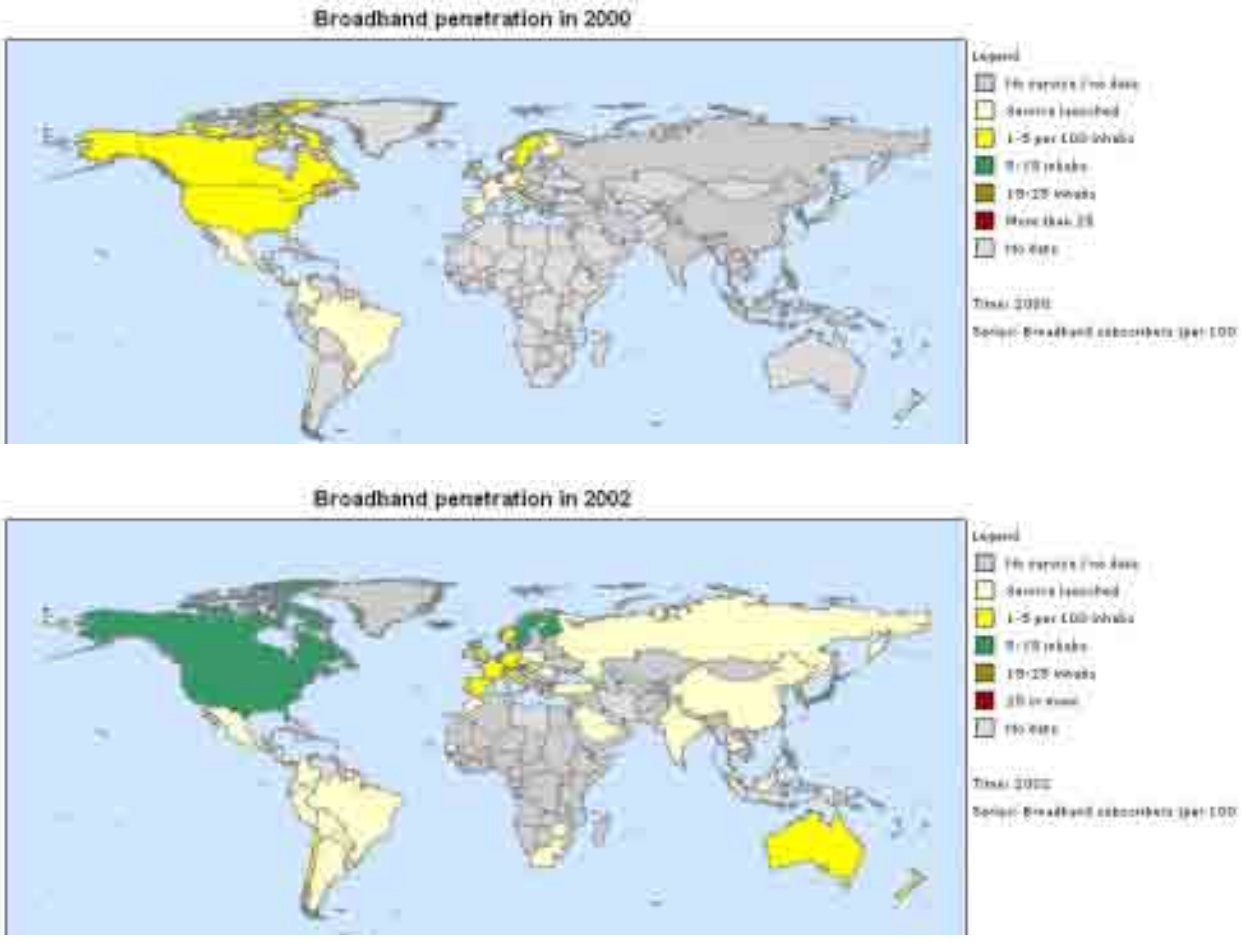
Two years later, in **2002**, the number of economies having launched service had reached 71 and three economies now had above 10 subscribers per 100 inhabitants (see Figure 1, second chart), namely Canada (11.2); Hong Kong, China (15.4); and the Republic of Korea (21.9). The latter was a clear leader and was able to showcase its technology in that year as it co-hosted the FIFA Football World Cup.[2] Elsewhere in the world, 2002 was a kind of nadir for the internet industry, following the bursting of the *dot.com* bubble at the start of the decade. Indeed, it was the Asia region, which had been largely unaffected by the *dot.com* bubble and the inflated prices paid for 3G licenses, that was leading the global broadband economy. In that year, in addition to the market leaders, broadband penetration in a further three Asian economies exceeded 5 per 100 inhabitants, in Taiwan, China (9.4), Japan (7.4) and Singapore (6.5).

