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The Economic Benefits from Investment in Advanced Mobile Infrastructure and Services: The case of Thailand

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Contents

Overview of findings

Investment in advanced mobile broadband networks is likely to provide Thailand with significant short-term and long-term economic benefits. Using simple estimates of the short-term multiplier effect associated with this investment, an annual investment of $1 billion could be expected to generate more than $2 billion in annual stimulus to the economy and close to 80,000 jobs annually. These short-term benefits in terms of increased output and jobs are likely to be felt in the telecommunications sector itself, but also in sectors that supply the telecommunications sector: for example, suppliers of electronic equipment and computer and software services.

Even more relevant are the long-term economic benefits from this investment. These long-term benefits arise through increased productivity in the wider economy, as a result of the new communications and data transmission possibilities that are created by mobile broadband networks. These gains are especially likely in economic sectors that use telecommunications intensively such as financial services, wholesale and retail trade, and the media and entertainment sectors. Deployment of advanced mobile networks is also likely to stimulate innovation in the development of the mobile content and software sector in Thailand, an area that holds significant economic potential. Using a well-developed methodology that translates investment in telecoms into economy-wide economic gains, we estimate that annual investments of $1 billion per year between 2010 and 2014, will generate an economic gain that has a present value of $8.9 billion — in other words, a gain equivalent to increasing national wealth by $8.9 billion today. As an alternative measure of economic value creation, we estimate that annual consumer benefits from deployment of advanced mobile broadband networks might exceed $1 billion per year by 2014.

Mobile broadband networks are likely to play an important role in filling in the holes in broadband access that exist in emerging markets such as Thailand. In Thailand itself, the evidence shows that low broadband penetration sits alongside high interest in using the Internet. Fixed networks have thus far struggled to effectively address the pent-up demand in the market, just as in earlier era fixed networks failed to achieve anything close to universal penetration of voice services. Deployment of HSPA+ mobile networks is likely to provide a significant spur to competition in the wider broadband market, especially given trends in handsets and Internet Access Devices that are driving down costs to consumers. Mobile broadband networks also represent a reasonably effective way to deliver basic broadband access to smaller and medium-scale enterprises given that a clear access gap exists between these enterprises and larger ones.[1]

Consequently, delays to licensing of 3G spectrum in Thailand have hurt the Thai broadband market and the wider Thai economy, as we explain in this report.

While deployment of mobile broadband infrastructure will create widespread social and economic benefits, unlike other forms of infrastructure (e.g., roads and highways) this deployment is significantly a market-led deployment. The main requirements of government policy are minimal and should not be difficult to meet: a robust regulatory regime that establishes a fair and efficient allocation of spectrum property rights and which safeguards the competitive process by not tilting the "playing field" in the favour of one or other parties or technologies.

An obvious start to ensuring the creation of such a robust regulatory regime is a timely and transparent spectrum auction, a process that is likely to unleash efficient private investment in advanced mobile infrastructure. Thailand can significantly close the emerging gap in broadband access and use between itself and countries such as China simply by taking the right policy measures to encourage private investment and competition in the mobile market, measures that will impact the entire broadband market and the entire economy.

1 Summary of quantified benefits

1.1 **Consumer benefits:** Our calculations show that under reasonable assumptions the annual consumer benefit from introduction of 3G services in Thailand will exceed US$1 billion per year by 2014. These calculations are explained more thoroughly in Section 4 of this report.

1.2 **Economy-wide benefits:** Consumer benefits are a direct measure of increased consumer well-being from the introduction of a new product. However, the debate on the economic value of telecommunications infrastructure has

[1] An UNCTAD research project in Thailand finds that whereas virtually all larger businesses (more than 1000 employees) have Internet access, this falls to 50% or less for businesses with 25 or fewer employees. The same research finds higher labour productivity and sales per employee in businesses that do use the Internet. Source: Thailand Business ICT Survey, 2005, as quoted by Diana Korka, UNCTAD, in a presentation to the Global Event on Measuring the Information Society,

concentrated on the benefits from telecommunications infrastructure to the wider economy. These benefits arise in the following ways:

- *A conventional "multiplier" effect:* The telecommunications sector by investing more to expand its output buys inputs from other sectors. These other sectors in turn increase their own output and this leads to increased purchases from yet more sectors of the economy. A so-called Type II "output multiplier" captures the ultimate effect in terms of increased economy-wide spending once all the chains of purchases have been accounted for;

- *A dynamic effect on productivity:* Perhaps even more importantly, the wider availability of broadband infrastructure stimulates productivity and activity in sectors that use broadband. As with conventional voice telephony but perhaps to an even greater degree, use of broadband, Internet and email results in lower transaction costs, lower entry barriers for new businesses, new ways to reach consumers and bring products to market. These gains are not captured in conventional Input/Output multipliers, but over a period of several years they are surely as significant if not more significant than the induced spending as a result of greater network investment.

1.3 We use a "multiplier" methodology that is ultimately derived through consideration of the "social rate of return" that has, on average, been experienced for previous waves of telecommunications investment. This social rate of return quite roughly is a measure of the GDP increase as a result of additional telecommunications investment, reflecting both the static and the dynamic effects of such investment discussed above. Our estimate is that an annual investment of $1 billion in new networks by the entire industry over the five years from 2010-2014 will yield an increase in GDP that has a net present value of $8.9 billion.

1.4 Where will these benefits materialise? Table ES-1 offers some examples of sectors that can be expected to benefit from deployment of 3G broadband infrastructure:

Geneva, May 27-29, 2008.

Table ES-1: Key impacts from increased broadband/3G penetration[2]

Direct Impacts (short-term)	Sectors most likely to be impacted
Sectors that are major suppliers to telecoms	Business services, special machinery and apparatus manufacturers, transportation, and electricity, computer and software services.[3]
Impact on the telecom sector	Telecom sector purchases 30% of the value of intermediate inputs from within the sector
Economy-wide impacts (dynamic)	**Sectors most likely to be impacted**
Increased productivity and efficiency in using sectors	Business services (especially banking), wholesale and retail trade, radio, television and media sectors
Increased growth in related sectors	Development of applications and content, incentives to develop domestic capacity in producing relevant capital equipment, development of software sector

1.5 The methodology that we used is described more fully in Section 5 of this report, and further technical details regarding supporting evidence for the social rate of return is provided in Appendix 1.

Alternative multiplier estimate of economy-wide benefits

1.6 There is another "multiplier" method by which one can assess the impact of increased output and investment in the telecommunications sector. This method relies on the static multipliers for output and employment that are frequently provided in national income accounts and Input-Output tables. These multipliers do not (a) capture the dynamic and long-term effects of infrastructure investment in terms of increasing productivity and leading to new economic opportunities, and (b) they do not adequately capture the concepts of opportunity costs and financing costs of investment that our preferred method captures. Although we do not discuss these calculations further in the report, they do provide useful indications

[2] This table is based upon analysis of intermediate consumption by the "post and telecommunications" sector in Thailand, and analysis of the use of the outputs of post and telecommunications sector as intermediate inputs by other sectors. The sectors that have been labelled as most likely to be impacted are those which either form a relatively high share of the post and telecom sector's intermediate consumption, or sectors for which the outputs of the post and telecoms sector are a relatively high share of their own intermediate consumption. Intermediate consumption data were obtained from the 2005 Input-Output tables supplied by the Thai National Statistics Office.

[3] Computer and software services are evidently not reported as a distinctive sector in the 2005 Input-Output tables, and thus are likely to be classified under the "unclassified services" category.

of the magnitude of the economic gains from additional telecommunications investment resulting from the deployment of 3G networks in Thailand.

1.7 Table ES-2 reports estimated gains in output and jobs as a result of $1 billion per year of increased telecommunications investment over the period of 2010-2014. The gains in employment and output are based on average multipliers for the Indian ICT sector, which was the closest available proxy for Thailand that we were able to obtain. Using these estimates, we are able to show annual GDP gains of $2.3 billion each year, and annual job creation effects of about 77,500 jobs per year.

Table ES-2: Job creation and Employment impacts[4]

Type of benefit	Magnitude
GDP gain per $1000 of investment	$2300
Jobs gain per $1000 of investment	0.0775
GDP impact of $1 billion annual investment	$2.3 billion
Jobs gain from $1 billion annual investment	77,500
NPV of GDP gain over 2010-2014 at 5% discount rate	$9.9 billion

Conclusion

1.8 The upcoming 2100 MHz spectrum license offers Thailand a significant opportunity to encourage further investment in the mobile telecommunications sector. A well-designed and transparent spectrum auction process is the process most likely to generate the most efficient use of scarce spectrum. Allowing successful bidders the opportunity to outright “own” their own spectrum without having the encumbrances of the Build-Operate-Transfer (BOT) regime currently in place will boost competition and innovation in the Thai market. It offers a

[4] These estimates are based upon an ICT sector composite output multiplier of 2.3. To obtain the employment multiplier, we first took the reported impact of INR 100,000 increase in ICT sector output, which was 0.36 man-years. Using an exchange rate of 43 INR to a US dollar, this translates to 1.55 jobs per $1000 in additional ICT sector output. The Indian ICT multiplier might be contrasted with a US Type II multiplier of 2.9 for the telecom sector as used by Criterion Economics (2003). In order to account for the fact that GDP per worker in Thailand is roughly twice that in India, we halved the employment multiplier to reflect potentially lower labour intensity of production in Thailand.

welcome chance to resolve long-standing uncertainties that have played a part in the hesitant and rather minimal levels of 3G deployment and uptake in Thailand today. Given the value to Thailand of continued investment in advanced mobile telecommunications platforms, it is in the country's vital interest that further delays to the licensing awards are avoided.

2 Introduction

2.1 The following report discusses the economic benefits that can be reasonably expected to materialise from investment in advanced mobile network infrastructure in Thailand. The term "advanced mobile network infrastructure" might be seen as synonymous with the more widely-known term "3G" (although the actual technology proposed in Thailand might be more aptly labelled 3.5G). The economic benefits from investing in such infrastructure are substantially the economic benefits that can be expected to arise from increased diffusion and utilisation of mobile broadband technologies and services that utilise such technologies.