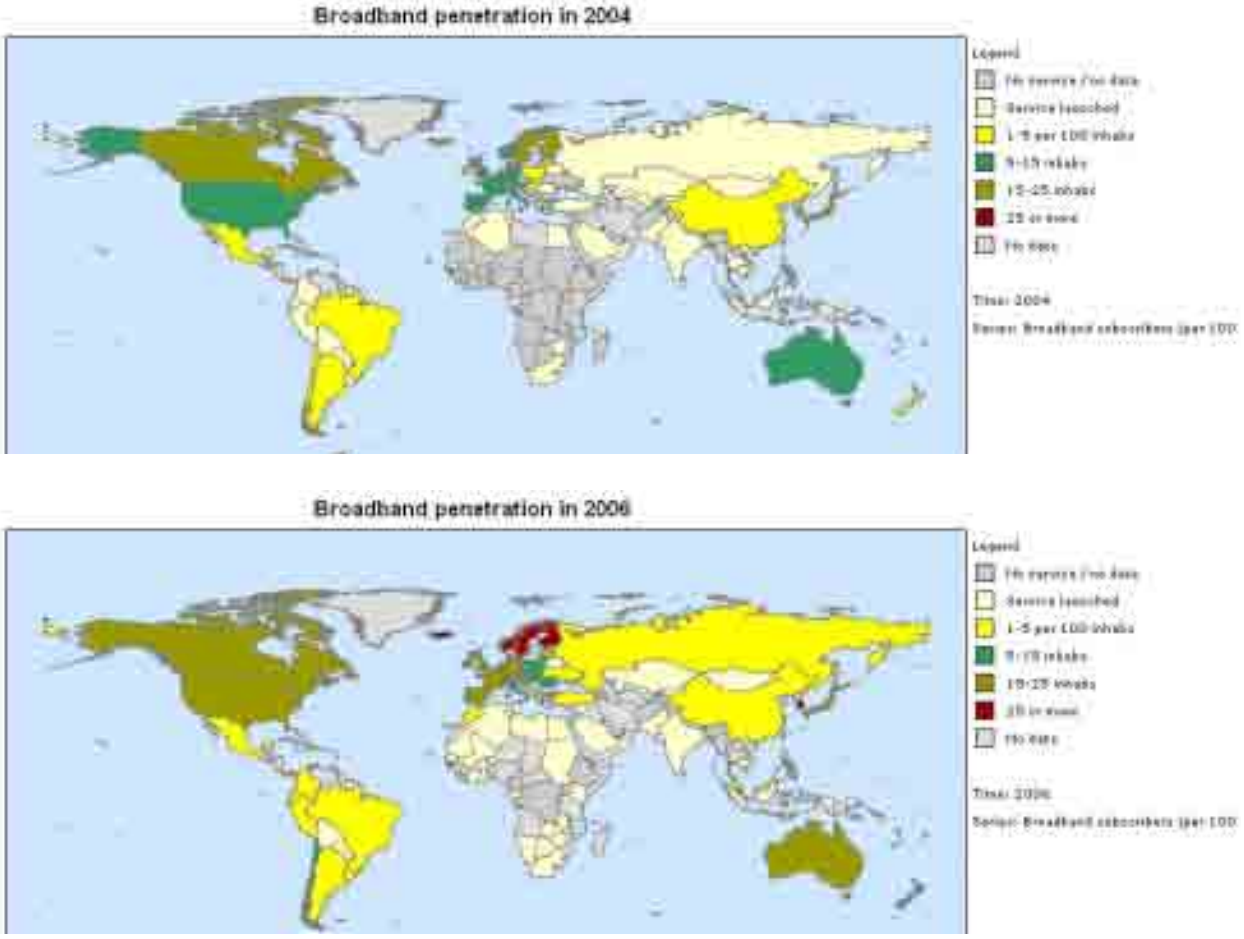
By **2004**, as the industry as a whole was beginning to emerge from the downturn, a much greater percentage of the broadband map was coloured in, with some 131 economies having commenced service (see Figure 1, third chart). In this year, some 22 economies had passed the significant

barrier of 10 subscribers per 100 inhabitants, which corresponds to roughly one-third of all households. Of these 22, six were in the Asia-Pacific region, including the two economies with the highest level of penetration: Hong Kong, China (22.4) and the Republic of Korea (24.8). By contrast, only three economies in the Americas hemisphere had passed this milestone (Barbados (10.2), USA (12.7) and Canada (16.9)), with the remaining ones being European. By 2004, there were also stirrings among the developing countries of the Asia-Pacific region with China reaching the 25 million subscriber mark, second only to the United States with 37 million in that year.

By **2006**, as broadband subscribers globally surpassed 300 million, broadband had been launched in some 166 economies (see Figure 1, bottom chart), including most of the Asia-Pacific region. By this stage, the early leadership of the Asian tigers had begun to erode as Europe had caught up, with Denmark becoming the first major economy to cross the 30 subscribers per 100 inhabitants mark, just behind the minnows of Bermuda (37.1) and Monaco (33.4).

Figure 1: **Broadband diffusion worldwide, 2000, 2002, 2004 and 2006**





Source: ITU World Telecommunication Indicators Database.

By **2008**, more than 180 economies worldwide have now launched broadband and global subscriber numbers have surpassed 500 million, if fixed and mobile broadband subscribers are added together. The leading economies, in terms of penetration, are now mainly the smaller economies of Europe – such as Denmark, Iceland, Netherlands, Norway and Switzerland – though Asian economies are still leading in the newer field of mobile broadband. However, as these economies approach the point at which most households that want broadband already have it, other factors become more important in differentiating between performance, such as speed of service, pricing and level of market choice. In addition, other factors – such as level of urbanization, size of local loops or degree of inter-modal competition between fixed-line and wireless services – come into play in explaining the small differences which exist in terms of penetration rate between the leading economies. These are explored below.