2.2 The report contends that, as with previous waves of investment in telecommunications and Internet infrastructure, the societal or "social" benefits from investing in networks that enable mobile broadband might be very substantial. This "contention" is based upon available economic evidence regarding the social returns from past waves of investment in telecommunications infrastructure. However, the suggestion that the benefits of next-generation *mobile* technology are very significant in countries like Thailand also reflects the reality of the telecommunications market in emerging markets, where mobile penetration has long-since outstripped fixed-line penetration and where fixed-line broadband networks have struggled to grow. Indeed, when outcomes in the voice market are analysed in even the briefest detail, it is clear that Thailand is an excellent example of the significant success of mobile networks in comparison to fixed-line networks.

2.3 Forecasts and projections available to us at this time do not suggest that there is likely to be a dramatic acceleration in fixed-line broadband networks. For instance, a report by BMI International suggests that in 2009, there would be at best between 3 to 4 broadband subscribers per 100 population.[5] While fixed-line technology may still offer capacity advantages over mobile broadband technology, the capabilities of mobile broadband are improving significantly. In developed markets, fixed-line broadband operators are increasingly offering speeds of 10 Mbps or more, but in Thailand most operators are only recently offering broadband packages of between 512 Kbps and 8 Mbps. This suggests that there may be significant potential, especially in the longer-term, for mobile broadband to reach consumers who may not be addressed by the current fixed broadband network.[6] In any case, the short and medium-term consumer benefits associated with provision of advanced mobile broadband services can still be expected to be substantial.

2.4 As a related point, it follows that the regulatory environment, while remaining technology neutral (i.e., not consciously favouring one technology over another) should focus on removing barriers to investment, entry and deployment of services. In the case of advanced mobile services, there may be significant advantages to a spectrum auction that results in the allocation of spectrum in a transparent manner, so that spectrum (a publicly-owned resource) is allocated to those who can make the most efficient use of it, with efficiency being defined in terms of societal costs and benefits. This may encourage investment by allowing some operators, currently in “BOT” arrangements with state-owned “host” carriers, to own their own spectrum.

2.5 The relevant network technology, i.e., HSPA and its successors, has matured significantly and gained a world-wide installed base. In addition, the development of more sophisticated handsets with increasing functionality, at lower prices, has complemented the growth of advanced mobile networks. Yet more recently, mobile operators in several countries offer “dongles” that enable subscribers to utilise mobile broadband data networks with “conventional” Internet access devices such as laptop computers. There are also moves afoot to develop low-cost laptops that specifically have the Internet access needs of users in developing markets in mind. Taken together, this evidence suggests that:

[5] Source: BMI International, *Thailand Telecommunications Report* Q3 2009.
[6] In the short-term, the “early adopters” of mobile broadband may be relatively affluent consumers who either use mobile broadband as a complement to existing fixed services or those consumers who have not thus far utilised a personal fixed broadband connection and may continue to bypass the fixed-line network. In the longer-term, as prices of mobile broadband fall and its capabilities grow, one might expect to see that relatively less affluent consumers in areas that are under-served by fixed broadband providers resort to mobile broadband services.

- Mobile broadband is increasingly a mature technology with a very large global user base. Given this, it makes sense for Thailand to adopt policies that encourage rapid and immediate adoption of this technology;
- Mobile broadband services will be deployed by a number of parties, some of whom are not active in the fixed-line market. This will deepen the level of inter-platform competition between mobile and wire-line services in Thailand. Numerous academic studies point to the benefits of robust competition between competing broadband platforms;
- Mobile broadband may well be able to replicate the marked success of mobile voice in expanding access where the fixed-line system failed to do so.

2.6 In this report, we attempt some quantification of the benefits of mobile broadband. While it is difficult to forecast the future with significant accuracy, our calculations are based on what we regard as reasonable and even conservative assumptions. There are two types of benefits that we enumerate here:

- **Benefits to consumers**, expressed in terms of the value to society from consumption of a good. While this value might seem hard to articulate in sheer monetary terms, there are well-developed tools in economics to estimate this value. The measure of consumer benefit derived from consumption of a good that we use is the "compensating variation" which can be understood as the amount of money that the government would have to pay society if it banned the consumption of that good. In the case of mobile broadband, the "good in question" in this case, we make estimates of this "consumer benefit" in the near future based on realistic assumptions about subscribership and revenues.
- **A measure of "total economic return",** which is similar to GDP. This "total economic return" is calculated based upon the anticipated investment in mobile broadband networks. It is well-known from established academic work that there are substantial "spill-over" benefits into the wider economy from investment in valuable telecommunications infrastructure. These "spill-over" benefits arise because telecommunications supports and enables a wide range of economic activities. This is especially likely to be true in the broadband era. The "total economic return" thus captures the

widespread economic benefit from investment in telecommunications infrastructure. The calculation is based upon a methodology that (based upon published econometric studies) derives the return to society from $1 invested in valuable telecommunications infrastructure.

2.7 We then also discuss the costs to society — using both the consumer benefit and total economic return measures derived above — of delaying investment in advanced mobile networks. We argue that there are likely to be significant benefits from early adoption of the relevant technology in Thailand—"early" in this sense is a relative term, since Thailand is already a late adopter compared to other nations. However, we argue that the timely deployment of advanced mobile networks will spur the development of services and content in Thailand, while delaying deployment might run the risk that innovation in content and services that could have been successfully generated in Thailand would be lost, perhaps even permanently.

2.8 It is very important to note that our discussions are based on social returns and consumer benefits from timely deployment of advanced mobile infrastructure and services. This is not necessarily synonymous with making a "business case" at the level of individual operators for early deployment of advanced infrastructure. Indeed, we are not advising individual operators as to the profitability of investment opportunities in advanced mobile networks. Rather, we are making a case that takes *the perspective of society as a whole*. This perspective takes into account the fact that in the past, the returns to society as a whole from investment in telecommunications have exceeded the returns to the investors in telecommunications networks.[7] From this perspective, welfare is maximised by policies that facilitate investment and adoption, and is hurt by policies that impose artificial delays that delay or restrict investment and adoption. Since the mobile industry in many emerging economies, unlike its fixed-line counterpart, has been substantially driven by business decisions of private investors, the inference is that investment in mobile networks is usually both privately profitable, and socially valuable. Thus regulatory micro-management of the industry is not required—rather the goal of the regulatory framework should be to create "rules of the game" that encourage competition between private companies to emerge. Policies such as timely and transparent spectrum licensing processes are

[7] This is also likely to be true of other essential infrastructure. A careful econometric analysis of the benefits to OECD economies from investment in telecommunications infrastructure between 1970 and 1990 can be found in Roeller and Waverman (2001).

precisely where regulators have a crucial role in creating the optimal investment environment.

Quantitative conclusions

2.9 Our consumer benefit calculations show that (in net present value terms) the expected benefit to consumers from deployment of 3G networks will (taking the average across all scenarios calculated) likely exceed $1.5 billion per year by 2014. Alternatively, the NPV of the **cumulative** consumer benefits over the years from 2010 to 2014 is (averaged across all scenarios) $4.4 billion.

2.10 Our total economic return calculations show that (in net present value terms) the expected total economic return based upon $5 billion of investment ($1 billion per year for each year between 2010 and 2014) in long-lived network infrastructure assets by mobile operators is $8.9 billion.

2.11 We also calculate that the inability to achieve 3G deployment over the 2007-2009 period — when one could reasonably have expected at least some deployment to occur— may have exceeded $1 billion in terms of cumulative consumer surplus foregone. In terms of total economic return foregone, the economic loss may have exceeded $2 billion.

2.12 These calculations are based upon several assumptions and are necessarily speculative in their nature. However, we believe that the assumptions underlying the calculations are inherently reasonable and conservative ones; thus the calculations should be taken as an indication of the magnitude of the economic benefits that can be expected from deployment of advanced mobile services in Thailand.

2.13 Table 1 below summarises the calculations of economic benefit (and costs of delay) discussed previously.

Table 1: Summary of economic benefit and cost calculations

Consumer Benefits	Average NPV of cumulative consumer benefits (2010-2014)	$4.4 billion
	Average consumer benefit in 2014	> $ 1.5 billion
	Average Lost consumer benefit (2007-2009)	Approx $1 billion
Total Economic Return	Total Economic Return from $5 billion investment	$8.9 billion
	Lost return from postponing investment from 2007 to 2010	$2.2 billion

Note: For the consumer benefit calculation, "average" refers to the average value across all scenarios.

Structure of report

2.14 The remainder of this report is structured as follows:

- Section 3 discusses (a) the status of the telecommunications industry in Thailand, and (b) the potential role for mobile broadband in the Thai economy. In particular, there is evidence that Internet users significantly exceed Internet subscribers, suggesting that (particularly in the long-term) there is significant pent-up demand for personal broadband services;
- Section 4 discusses the consumer benefit calculations. We look at adoption rates of earlier waves of "3G" technology (UMTS/CDMA-2000) in developed markets, and also look at forecasts for revenue and take-up of 3G services in Thailand. We then use these data to calculate the consumer benefit from 3G deployment over the next five years;
- Section 5 discusses the "total economic returns" or GDP calculations based upon the investment multiplier methodology;
- Section 6 estimates the costs articulated in both GDP and consumer benefit terms of delayed adoption of 3G in Thailand. In this section, the costs are evaluated based on benefits foregone by Thai consumers and the Thai economy during 2007-2009, a period in which 3G services might have been extensively deployed in Thailand but were not;

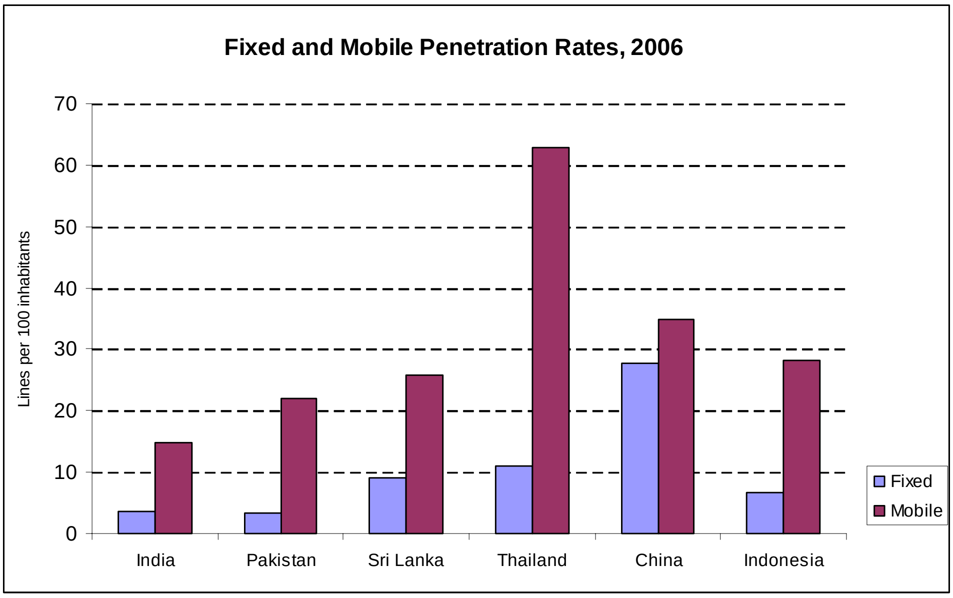
- Section 7 draws some brief policy conclusions, particularly as they pertain to the role of licensing and spectrum auctions;
- Appendix 1 provides some further methodological details.

2.15 Since the assumptions underpinning our calculations are very important to the credibility of our analysis, we provide an extensive discussion of the evidentiary basis for our calculations.

3 Mobile and fixed telecommunications markets in Thailand

3.1 The most striking feature of the Thai mobile market is that among a group of arguably comparable Asian nations, Thailand has the greatest discrepancy between its fixed-line and mobile penetration rates. This suggests quite directly that even compared to a peer group where mobile diffusion has significantly outstripped fixed-line diffusion, Thailand is something of an extreme example. It also suggests that the Thai mobile sector is very dynamic. While there are complex institutional and market structure issues that may explain why the fixed-line market in Thailand has been particularly slow-growing in relation to the mobile market, it seems unlikely that there will be significant growth in the fixed-line sector in terms of fixed voice subscribership and growth rates.

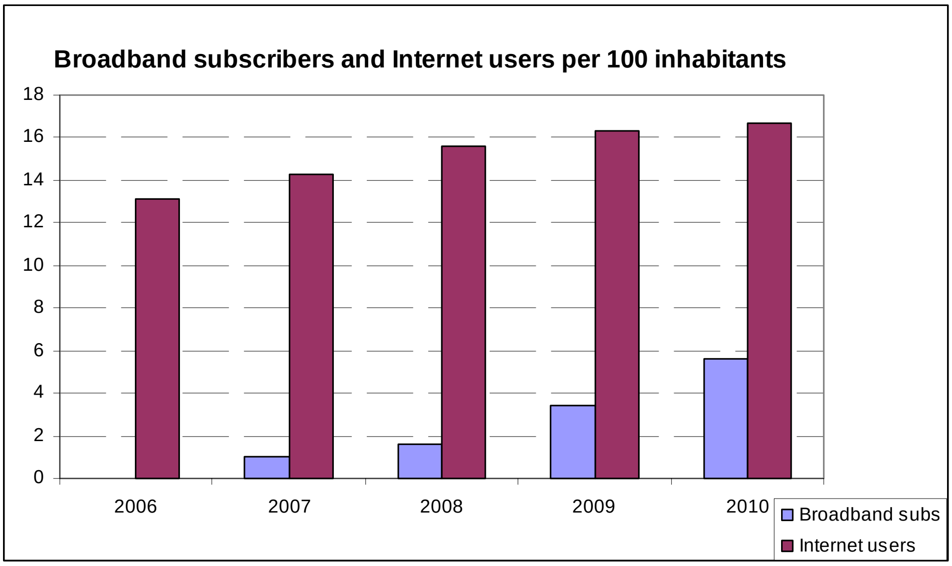
Figure 1: Fixed and mobile telecom penetration rates, 2006



Source: ITU World Telecommunications Indicators 2008

3.2 Indeed, the relative sluggishness of the fixed-line sector appears to show up in slow rates of (fixed) broadband adoption thus far. Deployment of fixed-line broadband has significantly lagged Internet usage in Thailand, suggesting that there is a significant portion of Thai users who currently use public-access points (such as Internet cafes or libraries). These data suggest that there is already strong demand for at least basic Internet services (and perhaps more), but that the demand has not been matched by developments on the supply side of the Internet market.

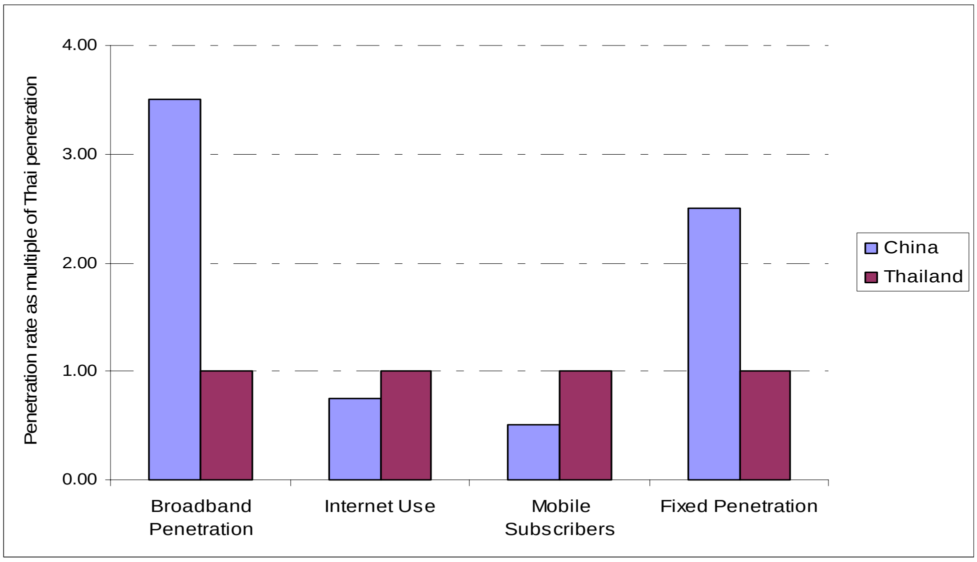
Figure 2: Internet users and broadband subscribers



Source: BMI, Thailand Telecommunications Report, Q3 2009, p.20.

3.3 Figure 3 provides some further evidence of the relatively mature nature of Internet demand in Thailand, along with evidence of a supply-side underperformance in the delivery of broadband and fixed-line services. The chart shows the multiple of the Chinese level of penetration or usage of particular technologies relative to the Thai level. Thus, based on broadband subscribers per 100 inhabitants, the chart shows that China in 2007 had more than 3 times as many broadband subscribers per 100 inhabitants as Thailand did. However, Thailand led in both Internet usage and in mobile penetration, but was far behind in terms of fixed-line penetration.

Figure 3: Broadband and Internet usage, China versus Thailand, 2007



Source: ITU World Telecommunications Indicators, 2008.

3.4 Table 2 provides some germane information on business usage of technology in Thailand compared to China and the highly-developed market of Hong Kong. It shows that Thai businesses are more likely to have a web presence than Chinese businesses, but less likely to have Internet access. The proportion of businesses in Thailand that use computers is also quite high. These data pertaining to business use, along with the data on Internet use by consumers in Thailand, further underscore that to the extent the "Information Economy" in Thailand falls short of its potential (at least as measured in terms of performance relative to peers), the deficit is substantially linked to problems on the supply side of the Internet market in Thailand.

Table 2: Business use of key technologies

Country	Business with Internet access	Business with web presence	Business using Personal Computers
Thailand	55%	26%	80%
China	68%	22%	n/a
Hong Kong	85%	41%	92%

Source: Diana Korka, UNCTAD, 2008.

Implications for 3G take-up

3.5 The data provided above suggest that the fixed-line sector has been relatively stagnant in Thailand, whereas the mobile sector has expanded dramatically. There is also a clear void in Internet supply, where either for reasons of price or availability, the fixed-line broadband market is unable to address the significant demand for Internet usage that exists among Thailand's businesses and consumers.

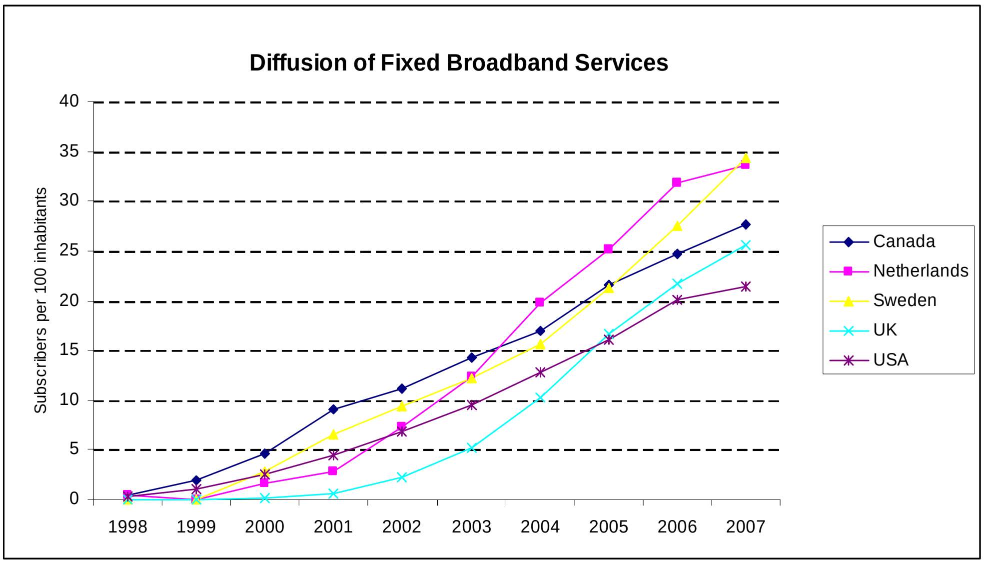
3.6 At the same time, one cannot straight-forwardly extrapolate from the evidence available from the voice market to the broadband market. For one thing, even though technologies such as Evolved HSPA might offer peak download rates of 28 to 42 Mbps, in practical terms such download speeds are not available to end-users. In the developed world, the latest fixed-line deployments will continue to dominate mobile broadband deployments in terms of bandwidth and capacity offered, even as mobile broadband deployments become increasingly price-competitive and quality-competitive with respect to conventional fixed offerings such as ADSL.