2. Why Asia?

2.1 Asian Pioneers

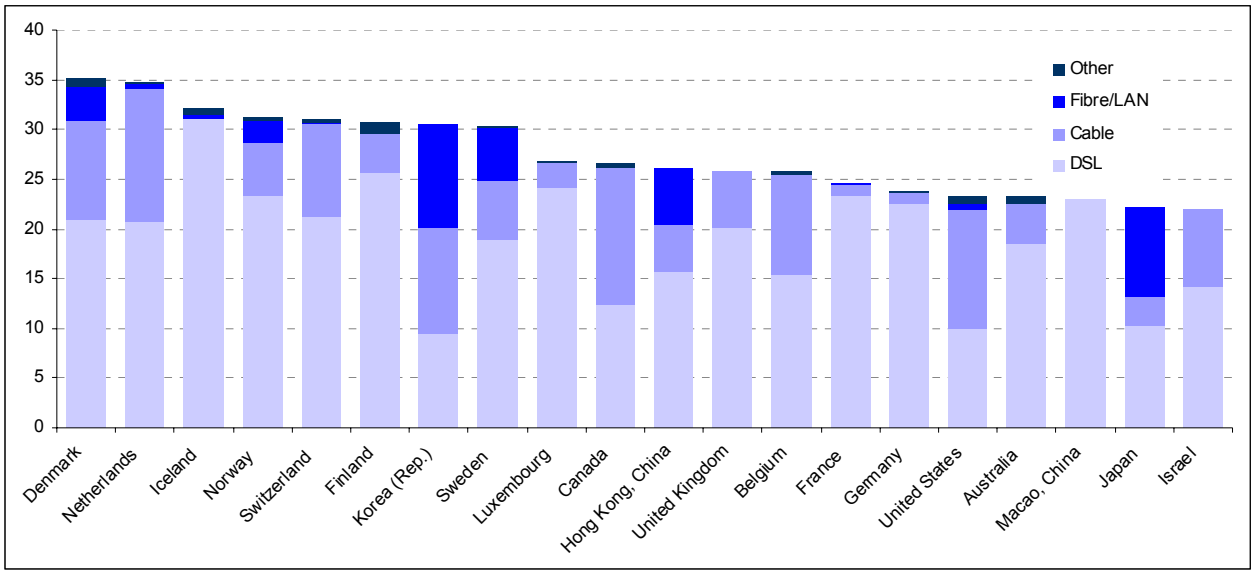
Although the gaps between the leading Asian economies and the rest of the world on broadband penetration have narrowed over time, and indeed some of the smaller European economies are

now leading the race, it is nonetheless instructive to look at Asia for lessons on promoting broadband and on the impact it is having on development. This is for a number of reasons:

- The early start that Asian economies had on their broadband adventure, both for fixed-line and mobile services.
- The fact that Asian economies frequently have broadband service with higher performance, especially where it is based on fibre, and which is generally cheaper than elsewhere.
- The diversity of Asia, which offers many different models for broadband, including state-driven and private-sector driven, fixed-line or wireless-based, and including both developing as well as developed economies.

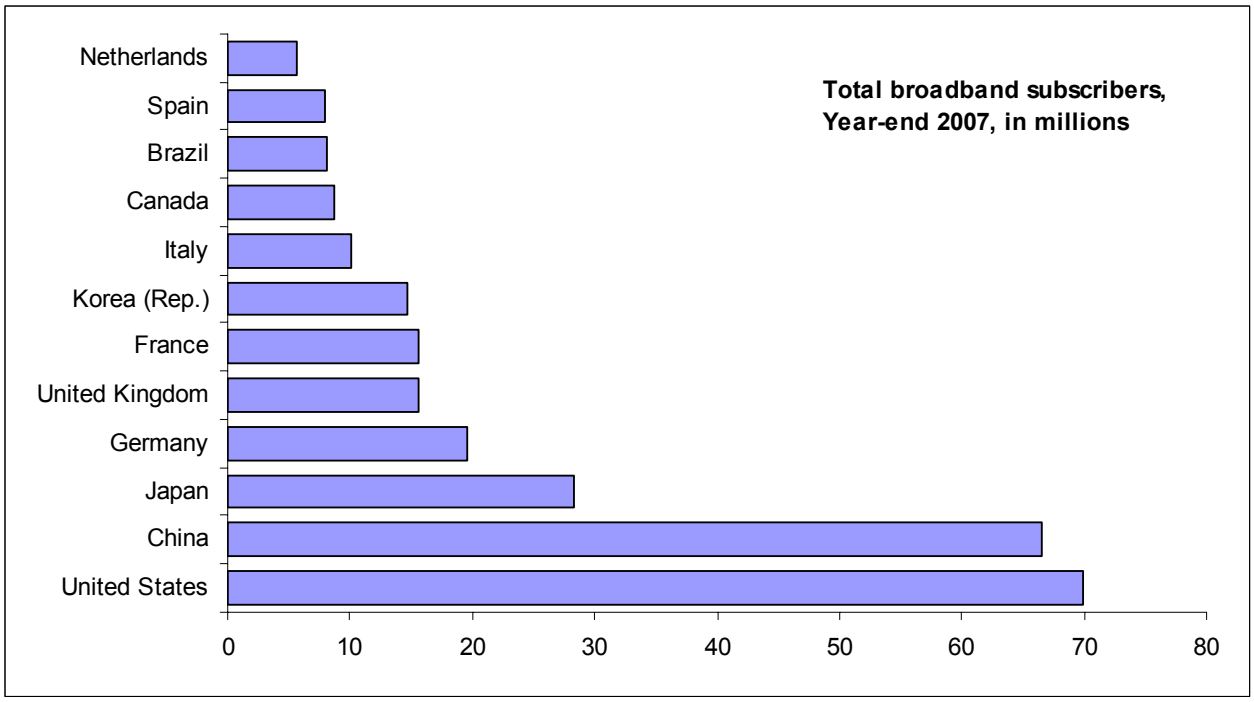
The leading broadband economies, by penetration rate, are shown in Figure 2 and the leading economies in terms of number of subscribers, at the start of 2008, are shown in Figure 3.

Figure 2: Top 20 fixed-line broadband economies, in subscribers per 100 subscribers, by technology, year-end 2007



Source: ITU/OECD/World Bank.

Figure 3: Leading fixed-line broadband economies, in excess of 5 million subscribers, year-end 2007



Source: ITU/OECD/World Bank.

The Asia-Pacific economies that feature among the world leaders have a number of distinguishing factors which help explain their success:

- They are more likely to have **inter-modal competition**. This case is well-illustrated by the Republic of Korea, whose total of almost 15 million fixed-line broadband subscribers (at year end 2007) were almost equally split between DSL, cable modem and LAN/fibre optics platforms. Furthermore, if the mobile broadband subscribers were added to this chart, the variety of platforms is even greater with 3G mobile (both Wideband CDMA and CDMA 2000 1x EVDO), Wi-Fi subscribers and WiBro (a local Korean implementation of WiMAX) added to the mix. Inter-modal platform competition seems to be just as important for promoting market growth in broadband as competition between companies using the same technology.