3.7 However, in the context of Thailand, where fixed line broadband service providers do not offer more than 8 Mbps (for ADSL), mobile solutions such as HSPA are likely to be fairly competitive with fixed-line offerings, at least in terms of consistent download speeds experienced by users. In addition, fixed-line networks are not universal in Thailand, as they are in most developed nations — thus according to BMI, the current broadband network of TOT reached only about 60% of the population as of year-end 2008.

3.8 These developments suggest that there is a significant potential, particularly in the long-term, for mobile broadband services facilitated by advanced mobile networks to plug some of the unquestionable supply-side “gap” in the Thai market. In the short-term, there may still be significant numbers of users, particularly among the current post-paid customer segment, who could either use mobile broadband services as a significant substitute or significant complement to existing fixed-line services.

3.9 Indeed, the number of broadband subscribers in Thailand is still so low that in terms of the typical “s-shaped” diffusion dynamics associated with new technologies, Thailand is still far off from achieving critical mass. Mobile broadband may have a critical role in accelerating adoption and achievement of critical mass. Achievement of critical mass leads to a significant increase in the economic contribution and economic value of broadband services. At a basic level, there is a stronger “network effect” wherein the value to consumers of being connected — and the foregone value associated with not being connected — increases with the size of the network. Achievement of critical mass also enables scale economies to arise in development of products that utilise the network, resulting in greater spill-over effects into the wider economy. Figure 4 provides an example of the typical diffusion pattern for broadband services witnessed in developed markets.

Figure 4: Fixed broadband adoption dynamics



3.10 It can be seen that while fixed broadband services were introduced in most markets around 1998, there was usually a period of two to three years before these services entered a period of very rapid adoption. The delay was most pronounced in the UK, and least in Canada. In Canada, there was strong inter-platform competition between cable modem and ADSL services from the outset, whereas in the UK, the incumbent fixed-line operator, BT, began promoting DSL (in competition with the cable broadband offerings of Virgin Media) relatively late (around 2001). In all cases, however, once a critical mass of between 3 and 5 percent penetration of broadband was achieved, a period of very rapid growth commenced, which only started tailing off in 2005 and 2006. In many markets, platform competition (e.g., cable versus ADSL) was a key factor in initiating growth.

3.11 In the case of Thailand, one can expect that the deployment of advanced mobile networks using HSPA networks will hasten the achievement of critical mass, leading to perhaps significantly more rapid overall Internet take-up than would otherwise exist. Indeed, competition between mobile and fixed operators in provision of broadband and Internet services could provide a basis for sustained platform competition in the developing world.[8]

[8] Note: this does not amount to a prediction that diffusion dynamics in Thailand will resemble those in the developed world. Rather, the example of broadband diffusion in the developed world is used to illustrate the key ideas of critical mass and network effects discussed above.

Handsets and devices

3.12 Thus far we have compared Thailand to its peers, such as China, and found that broadband and Internet subscriber levels have lagged in Thailand, despite high levels of usage via public access points and high levels of interest by consumers and business alike. This, we have suggested, reflects a failure on the supply side of the market. However, another barrier to adoption — one that is common to Thailand and comparator nations — is the cost of Internet access devices.

3.13 Average disposable income in Thailand is around $4500 per year (gross)[9], or about 10% of that in countries such as the United States. Yet the cost of laptop computers is actually higher in Thailand than in the United States. Indeed the price of most "ICT" capital goods is no lower, and often higher (as a result of import tariffs) in developing countries than in advanced markets such as the United States.

3.14 However, the price of handsets is significantly lower than the price of laptop computers, on average. An "entry-level" 3G handset can be obtained for as little as US$100. In the Indian market, there is talk of affordable "smart phones" costing around 10,000 Indian rupees, or just over $120. While many of the highest-specification handsets may cost as much as $500 (or even more), there are efforts underway to reduce the costs of these handsets, in order to boost both business and consumer connectivity. Thus:

> *"'We are in talks with all operators to explore, along with our OEMs (original equipment manufacturers), how this space can be penetrated so as to increase the addressable market. We are working to make sure 3G entry-level phones start at Rs 4,000. Affordable 3G smartphones, beginning at Rs 10,000, will bring in a new dimension to enterprise connectivity," Qualcomm India and South Asia president Kanwalinder Singh told ET'." (Economic Times, 19 Sep 2008)*

3.15 Further, as shown in Figure 5, the average price of 3G-enabled handsets has exhibited steady decline, and one can thus reasonably expect similar levels of deflation to apply to the currently high-priced handsets.

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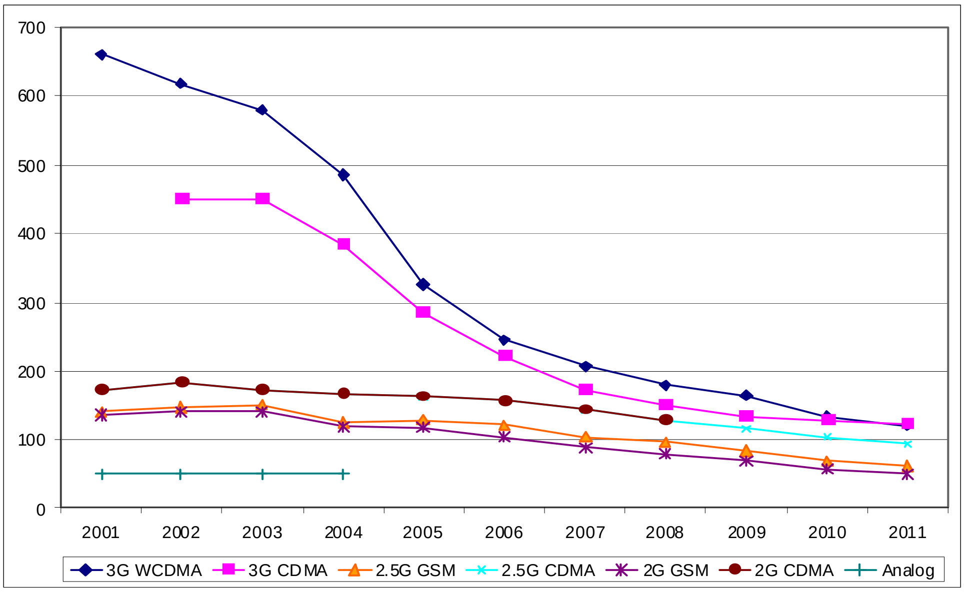
[9] Source: http://www.worldsalaries.org/thailand.shtml

Figure 5: Trends in average selling price (US$) of handset types



Source: LECG analysis based on Yankee Group data.

3.16 The relatively low and steadily declining price of handsets, coupled with their steadily increasing functionality, make them a viable Internet access device in emerging markets such as Thailand (note that the price declines above do not account for the fact that functionality and quality have also increased; on a quality-adjusted basis, the price decline would look even more pronounced). The evolution of the data-handling abilities of mobile networks and the increasing sophistication of handsets, combined with the pricing dynamics discussed above, suggests that there is a group of Thai consumers for whom mobile Internet could be the primary personal Internet access option.

3.17 However, mobile broadband networks also offer usage options for those many consumers who would wish to continue using their laptop as their primary access device, or who wish to use both the laptop and the handset as access devices. In many developed countries, there has recently been a significant increase in the use of USB "dongles" and data cards— although some of this adoption might be "complementary." [10]

[10] See "Mobile Broadband USB Modems Take off in Europe", Pete Nuthall, Forrester Research, July 22nd, 2008: http://www.forrester.com/Research/Document/Excerpt/0,7211,44577,00.html, arguing that mobile broadband technology is now a serious competitor to fixed-line broadband technology. Juniper Networks has forecast that there will be 1.7 billion mobile broadband subscribers by 2013. See http://www.computerweekly.com/Articles/2008/06/25/231205/mobile-web-users-to-top-1.7-bn-by-2013.htm.

3.18 In addition to this, there are well-publicised efforts underway to develop lower-cost computing solutions for developing nation markets. Examples of such efforts include:

- Massachusetts Institute of Technology's initiative to develop a $100 laptop specifically for facilitating Internet access in developing nations;
- Efforts by Tata in India to develop a laptop for as little as $20;
- Commercial efforts such as the Eee PC, which is available in the Asian market;
- "Community"-oriented efforts such as the Intel Community PC launched in China and India. Although some are designed for "shared" usage—i.e., at Internet kiosks—some of the products launched under this umbrella aim to be "family PCs" or "worker PCs."[11]

3.19 There is a convergence of technological trends and evidence which suggests that for late-adopting markets (i.e., developing markets where fixed broadband has not, and may not, diffuse widely), mobile broadband networks are a significant source of platform-based competition to the traditional fixed-line networks. The greater scalability of mobile networks combined with the increasingly low cost of Internet access devices suggests that in some cases mobile broadband may well supplant fixed-line broadband. Particularly in Thailand where Internet usage significantly outstrips personal Internet subscriptions, it would appear that the success of mobile networks in expanding access to telephony and text-messaging services may well be extended into the broadband arena.

3.20 Lastly, it is worth considering some additional attributes of Thailand. The country already has a significant ICT sector, with manufacture of computers and computer parts already forming a significant economic sector (valued at $15 billion). The Thai software market is valued at around 77 billion TBH, or roughly $2.3 billion. This sector experienced growth rates of around 35% or more a year between 2004 and 2007. Since the size of these other ICT sectors is likely to be a reasonable indication of the diffusion of wider ICT skills in the economy, one can view these data as providing further confirmation that the demand for broadband and data services does exist in Thailand.

[11] A complete listing of efforts to develop low-cost laptops and PCs can be found at http://www.infodev.org/en/Publication.107.html.

Implications for quantifying economic benefits

3.21 Overall, we believe that pent-up demand for Internet access, coupled with the value of mobility and expanded access that mobile Internet access offers, suggests that there is a significant niche in Thailand for the types of services that advanced mobile networks support. In the long-term, we believe that mobile broadband might become a crucial enabler for universal Internet access in Thailand, just as mobile voice services have ensured that there is near-universal access to voice services in Thailand.

3.22 However, in the short and medium terms (over the next 5 years), one would expect that take-up of higher costing, higher value-added mobile data services commences with relatively affluent customer groups (such as those currently on some form of post-paid plan). However, as we show next, the aggregate consumer benefits even from assuming relatively conservative take-up of 3G services (based upon assuming that costs of 3G/mobile data services) remain relatively high. The corollary of this is that regulatory or other policies that delay the adoption of such services still impose a significant cost on Thai society.

4 Consumer benefits quantification

4.1 In this section, we use established methodologies to calculate consumer welfare from the introduction of a "new good." In this case, the "new good" in question is an integrated voice and data/Internet offering that also has the added benefit of mobility. [12]

4.2 One obvious objection to using such a welfare calculation in this context is that, in fact, the "good" in question is not really new. There are already other voice and data offerings in the market, which are significant substitutes to 3G/HSPA+ enabled services. There might be the objection that subscribers who switch to 3G services stop purchasing 2G services. Thus the welfare gains attributed to 3G services might be over-estimated because we fail to account for the "displacement" of 2G by 3G. However, Hausman (1997) demonstrates that unless the "older product" (2G) is withdrawn from the market altogether, one does not have to make an adjustment for "displaced" sales of the older product. [13]

[12] The term "good" here is a generic term covering both physical goods and services.

[13] Hausman adds that only when the older product is withdrawn altogether do "significant complications arise."

4.3 Second, at a more intuitive level, the types of services enabled by 3G mobile broadband are genuinely new in terms of the combination of attributes that they offer. This is especially the case because they combine mobility, voice and broadband, and in the developing world, their impact might be expected to at least approach the impact of mobile voice services or to the impact of broadband in the developed world.

Conceptual basis for calculating consumer welfare gain

4.4 We begin by defining what we mean by consumer welfare. "Consumer welfare" in this case is defined as the increase in consumer well-being (measured in monetary terms) through the introduction of a good or a service. Alternatively, the measure of consumer welfare that we rely on — the "compensating variation" — can be interpreted as the amount of money that the government would have to pay consumers in order to compensate them for the fact that a good or service is not available. The "compensating variation" is part of a branch of economics (consumer theory) that has well-established methods for translating the relatively abstract economic concepts such as "utility" or "welfare" into well-defined "money metric" terms. The development of econometric models of consumer demand has helped economists to estimate relationships between price and the demand for a good or service, and thus estimate the price at which demand for this service vanishes. This "zero demand" price can also be used to gauge the effect of a policy that causes the good to be unavailable. The loss in consumers' well-being from such a policy is equivalent to the loss in well-being from a price increase that raises the price of the good to the point where demand for the good is zero.

4.5 It should be noted that welfare measures such as the compensating variation and the closely related concepts of the equivalent variation and the consumer surplus are not included in measures of GDP or national income.

Applications in the telecommunications sector

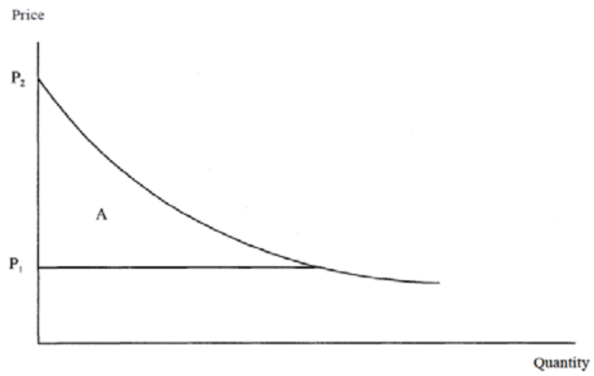
4.6 The concept of the compensating variation has been utilised to place a valuation on the introduction of new goods and services in the telecommunications sector. Most notably, the compensating variation has been utilised to estimate the welfare gains to US consumers from the introduction of voice messaging services in the late 1980s and early 1990s, and from the introduction of cellular mobile telephony in the same time period. Hausman (1997, 2002) has used the compensating variation as a basis for calculating both the value to consumers of the new services in question and the costs of regulatory policies that seriously delayed the introduction of these new services.

4.7 Hausman's methods for calculating the compensating variation provide two alternative means for calculating the welfare gain from the introduction of a new service. First, Hausman describes an approximate approach to computing the compensating variation, under which $CV \approx 0.5 \frac{P_1 Q_1}{\alpha}$, where the numerator is the revenues generated by the new product, and the denominator is the own-price elasticity of demand for that product. Second, Hausman describes an "exact" method for calculating the compensating variation using a specific functional form for the demand curve, and accounting not just for price elasticity, but also income elasticity. The "exact" method that Hausman describes tends to produce higher estimates of the consumer welfare gain than the "approximate" method, and we do not use this method in our subsequent calculations.

4.8 Figure 6 provides a diagrammatic representation of the consumer welfare gain. Here, P_2 represents the "virtual" price at which demand for the new good or service is zero, and P_1 is the price at which it is actually sold. The area marked A under the demand curve is the consumer welfare gain. We rely on a linear approximation to this welfare gain. Using the "approximate" approach described above, it is not necessary to separately calculate the virtual price at which demand is zero. Rather, we only require information about current revenues and elasticity to estimate the consumer welfare gain.[14]

[14] When we discuss "price" in this document, we are generally referring to an "all-in" price: that is, a price that reflects both the costs of subscription and usage, as well as annualised handset costs.

Figure 6: Consumer welfare gain from a new good (from Hausman(1997))[15]



Calculations for Thailand

4.9 We present a calculation of the consumer welfare gains that might reasonably expected from consumer uptake of 3G/HSPA+ services in Thailand. This requires projecting likely revenues from such services over the next five years, and employing a suitable range of elasticity measures.

4.10 There is likely no “perfect” or precisely correct evidence that can guide us in quantifying the uptake of 3G, and the likely revenue streams from 3G. Therefore, we have relied upon a variety of evidence including:

- Precedents for adoption of previous waves of mobile technology in both developed and developing markets;
- Existing forecasts made regarding 3G subscribership levels, along with sensible assumptions regarding Average Revenue per User (ARPU);
- Statements from analysts and industry sources regarding potential uptake levels of 3G services.

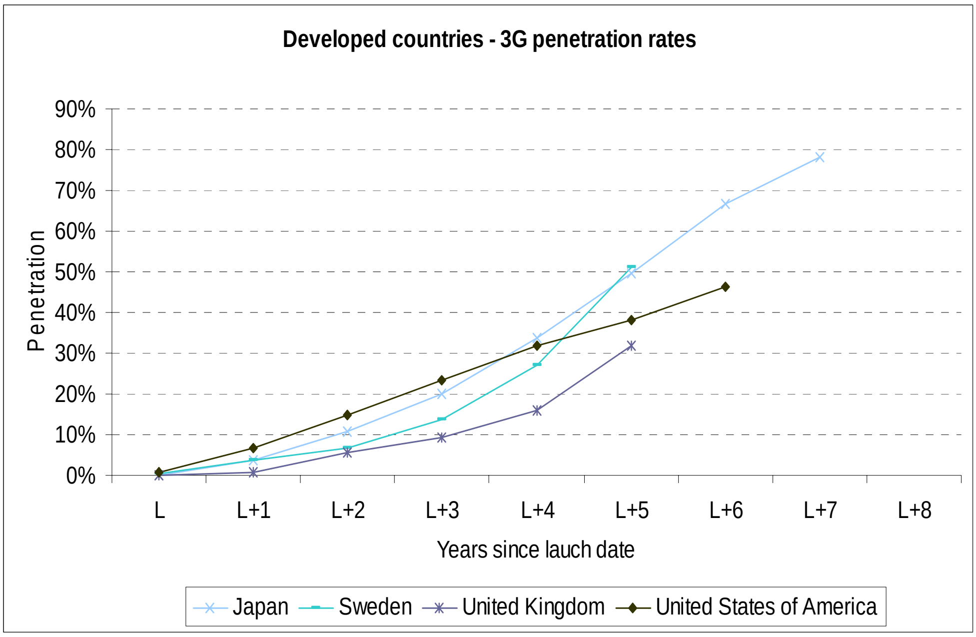
Evidence from 3G adoption in other markets

4.11 It may be instructive to examine the diffusion of WCDMA/UMTS (the original 3G standard) and its successor technologies in developed markets. The evidence shows that even the initial technology deployed delivered much lower speeds than fixed-line networks, and even though network costs were higher, network expansion slower and hence network coverage much patchier, sales of WCDMA handsets actually outstripped the sales of GSM/2G handsets at a similar stage of

[15] See Hausman, Jerry A., “Valuing the Effect of Regulation on New Services”, Brookings Papers on Economic Activity: Microeconomics, 1997, and “Mobile Telephone”, Chapter 13 in *Handbook of*

their evolution. Figure 7 shows the penetration rates (i.e., connections per 100 inhabitants) achieved by WCDMA within 5 years of its launch in some key developed markets.

Figure 7: Adoption rates for 3G[16] in key mature markets



Source: LECG analysis, based upon data gathered from Wireless Intelligence.

4.12 In most of these markets, 3G penetration reached between 30% and 80% within about five years of launch. While it is unrealistic to expect that – given differences in purchasing power and the expectation that 3G handsets will (in relation to average incomes) remain relatively expensive for many Thai consumers — Figure 7 amply demonstrates that the notion (now receding) that 3G technology was not enthusiastically embraced in developed markets is an incorrect one.