- The Asia-Pacific economies among the leaders are more likely to have a **high percentage of fibre optic users** (fibre to the home (FTTH) or fibre-to-the-kerb) among total broadband users. Japan and Hong Kong, China both illustrate this point. Japan is second only to Korea in its penetration of FTTH (around 9 per cent per 100 inhabitants) with Hong Kong, China not much further behind with 6 per cent. In both countries, fibre and apartment LANs have served as a way of introducing greater competition to the

market, through Yahoo! BB and Hong Kong Broadband Network respectively. Fibre is also used as the basis for IPTV services in both countries.

- Thirdly, and partly as a result of these two factors, Asian broadband users frequently pay **lower prices** for broadband than their counterparts in the rest of the world. As shown in Figure 4, Japan and the Republic of Korea, which both offer speeds of up to 51 Mbit/s download for broadband, charge users less than US$1 per Mbit/s per month. Three other Asian economies – Viet Nam, Singapore and Taiwan, China – also feature among the ten lowest priced broadband economies. The case of Viet Nam is particularly noteworthy because, although typical speeds on offer are just 1.5 Mbit/s, it is able to offer some of the lowest entry-level prices, at below US$5 per month.

2.2 Developing Asia

The leading Asian economies have become role models for developing Asia. This is exemplified in the fact that entry-level prices for broadband among developing Asian economies are typically among the lowest anywhere in the world. As shown in Figure 5, in addition to Viet Nam, there are six other Asian economies that have entry-level broadband prices below US$10 per month, which is less than a tenth of the global average in mid 2007 (US$108: note that this is a simple, unweighted average with each country with broadband counting as one case). Overall, Asian prices are below the world average in every price category (low-speed, high-speed, per Mbit/s and as % of monthly GNI per capita) even though average broadband speeds are higher in Asia than in the rest of the world.

Figure 4: Ten economies with lowest broadband prices worldwide, in US$ per 1 Mbit/s per month, mid 2007

	Lower speed		*Higher speed*		*Lowest sampled cost*		
Rank	*Monthly charge US$ 2007*	*Speed (kbit/s) Down 2007*	*Monthly charge US$ 2007*	*Speed (kbit/s) Down 2007*	*US$ per 1 Mbit/s 2007*	*as a % of monthly income (GNI)*	*ISP*
1 Japan	28.57	8'192	35.70	51'200	0.70	0.00	Yahoo BB
2 Korea (Rep.)	29.94	10'240	48.11	51'200	0.94	0.01	KT
3 Netherlands	12.25	4'000	27.30	20'000	1.36	0.00	Orange
4 Taiwan, China	6.08	256	22.20	12'288	1.81	0.02	Chunghwa
5 Sweden	14.65	1'000	44.23	24'000	1.84	0.01	Tele2
6 France	20.39	2'000	40.91	20'000	2.05	0.01	Neuf telecom
7 Singapore	13.49	512	80.81	30'720	2.63	0.01	StarHub
8 Viet Nam	4.34	1'536	4.34	1'536	2.82	0.62	FPT Communications
9 Finland	34.07	1'024	68.28	24'000	2.84	0.01	Elisa-Lajaakaista
10 Switzerland	40.82	3'500	57.48	20'000	2.87	1.05	Bluewin
World Average	**107.95**	**759**	**278.18**	**4'392**	**299.21**	**97.43**	

Source: ITU.

Figure 5: Asian economies with entry-level broadband prices below US$10 per month, mid 2007

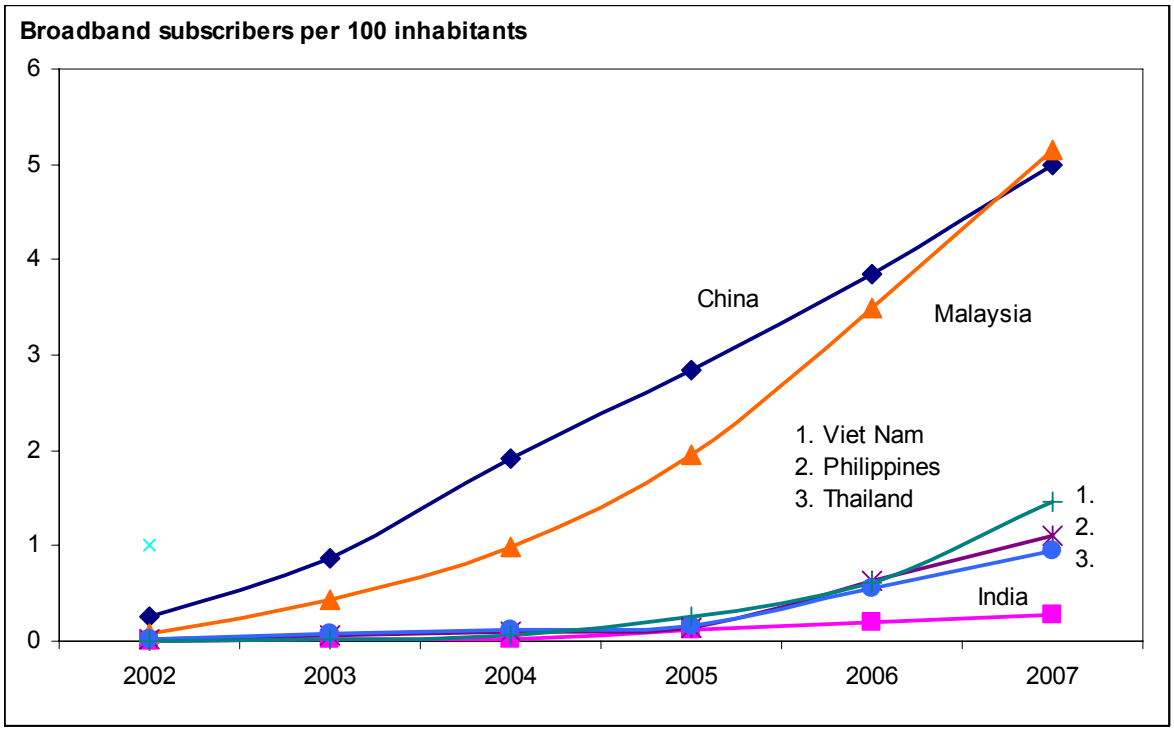
	Lower speed		*Higher speed*		*Lowest sampled cost*		
	Monthly charge US$ 2007	*Speed (kbit/s) Down 2007*	*Monthly charge US$ 2007*	*Speed (kbit/s) Down 2007*	*US$ per 1 Mbit/s 2007*	*as a % of monthly income (GNI)*	*ISP*
1 Viet Nam	4.34	1'536	4.34	1'536	2.82	0.62	FPT Communications
2 Malaysia	5.80	384	5.80	384	15.11	0.39	TMNET
3 Taiwan, China	6.08	256	22.20	12'288	1.81	0.02	Chunghwa
4 China	7.88	512	7.88	512	15.38	1.43	E-NET
5 Sri Lanka	9.01	512	9.01	512	17.60	2.09	SLTnet
6 Maldives	9.27	256	15.38	512	30.03	1.44	Dhiraagu
7 India	9.65	256	37.48	2'048	18.30	3.54	Tata Indicom
Asia	**70.06**	**818**	**222.36**	**4'587**	**278.89**	**60.85**	
World	**107.95**	**759**	**278.18**	**4'392**	**299.21**	**97.43**	