4.13 In the case of Thailand, ARPU (revenue per customer) is only about $7 per month on average. Only about 10% of subscriptions are post-paid subscriptions, although ARPU per post-paid subscriber is over $20 (as reported by Wireless Intelligence as of Q3 2008). Against this, it should be remembered that the "3G" technology likely to be deployed in Thailand in 2010 is far more advanced than the 3G technology deployed in the UK (for example) in 2003. This is the case

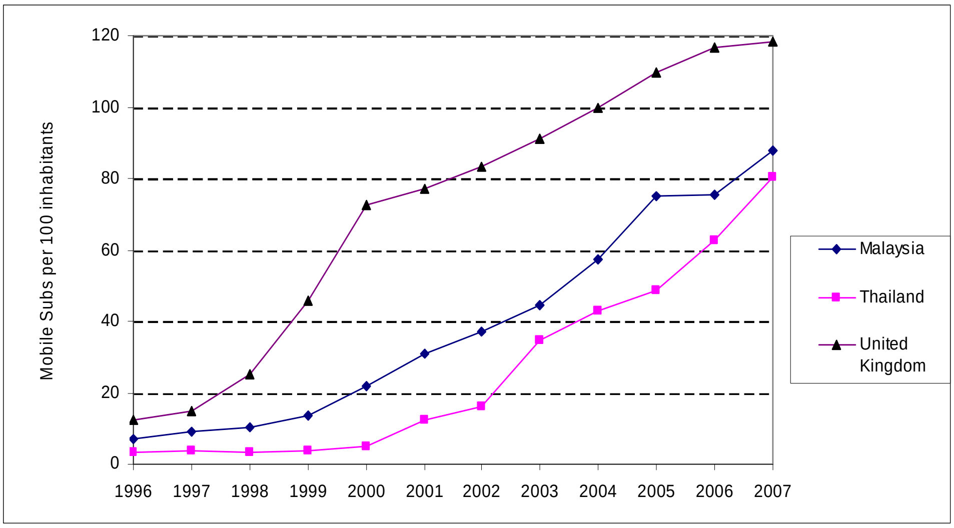
Telecommunications Economics, edited by M.E.Cave, et al., (2002: Elsevier Publishers, Amsterdam).
[16] Note: 3G here is defined as WCDMA/UMTS or CDMA-2000 and CDMA-2000 (EVDO) technologies. It does not include EDGE or GPRS.

when viewed through the lens of both download speeds and of handsets capability. There is a significant vacuum in the Thai Internet access market which did not exist in the developed markets whose experience is depicted in Figure 7. Further, there is a much wider range of complementary content, supporting services and features available for 3G telecom services in 2010 than there was in 2003. Thai network operators have the benefit of being able to tap into the experience of other operators around the world. To the extent that network effects in terms of technology transfer and transmission of know-how apply at a global level, then Thailand stands to benefit from these effects.

Evidence from the experience of Thailand

4.14 The experience of Thailand and other emerging markets in terms of adoption of 2G mobile services is also informative. Once the fall-out from the Asian economic crisis of the late 1990s was resolved, the Thai market witnessed significant entry and expansion, leading to explosive subscriber growth between 2001 and 2006.

Figure 8: Mobile subscriber growth, Thailand, UK, and Malaysia



Source: ITU World Telecommunications Indicators Database 2008.

4.15 It should be remembered that throughout this period of explosive growth, the Thai mobile market still exhibited a number of peculiar features that while perhaps understandable in Thailand's economic and political context were not optimal from the perspective of fostering competition and investment in the mobile/wireless sector. For example, private cellular operators continue to operate under the "Build-Operate-Transfer" (BOT) regime, characterised by frequent disputes with respect to network access charges and revenue-sharing arrangements. If 3G services are rolled-out following a spectrum licensing process that allows private operators to own spectrum and to free themselves from the BTO regime, this would eliminate a significant source of uncertainty and foster greater investment and competition in the 3G arena from the commencement of such services.

4.16 Thus while it is true that there are many reasons — ranging from user skills to constraints on international bandwidth to equipment costs – to believe that 3G penetration in the near-term will not reach 40% to 50% of the population (as 2G penetration did by 2005), the experience of deployment of 2G services suggests that especially if fully competitive conditions are established, then a new technology that exploits a niche in the market can diffuse very quickly.

Forecasts

4.17 Available forecasts from BMI (which provides relatively detailed coverage of the Thai telecommunications market) suggest that 3G subscriber levels could reach about 8.5 million subscribers by 2013, or around 9% of the market. Forecasts made by BMI in 2006 — on the assumption that licenses would be granted in 2007 — demonstrated similar expectations about diffusion,

Table 3: BMI Forecasts 2009 and 2006

2009 Forecasts		**2009**	**2010**	**2011**	**2012**	**2013**
	Subscribers (Millions)	1400	3800	6200	7904	8465
	As % of Total	2	4.9	7.24	8.55	8.66
2006 Forecasts		**2007**	**2008**	**2009**	**2010**	
	Subscribers (Millions)	900	2100	4100	5535	
	As % of Total	2.1	4.2	7.6	9.5	

Source: BMI reports, 2006 and 2009.

4.18 Forecasts made by operators in other emerging markets appear markedly more optimistic than these forecasts. For example, in China some operator were forecasting that about **30%** of *existing subscribers* would have adopted 3G services by 2013.

4.19 Additionally, and perhaps quite relevant to assessing potential uptake in Thailand, Wireless Intelligence forecasts that HSPA take-up in Indonesia would reach 5.3 million subscribers in 2010, some 2.5 years after the launch of such services, representing about 5% of overall connections.[17] Given that Thailand in 2009 has higher income levels than Indonesia, and a more mature and sophisticated mobile market than Indonesia did in end-2007, one would expect that Thai penetration rates for 3G/HSPA services would be significantly higher than Indonesia's penetration rates. [18]

Adopted assumptions

4.20 Taking all the myriad factors discussed above into account, and acknowledging that there is no real science to developing such forecasts, we adopt an assumption that if 3G services are rolled out in 2010[19], by 2014, the penetration rate of such services would have reached between 10 (low-end) and 20 (high-end) subscribers per 100 population.

4.21 We also adopt an assumption that revenue per subscriber attributable to 3G services could be between $200- $300 per year (including some annualised attribution for handset expenditure) in inflation-adjusted terms.

4.22 Based on existing estimates of own-price elasticity for mobile services, we assume a range of elasticity between -0.5 and -1.0. It may be the case that price elasticity for 3G services in markets such as Thailand could be higher than this range, but reliable indications of this are simply unavailable. This elasticity would account for sensitivity to both the price of access and the price of calls.

4.23 Table 4 indicates the subscriber and revenue projections in each case. The implications of these forecasts is that by 2014, the revenues from 3G services are in a range from about $1.26 billion per annum to $3.78 billion per annum. (In real terms).

[17] Source: Presentation of Ricardo Tavares to NTC Thailand, April 2008.
[18] At PPP exchange rates, the Thai per capita GDP is about twice the Indonesian level.
[19] Note that some 3G services are already being offered in Thailand, but in the absence of full-fledged commitment to 3G investment, the service rollout is limited. We believe that a successful spectrum license will create a competitive environment leading to more aggressive rollout and lower prices. Also note that while some existing networks support EDGE and GPRS, we do not regard these as either 3G services, or capable of supporting the type of mobile broadband services that 3G/HSPA can support.

Table 4: 3G subscribers and related revenues using adopted assumptions

		2010	2011	2012	2013	2014
Low-end forecast [20]	Penetration	3%	5%	7%	9%	10%
	Subscribers (000s)	1890	3150	4410	5670	6300
	Revenue (ARPU = $200) ($ 000)	378,000	630,000	882,000	1,134,000	1,260,000
	Revenue (ARPU = $300) ($000)	567,000	945,000	1,323,000	1,701,000	1,890,000
High-end forecast	Penetration	3%	7%	11%	15%	20%
	Subscribers (000s)	1890	4410	6930	9450	12600
	Revenue (ARPU = $200) ($ 000)	378,000	882,000	1,386,000	1,890,000	2,520,000
	Revenue (ARPU = $300) ($000)	567,000	1,323,000	2,079,000	2,835,000	3,780,000

4.24 Table 5 shows the various calculations of consumer benefit that can be derived from the combinations of the elasticity, ARPU and subscribership assumptions made above.

[20] The terms “low end” and “high end” refer, respectively, to the scenarios in which the adoption rate of 3G/HSPA reaches 10% by 2014, or 20% by 2014.

Table 5: Consumer benefit calculations under different scenarios

Consumer benefit calculations under various scenarios ($000s)							
Forecast	Revenue	*Elasticity*	2010	2011	2012	2013	2014
Low-end	ARPU = $200	*0.5*	378,000	630,000	882,000	1,134,000	1,260,000
Low-end	ARPU = $300	*0.5*	567,000	945,000	1,323,000	1,701,000	1,890,000
Low-end	ARPU = $200	*1*	189,000	315,000	441,000	567,000	630,000
Low-end	ARPU = $300	*1*	283,500	472,500	661,500	850,500	945,000
High-end	ARPU = $200	*0.5*	378,000	882,000	1,386,000	1,890,000	2,520,000
High-end	ARPU = $300	*0.5*	567,000	1,323,000	2,079,000	2,835,000	3,780,000
High-end	ARPU = $200	*1*	189,000	441,000	693,000	945,000	1,260,000
High-end	ARPU =$300	*1*	283,500	661,500	1,039,500	1,417,500	1,890,000

4.25 The calculated annual consumer benefit in 2014 ranges from $630 million in 2014 to $3.78 billion. The larger point here is that the consumer benefit is substantial and probably likely to be close to or above $1 billion per annum by 2014. The average of the various scenarios is $1.77 billion.

4.26 Another way to consider the consumer benefits is via a **net present value** calculation of the cumulative benefit between 2010 and 2014. Using a discount rate of 5%[21], one can show that the NPV of the consumer benefit ranges from $1.8 billion to $8.8 billion. Thus the overall conclusion is that the cumulative benefit during 2010-2014 to consumers from deploying 3G networks is likely to significantly exceed $1 billion. This is true even if very conservative assumptions are used.

4.27 We next turn to another way to evaluate the societal benefits of the proposed deployment of advanced mobile networks. This is the "total economic return" calculation, based upon an investment multiplier derived from previous economic literature of the social value of investment in telecoms infrastructure.

[21] This is about the "social" discount rate appropriate for valuing the public or societal benefits of a project , as suggested by the *HM Treasury Green Book* used in the United Kingdom.