Source: ITU.

The low-priced Asian economies include both China and India, the world's most populous economies. No prior models exist for economies that have gone from developing to developed status with the benefits of low-priced access to information, and it is entirely possible that a new model of economic development might emerge as a result. China has experienced a remarkable compound annual growth rate in broadband penetration of 81 per cent between 2002-2007, to reach 66 million subscribers at the end of that year. Yet it still has the slowest growth rate among the developing Asian economies highlighted in Figure 6. Malaysia, growing at 131 per cent per year, overtook China in terms of penetration rate in 2007 and even India, lingering towards the bottom of the chart, is doubling every year, on average. But Viet Nam is the standout case, with a CAGR over the period 2002-07 of more than 300 per cent, which shows what can be achieved when broadband prices are among the lowest in the world.

To return to the case of China, it is instructive to compare its growth against the other economic powerhouse, the United States. It is possible to compare the year in which both economies reached a penetration level of 5 per 100 inhabitants for different ICT services (Figure 7). For fixed line telephone, USA reached that level in 1912, but it took China a further 85 years to reach it. For PCs, the catching up process took 22 years and for Internet users it was eight years. But for mobile phones and broadband, the catching up process took just seven and five years respectively. Furthermore, although China still has fewer PCs or internet users than the United States, by the end of 2008 it will nevertheless have more broadband users. Although broadband speeds in China do not yet match those in the United States, the entry-level price for low-speed services is just one-third of that charged in the US, suggesting the potential for narrowing the gap further.

Figure 6: Broadband penetration rates, per 100 inhabitants, in selected developing Asian economies, 2002-2007



Source: ITU World Telecommunication Indicators Database.

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Figure 7: The narrowing gap between the United States and China in ICTs
Year in which each country reached 5 per cent penetration (per 100 inhabitants) for selected ICTs

Country	Fixed-line	PC	Internet users	Mobile	Broadband
USA	1912	1983	1994	1993	2002
China	1997	2005	2002	2000	2007
Gap (years)	85	22	8	7	5
Year when China overtook USA in subscribers	2002	n/a	n/a	2000	2008

Source: World Bank, adapted from ITU World Telecommunication Indicators Database and AT&T.

3. Broadband and economic growth

The example of China catching up with the United States, and of other developing Asian nations prospering in their broadband development, raises the question of how broadband will impact future trajectories of economic growth.

3.1 Growing evidence of the benefits of broadband

There is a growing body of literature which points to the potential of broadband for promoting development. The theoretical basis for this takes into account

- The shift from intermittent to "always on" access to information that broadband permits;
- The availability of higher speeds and lower unit costs. Closely associated with this is the reduction in waiting time for access to information and waiting for a website to load;
- The enhancement of user experiences through multimedia, both in the residential field (e.g., the rise of video on demand services, such as YouTube) and in the business field (e.g. the facilitation of e-commerce);
- The access that broadband provides to global markets, for instance for outsourcing, and for encouraging global, real-time, transparent competition;
- The ability of broadband to "cannibalize" other services, for instance by substituting downloaded video-on-demand for live TV shows, or substituting voice over broadband for regular telephone service. Broadband's ability to offer multiple play should generate cost savings and efficiencies.

A number of studies have attempted to document how broadband can promote growth at the micro-economic level. For instance:

- By contrast with narrowband users, broadband users tend to visit a wider range of site and to make greater use of content-rich or socially-interactive websites. The faster download speeds also mean user tend to spend less time at a particular site);[3]
- An early attempt to study the business impact of the internet found that, by 2002, it had already achieved cumulative business savings of US$155 billion in the United States, which would presumably be much greater with broadband;[4]
- Broadband is credited with boosting e-commerce sales, for instance for sales of movies both for online delivery and for online ordering;[5]
- Mobile broadband can improve business processes even further, by generating productivity savings of up to US$6.9 billion in the case of the US healthcare sector;[6]
- Broadband can also assist communities, as was shown in the study of its impact on economic activities in ten US communities between 1998 and 2002 where it had added 1-1.4 percentage points on job growth.[7]

The benefits of broadband are not limited to the commercial arena. It can help with social and cultural development across a wide range of fields. For instance:

- A study conducted by Climate Risk for the Australian incumbent, Telstra, shows how broadband creates opportunities for low-carbon development.[8] The report identifies seven

opportunities for carbon reduction or abatement, all of which are based on the use of broadband networks. These include remote management of power appliances and presence-based power, telecommuting, real-time freight management and on-live high definition video-conferencing.