5 Total economic return calculations and the "investment multiplier"

Background and discussion

5.1 It is widely agreed that investment in telecommunications infrastructure has widespread societal benefits. Empirical evidence for the "spill-over" effects of such investment into the wider economy is now ample. Greenstein and Spiller (1996)[22] found significant evidence that the diffusion of advanced telecommunications networks helped in advancing economic activity in services. The paper by Roeller and Waverman (2001)[23] examined the effect of the diffusion of fixed-line telecommunications infrastructure on GDP in the OECD area, and concluded that a significant portion of the growth in GDP between 1970 and 1990 could be attributed, directly and indirectly, to the expansion of fixed-line telecommunications. Other papers, at a macro-economic and micro-economic level, have also found a significant effect of connectivity on GDP, enterprise productivity and even on social attitudes and attitudes to economic participation among women in rural areas of the emerging world.

Benefits derived from telecoms investment

5.2 There are likely to be both significant **static and dynamic effects** of investment in telecommunications infrastructure. The static effects refer to:

- The job-creation and the expanded output (GDP) in the sector (telecommunications) in which the investment is made in the first place;
- The "indirect" effects on the aggregate economy created by the increased purchases by the telecommunications sectors from other sectors. This is the familiar "multiplier" or "ripple" effect that increases final expenditure in the aggregate economy.

The dynamic effects of increased telecommunications investment are perhaps the more interesting ones. Such effects include:

[22] Greenstein, Shane and Pablo T. Spiller, "Modern Telecommunications Infrastructure and Economic Activity: An Empirical Investigation", *Industrial and Corporate Change*, December 1995, pp.647-665.

[23] Roeller, Lars-Hendrik, and Leonard Waverman, "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach", *American Economic Review,* September 2001, pp.909-923.

- Increased productivity and cost-savings in sectors that use more telecommunications. In the developing world, this has substantially occurred because of mobile telecommunications networks. For example, Jensen (2007)[24] found that introduction and usage of mobile telecommunications service in a fishing region of Kerala (India) helped to entirely eliminate wasteful dumping of fish, increased fishermen's profits and reduced the average price of fish to consumers. Jensen's study provides dramatic, systematic (as opposed to anecdotal) evidence of the way in which telecommunications and ICT infrastructure help to reduce transaction costs, and improve the allocation of resources in an economy;

- Creation of services and content that would not have existed without the telecommunications investment. For instance, many now-familiar applications ranging from Adobe's Flash Player to mobile gaming software in Japan and Korea have been developed on the back of the spread of fixed and mobile broadband networks;

- Potential social benefits such as reduction of travel time, resulting in environmental savings (although a rigorous quantification of the net effect of telecommunications and the Internet on the environment has thus far proved elusive);

- Intangible benefits such as improved aspiration and mobility within societies as a result of the awareness that is created by greater connectivity. Jensen and Oster (2007)[25] found that the availability of cable television in rural India encouraged both more assertive attitudes among rural women in terms of social behaviours, and also encouraged greater autonomy in terms of women making important decisions regarding their households and even with regard to child-bearing. Their suggestion is that greater access to television and information helps to reduce social practices such as gender selection and restriction of female economic activity that could carry adverse economic consequences. Interestingly, Jensen and Oster find that the effect of greater information

[24] Jensen, Robert, "The Digital Provide: Information (Technology), Market Performance and Welfare in the South Indian Fisheries Sector", *Quarterly Journal of Economics*, August 2007, pp.879-924.
[25] Jensen, Robert and Emily Oster, "The Power of TV: Television and Women's Status in India", NBER Working Paper No.13305, August 2007.

availability on social attitudes and behaviours was remarkably rapid in India.

5.3 In the case of a country like Thailand, if the main impact of investment in advanced mobile networks is to expand the access and availability of broadband one can expect effects that are broadly similar to those described above.

5.4 Some particular opportunities that might arise in Thailand include:

- **Creation of local content and software that is encouraged by increasing adoption of broadband networks.** Mobile broadband networks may prove instrumental in propelling Thailand towards achieving a critical mass of broadband subscribers. This in turns creates the scale effects that enable significant development of ancillary content and applications. A powerful example of this comes from Thailand itself. As early as 2003, a multi-player online game called Ragnarok had as many as 700,000 players in Thailand.[26] While the availability of content such as online gaming is a spur for broadband adoption, the availability of broadband is in turn a spur for the further development of such content and software. The great success of Japan in developing an online content and services market based largely on mobile platforms is another encouraging example in this regard;

- **Fostering enterprise connectivity.** Currently, Thai enterprises are less likely to have Internet access than their counterparts in China, for instance, but more likely to have a web presence. This suggests that Thai businesses are (at least relatively) more willing to embrace the Internet than their rivals elsewhere, but because of supply-side factors, actual Internet connectivity is somewhat inadequate. If Smartphone prices continue to decline in line with their historical trend, then these devices could play an important role in fostering small business connectivity in particular. Indeed, there is some evidence that leading players in the handset space such as Qualcomm are now focussed on opportunities in emerging Asia (as discussed previously).

We next turn to a discussion of the "total economic return" methodology, and then to its implementation in the case of Thailand.

Total economic return methodology

Basic concept

5.5 The basic concept behind the “total economic return” multiplier is that an increase in the availability of valuable telecommunications infrastructure has a long-lasting impact on economic productivity and growth. For example, adding a telephone line or a broadband line might require an investment of $1000, but this investment generates a flow of economic benefits for a long time period.

Total economic return

5.6 The “Total Economic Return” from an investment project can be described as the Net Present Value (NPV) of the benefits that the project generates for society over its useful economic life.

5.7 Consider for example a telecommunications firm that invests money to provide broadband service to an additional customer. The firm may have to spend money on electronics at the central office and at the customer premises, and on labour to dig a path and physically connect the customer. These expenditures on labour and capital inputs have an immediately stimulating effect on the economy. For example, the firm from whom the telecoms firm purchases its inputs might in turn purchase a higher volume of inputs from its own suppliers, or hire more labour. Thus there is a **direct effect** of the telecom firm’s higher expenditure on the economy.

5.8 Longer term, the additional broadband line may help the customer work from home, shop online, access emails, and participate in many other economic activities. Thus there is a “indirect” effect on productivity and output. Some of this indirect effect may be in the form of higher profits to the firm (which are part of GDP) that invested in the telecom asset; other parts of this indirect effect may include higher productivity or output in the online commerce sector, for instance, which is realised over many years.

5.9 The total economic return is the sum of all benefits, private and public, direct and indirect. To the extent that these benefits are not realised immediately, but in the future, there is a need to evaluate the sum as a sum of all the discounted benefit flows (similar to discounted cash flows). The “total economic return” expressed in NPV terms has the following interpretation: it is the lump sum that society should

[26] http://yaleglobal.yale.edu/content/broadband-driven-online-games

expect today in lieu of the stream of present and future benefits generated by the project under consideration. Thus when we say that the “NPV of the GDP gains” from an investment is $X, what we are really saying is that all current and future increases in GDP have a benefit equivalent to $X earned today.

Social rate of return and the total economic return

5.10 The social or “total economic rate of return” from a particular asset is defined as the annual return on $1 invested in an asset. Consider, for example, $1 invested in a switch that costs $1 and has an infinite life (no wear and tear). Suppose that as a result of investing in the switch, society realises an annual benefit of 30 cents every year. That is, society is richer every year by 30 cents as a result of this investment in switching equipment.

5.11 Thus the social rate of return or “total economic rate of return” (including depreciation) on the switch is 30% per annum.

5.12 The total economic return from the switch can be evaluated as the NPV of all the annual income increments of 30 cents that the switching equipment “returns” to society. However, in order to establish the NPV, one needs to consider the appropriate rate at which these future benefit flows should be calculated.

Discount rate

5.13 The discount rate that is appropriate to use is the cost of capital that is faced by the firm making the investment in the switching equipment. This is because the cost of capital measures the return that the project must earn taking into account the fact that by investing in the project the investors in the firm have foregone the opportunity to invest in other activities. In order to compute a Net Present Value, this is the appropriate opportunity cost to be considering.

Derivation of the “total economic return” multiplier

5.14 The total economic return is the NPV of all future benefit streams, discounted using the firm’s cost of capital. In practice, it can be shown that the total economic return on an investment project is simply m times I, where m is a multiplier and I is the NPV of the investment in the project (that is, the present value of all current and future planned investment). The multiplier, m, can be shown to be simply the ratio of the social rate of return, s, and the private cost of capital r, although if the asset does not have an infinite life, the total economic return has to be adjusted downwards.

Figure 9: Total economic return multiplier

Total economic return: net flow per period : $R_t = s.I$

Where: I = NPV of investment cash flows.

Total economic return: net present value (stock): $R = \int sI_{.} e^{-rt} .dt$

For large N, the total economic return equals approximately I (s/r) = I.m, where the total economic return multiplier m = (s/r).

For small N the adjusted total economic return multiplier m_N is used.

$$\int_0^N sI_{t\,.} e^{-rt} .dt = I(s/r).[-e^{-rt}]_0^N = I(\rho/r).(1-e^{-rN})$$
$$= I(s/r).\ m_N$$

Where: $m_N = 1-e^{-rN}$

,

Total economic return = I (s/r) for N = ∞
= I(s/r).(0.86) for N = 20; r = 10%
= I(s/r).(0.78) for N = 15; r = 10%
= I(s/r).(0.63) for N = 10; r = 10%

Evidence on the social returns to telecom investment

5.15 Perhaps the most useable evidence on the social rate of return from telecommunications investment can be derived from the econometric study of Roeller and Waverman. Roeller and Waverman's evidence generally suggests that the social rate of return on telecommunications investment is in the range of 30% to 60%. These social rates of return can be calculated based on the relationship that they obtain between an increase in telecommunications penetration and GDP. In their study, telecommunications penetration is the measure of the useful telecommunications capital stock in a country.