- In a similar vein, the Report of the Global eSustainability Initiative (GeSI) entitled "Smart 2020: Enabling the low carbon economy in the information age"[9] looks at the enabling effect of ICTs, and especially broadband, in terms of generating opportunities for carbon abatement that are five times greater than the direct carbon emissions of the ICT industry itself.
- Broadband can contribute to improvements in the quality of life, as illustrated by a BT study of flexible working patterns among small businesses, which showed that 82 per cent of small businesses that had adopted broadband reported a better work-life balance.[10]

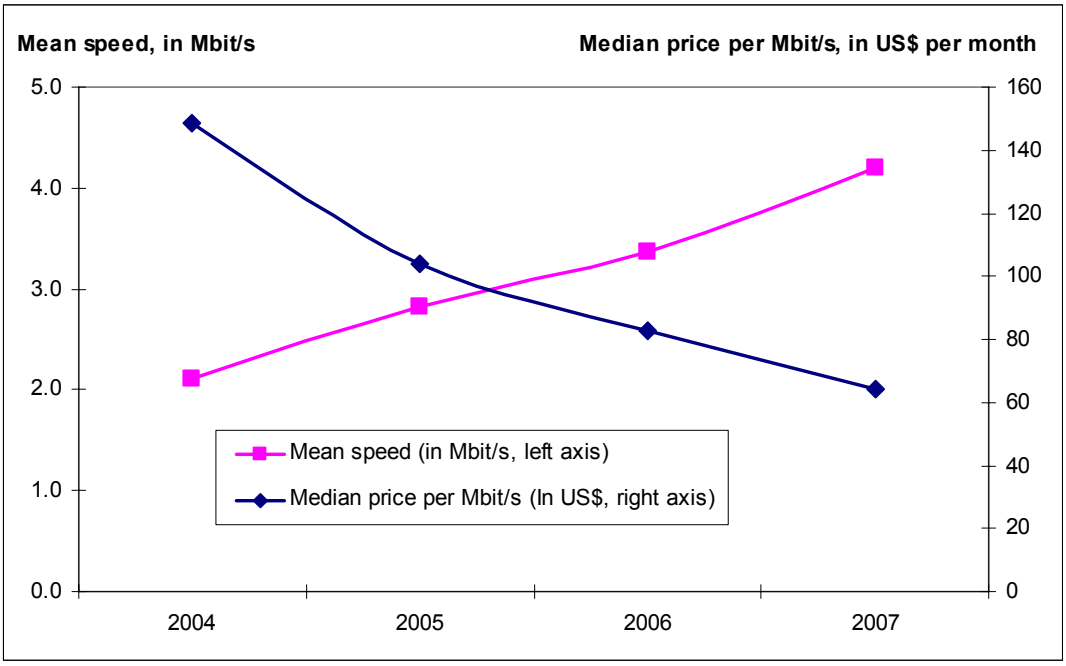
3.2 Performance/price ratios

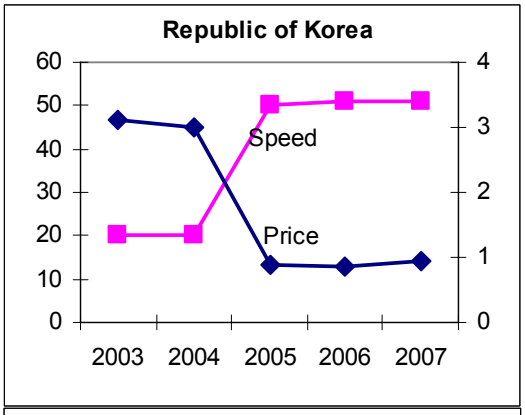
In analyzing the developmental impact of broadband, it is important to use the most recent data. The reason for this can be illustrated by the rapidly improving performance/price ratio for broadband worldwide. Figures tracked by Biggs and Kelly (forthcoming, 2009) show the trends over time in broadband price reduction and speed increase, worldwide. Between 2004 and 2007, for some 170 economies, median broadband prices, per Mbit/s per month, fell by a compound rate of 25 per cent per year while average broadband speeds rose by 26 per cent per year (see Figure 8). Taking these two trends together, it can be seen that the performance/price ratio of broadband is doubling in less than 18 months.

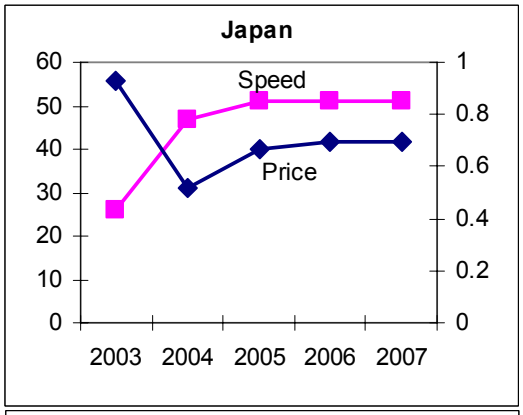
Furthermore, in some parts of Asia, the rate of improvement is even greater. In the Republic of Korea and in Malaysia, for instance, the performance to price ratio has doubled in just 12 months over the period 2003-07. At such exponential rates of improvement, it is clear that the market environment will continue to evolve rapidly, with products and services that are not commercially viable to offer at the moment, because of speed or price constraints, becoming viable within just a few years. So, for instance, the concept of downloading full-length movies was a pipedream just a few years ago but has now become commonplace in many countries, even in high-definition format. Similarly, because broadband is always-on and additional bandwidth use is close to zero marginal cost, voice over broadband is increasingly substituting for telephone service.

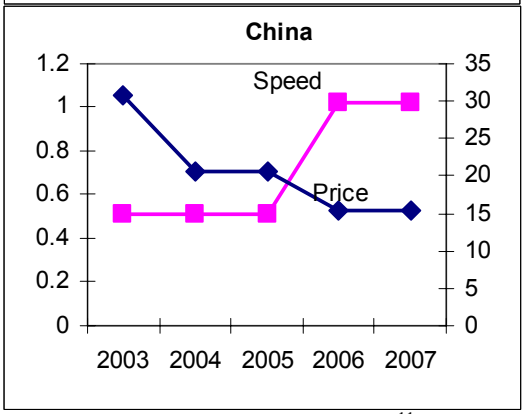
Of course, it is not possible to forecast whether these trends will persist over a long period, as was the case for instance for Moore's Law for semiconductor price performance, which has been sustained since the late 1960s. And the rate of growth in bandwidth availability falls short of the predictions in Gilder's Law, which forecasts a tripling every 12 months. But the rates of improvement are none the less impressive and are being observed equally in both developed and developing nation contexts.

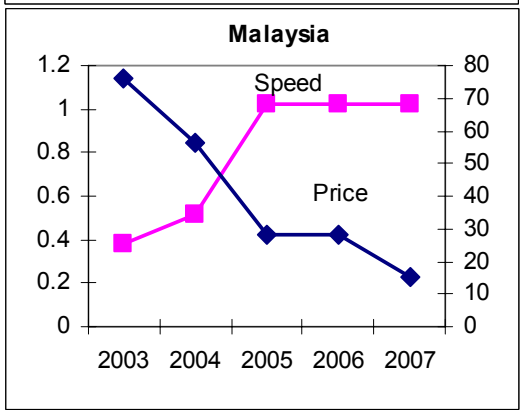
Figure 8: Trends in broadband speeds and pricing, globally 2004-2007, and in selected Asian economies, 2003-07











Source: Biggs and Kelly (forthcoming, 2009).[11]

3.3 The wider picture

While it is clear that the evidence in broadband's favour is growing, the studies of its impact currently undertaken tend to relate to North America and Western Europe, where broadband's impact was delayed compared with Asia, and the evidence relates to the early years of the 2000s, before the higher speeds and lower prices for broadband became widely available and while its penetration was still quite limited. There is a lack of evidence for Asia, and a requirement to look at recent more trends.

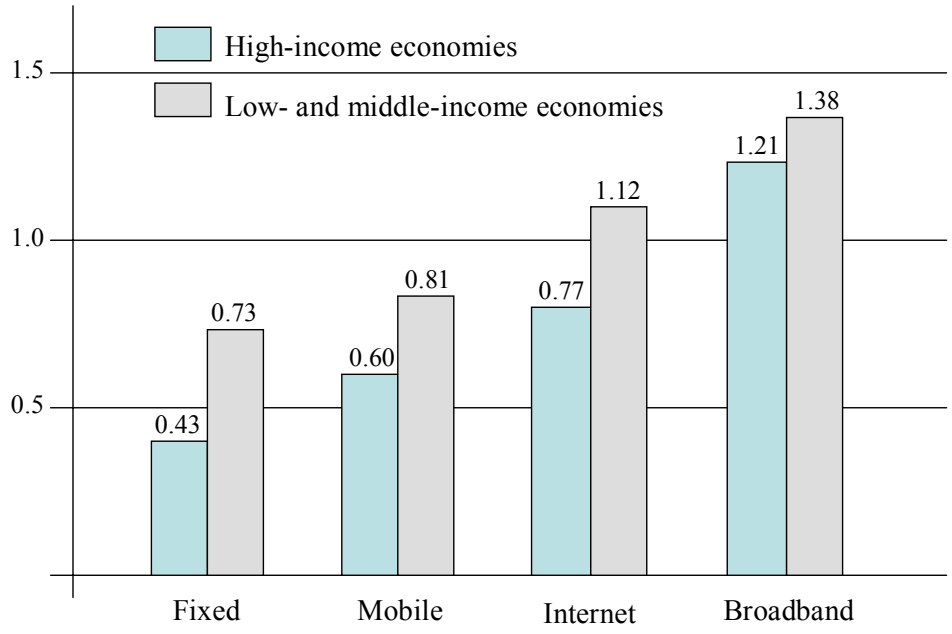
Two recent pieces of research, by the OECD and the World Bank – the two co-hosts of this symposium – help to fill some of this gap and to identify areas for future work.

In 2008, as part of its preparations for the Seoul Ministerial Summit on the "Future of the Internet", **OECD** published the background report "Broadband and the Economy"[12]. It provides a systematic review of the evidence on broadband's current and future impact on the global economy. The report argues that broadband is a general purpose technology (GPT) enabler. The report notes that the true benefits of broadband – like forerunner GPTs such as electricity or steam power – will come not so much its direct impact but rather from the applications it enables and the associated productivity gains.

At the start of 2009, **World Bank / *info*Dev** will publish its second Information and Communication Technology for Development (ICT4D) Report, entitled "Extending Reach and Increasing Impact". The report contains a chapter on the economic impact of broadband which attempts to put hard figures on the boosts to growth that can be expected from broadband. Based on research from Christine Zhen-Wei Qiang, the report presents a cross-country growth analysis to look at the impact of broadband and other ICTs on growth in 120 countries between 1980 and 2006. The analysis showed that an extra ten percentage points of broadband penetration by 2006 accounted for a 1.21 percentage point increase in per capita GDP growth in developed economies (Figure 9), which is astonishingly high given that the overall rate of growth during this period was only 2.1 per cent. Furthermore, among developing economies, broadband appears to boost GDP growth by 1.38 percentage points for each ten percentage points of penetration. Although it is less significant from a statistical point of view (due to the lack of developing economies that have broadband, and their later start in take-up), this result for developing economies does indeed point to a new model of development.

What is also remarkable about the analysis is the fact that the impact of broadband is so much higher than that observed for other ICTs, such as fixed-line, mobile or narrowband internet. Broadband's impact in developed countries, for instance, is found to be twice the impact of mobile phones, even though the latter is more widely penetrated. Much more has been written about the economic impact of these other services while broadband is still relatively under-researched.

Figure 9: Growth effects of ICTs: Percentage point increase in GDP per capita for every ten percentage point increase in ICT penetration, 1980-2006



Source: Qiang 2008.[13]
Note: All results are statistically significant at the 1 percent level except for that of broadband in developing countries, which is at the 10 percent level.

Some evidence of the beneficial impact of broadband on the economy can be seen in the rising share of the contribution of ICT to GDP in broadband-intensive economies. In the case of the Republic of Korea, the percentage contribution of telecommunication services (including broadband) to GDP more that doubled, from 2.05 to 4.99 per cent, between 1995 and 2005, the decade of broadband's expansion in the Korean economy.

Of course, there is a difficulty in interpreting causality, in that wealth and ICT use rise concurrently, and therefore it is possible that it is rising wealth which is leading to rising broadband use (i.e., because internet use becomes more affordable as incomes rise and because affluence also brings more leisure time). Statistically, this reverse causality cannot be rejected. But, given the growing literature at the micro-economic level about the benefits of broadband, it must be assumed that the causality works both ways and that the relationship between broadband and economic growth is mutually beneficial.

4. Conclusions

Clearly, more work is needed to investigate the nature of the link between broadband and economic growth, at both micro-economic and macro-economic levels, and especially to understand how it works in developing economies where use of broadband is still in nascent

stages. To date, too little of this research has been done in Asia, which has historically led the way. It is also too early to trumpet the argument that the improvements in the performance/price ratio that have been observed for broadband, especially in Asia, can be sustained in the long-term with the kind of longevity demonstrated by Moore's Law for semiconductors. Nevertheless, the evidence points to the fact that broadband, although still in its infancy, is having a profound and positive effect on economic, social and cultural development. What is more, the vectors of future change, with rising speeds and falling prices, suggest that the best is yet to come.

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[1] See Atkinson, Robert and Castro, Daniel, 2008 "Digital Quality of Life: Understanding the personal and social benefits of the Information Technology Revolution", IITF, Washington D.C. 179pp, available at: http://www.itif.org/index.php?id=179.

[2] The early success of the Republic of Korea as a market leader in Broadband is documented in the ITU report "Broadband Korea: Internet Case Study", March 2003, available at: http://www.itu.int/ITU-D/ict/cs/korea/material/CS_KOR.pdf.

[3] See Rappoport, Paul N., Kridel, Donald. J. and Taylor, Lester D. 2002. "The Demand for Broadband: Access, Content and the Value of Time." Washington, DC. available at: http://aei-brookings.org/admin/authorpdfs/redirect-safely.php?fname=../pdffiles/phpvw.pdf.

[4] See Varian, Hal, et al. 2002. "The Net Impact Study: The projected economic benefits of the Internet in USA, UK, France and Germany." Berkeley, available at: http://www.netimpactstudy.com/NetImpact_Study_Report.pdf.

[5] See Smith, Michael D., and Rahul Telang. 2006. "Piracy or Promotion? The Impact of Broadband Internet Penetration on DVD Sales" Carnegie Mellon University, Pittsburgh, available at: http://archive.nyu.edu/bitstream/2451/14958/2/USEDBOOK16.pdf.

[6] See Entner, Roger. 2008. "The Increasingly Important Impact of Wireless Broadband Technology and Services on the U.S. Economy." An Ovum Study for CTIA-The Wireless Association. Available at: http://files.ctia.org/pdf/Final_OvumEconomicImpact_Report_5_21_08.pdf.

[7] See Gillett, Sharon E., *et al.* 2006. "Measuring the Impact of Broadband Deployment." Prepared for the U.S. Department of Commerce, Economic Development Administration, Washington, DC, available at: http://www.eda.gov/ImageCache/EDAPublic/documents/pdfdocs2006/mitcmubbimpactreport_2epdf/v1/mitcmubbimpactreport.pdf.

[8] See Climate Risk pty (2007) "Towards a high-bandwidth, low-carbon future: Telecommunication-based opportunities to reduce greenhouse gas emissions", Sydney, 93pp, available at: http://www.itu.int/dms_pub/itu-t/oth/06/0F/T060F0060080023PDFE.pdf.

[9] See GeSI (2008) "Smart 2020: Enabling the low carbon economy in the information age", available at: http://www.smart2020.org/.

[10] See BT Business (April 2007) "State of the Small Business Nation", London, 7pp, available at: http://businessclub.bt.com/stateofthenation.pdf.

[11] See Biggs, Phillippa and Kelly, Tim "Trends in Broadband pricing" *Info*, Forthcoming 2009.

[12] See OECD (2008) "Broadband and the Economy: Ministerial Background Report", OECD Ministerial Meeting on the Future of the Internet Economy, Seoul, 17-18 June 2008, available at: http://www.oecd.org/dataoecd/62/7/40781696.pdf.

[13] See Qiang, Christine Zhen-Wei, 2008, "Telecommunications and Economic Growth", World Bank, Washington DC.