5.16 By then estimating the increased investment required to finance an increase in telecommunications penetration, one can estimate the additional GDP obtained from an additional dollar invested in a telecommunications network. In this case, the less costly the increase in telecommunications penetration, the higher is the social rate of return on the investment, and the higher is the "total economic return" multiplier described above. For example, the total economic return is higher in the situation where an additional telephone line costs $500 to finance than in the situation where it costs $1000. The key insight from the Roeller-Waverman paper is that the social returns from telecom investment are well above the private cost of capital, so even projects that are not privately profitable may be worthwhile from a social perspective. Thus from a social perspective, the arguments frequently made by investment analysts that the "business case" for 3G does not exist are not especially relevant.

Other evidence of high returns to valuable infrastructure

5.17 Similarly, there is a large literature on the returns from investment in other valuable infrastructure, which also demonstrates that social returns from infrastructure investment often justify projects that are financially loss-making.

5.18 For example, ISPA (Instrument for Structural Policies for Pre-Accession) was one of the three European Union financial instruments (with Phare and Sapard) used to assist the candidate countries in the preparation for accession. An analysis of 58 ISPA infrastructure projects indicated an average financial rate of return (FRR) of negative 2.52 % (not including ISPA funding). The average Economic Rate of Return (ERR) was 13.04 % but the maximum ERR was 50 %[27] With reference to the low average FRR, the author states: "This is not surprising, because these infrastructures typically have low commercial returns and for this reason ask a capital subsidy to the European Commission."[28] These results indicate a very large difference between financial and economic returns and that the Commission considers the economic and social benefits sufficiently valuable to offset the financial losses that result from these projects.

5.19 There is also some evidence from investment in R&D and scientific investment demonstrating the existence of very high social returns to such investment (well above the private returns).

5.20 A study by Bernstein and Mohnen, for instance, concluded: "International R&D spill-overs directly contribute to productivity growth in both countries. International spill-overs from the U.S. account for about 60% of Japanese productivity growth. The contribution from Japan to the U.S. is smaller, but nevertheless not inconsequential, as the magnitude is 20%. The existence of international spill-overs imply that social rate of return to R&D capital exceed private returns. We estimated that the private rates of return to R&D capital are around 17% in both countries, while the social returns are three and a half to four times greater than the private return."[29]

5.21 Another study by Bernstein and Nadiri found social rate of return figures for R&D capital mainly in a range of 20%-45%, depending on sector, with some high technology sectors such as Scientific Instruments having rate of return of over 100%. These rates seem to have been relatively constant over the period of their study, 1965-85.[30]

Applicability of literature to 3G investment in emerging economies

5.22 While the estimates of social rates of return of between 30% and 60% derived from the Roeller-Waverman study may seem high, they are consistent with social returns estimated for other types of valuable investments. The key question is whether it is reasonable to expect similar social rates of return to investment in 3G mobile networks in emerging economies?

5.23 The following factors would lead us to answer the question in the affirmative:

- The key role of 3G networks in providing and extending broadband access in emerging markets where there is significant latent demand for broadband services that cannot be met by fixed-line investment;
- The development of a particularly mobile-phone centric culture in Asia, where there has been a remarkably strong development of mobile content in countries such as Japan and Korea. In the region's less developed economies, the much higher diffusion of mobile telephones compared to personal computers suggests that there is significant potential for aspects of the Japanese and Korean experience to be replicated elsewhere in Asia;
- The relatively low cost and scale-ability of mobile networks compared to their fixed line counterparts.

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[27] Massimo Florio, Vignetti, Silvia, "Cost-benefit analysis of infrastructure projects in an enlarged European Union: an incentive-oriented approach", dated May 2003, Working Paper n. 13.2003 – giugno (L52.1.1).

[28] Massimo Florio, Vignetti, Silvia, "Cost-benefit analysis of infrastructure projects in an enlarged European Union: an incentive-oriented approach", dated May 2003, Working Paper n. 13.2003 – giugno (L52.1.1), p16.

[29] Bernstein,J.I. & Mohnen, P. (1994), 'International R&D Spillovers Between U.S. and Japanese R&D intensive Sectors',

[30] Bernstein, J.I. & Nadiri, M.I. (1991), 'Product Demand, Cost of Production, Spillovers, and the Social Rate of Return', NBER Working Paper No. 3625.

5.24 Thus the combination of these factors should ensure that investment in 3G networks has a major impact in significantly expanding both voice and broadband connectivity. Thus the social returns from such investment should resemble the returns from expanding fixed voice connectivity in the OECD in the 1970-1990 period. In order to be conservative, however, we use the **lower bound (30%)** of the social rates of return implied by Roeller and Waverman's study.[31]

Cost of capital and multipliers

5.25 We use a cost of capital of 10% as the discount rate in our calculations. This is about in line with the cost of capital for most international telecommunications firms. The implied multiplier with a 30% social rate of return and a 10% cost of capital is 3. We assume an asset life of 15 years, implying that the multiplier should be scaled down to **2.35** (approximately).

Application to Thailand

5.26 The first step in applying the "total economic return" methodology to estimating the economic returns from investment in advanced mobile networks in Thailand is to estimate the likely investment in such networks.

5.27 However, our assumption here is that the investment occurs under competitive circumstances, following a transparent spectrum auction. As of 2009, the Thai mobile industry faced considerable uncertainty in two areas: (a) the macro-economic environment, which made it difficult to attract sufficient finance and raised concerns about potential demand for new services, and (b) uncertainty surrounding the spectrum licensing process for 3G services. Over the past few months, however, economic confidence has begun to return to the Asia-Pacific region, and there have been indications that the Thai economy has now started on a recovery path.[32] Equally, it now appears likely that there will be a spectrum auction at the end of 2009, and that as part of this auction, operators will not have to enter into revenue-sharing arrangements with TOT and CAT, such as prevailed (contentiously) under the BTO.

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[31] The PSTN network was subsequently used for data services and DSL. However, Roeller and Waverman's study used data from 1970 to 1990, and thus is largely capturing the impact of increased voice connectivity. It could however be argued that certain "complementary" factors such as education levels, the state of other infrastructure, the organisation of business and government activity, etc could serve to reduce the extent to which developing societies can exploit technology.

[32] http://enews.mcot.net/view.php?id=11661

5.28 Thus, in this present exercise, we assume that investment by **all network operators** in 3G services will total $1 billion per year (in real terms) for a five-year period from 2010 to 2014. This amount appears consistent with reports earlier this year by Pyramid Research that total announced investment by Thai mobile operators in 3G in 2009 would amount to $1.2 billion (Source: *Pyramid Points*, March 6th, 2009. http://www.pyr.com/points/item/090306.htm). While economic shocks and regulatory uncertainty in 2009 led to significant reductions in the announced scale of 3G investment (e.g., by AIS), the economic and regulatory situations may offer a better investment environment in 2010. Additionally, as we explain in the concluding section of this report, regulatory reform via the vehicle of spectrum licensing could provide a boost to investment and competition.

5.29 Using a discount rate of 10%, and a multiplier of 2.35, the total economic return from a cumulative investment of $5 billion (which has a net present value of about $3.8 billion over five years in 3G networks, is calculated to be about $8.9 billion). It should be borne in mind that this is a Net Present Value—i.e., it represents the lump sum paid today that would have a value equal to the flow of economic benefits generated by investment in 3G networks over the useful economic life of the network assets. It does not mean that Thai GDP will increase by $8.9 billion instantly.[33]

Table 6: Calculation of total economic return using multiplier method

	2010	2011	2012	2013	2014
Cap-ex	$1,000	$1,000	$1,000	$1,000	$1,000
Discount rate	10%				
NPV of investment	$3,791				
Multiplier	2.35				
Total Economic Return	$8,908				

Note: All monetary amounts are in millions of US dollars.

5.30 The exact calculation aside, the basic message is simple. The returns to Thailand from investment in advanced mobile networks are likely to be quite

[33] One objection that might be raised to this methodology is that it suggests more investment is inevitably good, without taking into account the fact that different projects yield different social returns. However, the social rate of return that was derived from the econometric estimates of Roeller and Waverman is essentially a calculation of a marginal product of an additional telecom line in a Cobb-Douglas production function framework. It can be shown (further details in Appendix 1) that the social rate of return is higher when marginal cost per additional line is lower — thus the methodology rewards "efficient" investment. In any case, we assume that the social rate of return captures an "average" social return across telecom investment projects, and then assume that the social returns from 3G investment might be reasonably similar.

large. This is particularly true because the proposed networks support HSPA technology, offering download speeds that are likely to be competitive with the insufficient fixed-line broadband offerings in the Thai market. There is almost certainly pent-up demand for broadband services in Thailand, which can be met (at least partially) via mobile broadband deployments and usage. The development of mobile broadband will play a crucial role in narrowing the "digital divide" in broadband between developed nations and nations like Thailand. Mobile broadband may play an important role in fostering the development of broadband-related content and applications, in increasing enterprise connectivity and enabling greater mobility across Thailand.

5.31 In the next section, we show that just as timely deployment of mobile broadband carries significant economic benefits (whether expressed in terms of consumer benefit or in terms of total economic return), delays in deployment of networks can deprive consumers and the wider economy of a significant portion of these benefits. Thus regulators should ensure that regulatory policy does not hold up the introduction of new goods or services. This is particularly the case for services such as mobile broadband where the "good" has already been introduced in many other nations, and where there is already a large global installed base of users.

6 The societal cost of delays in deployment

6.1 In this section, we show the societal costs that have already been incurred as a result of the fact that for various reasons Thailand has not licensed 3G spectrum. It was initially anticipated that spectrum licensing for 3G would occur in 2006/07, and that the first network deployments would happen in 2007. As of August 2006, forecasters were predicting that by 2010, nearly 10% of Thai mobile subscribers would be using 3G services.[34]

6.2 In the event, 3G services are unlikely to be deployed in Thailand until 2010. It might be argued that the 3G services being brought to market in 2010 are better than those that might have been brought to market in 2007. This is unquestionably true when one looks at quality and price for handsets, and when one looks at network data-handling capabilities. At the same time, 3G technologies were already fairly mature in 2007; there was already a significant global installed user base. Thus while 3G services launched in 2007 would have had a smaller market than those that will be launched in 2010, this still means that consumers and enterprises that could have made use of the types of services and functionalities that 3G technology facilitates were deprived of the welfare that they might otherwise have gained from using the services. Further, it should be remembered that the delay in introducing services in Thailand is not related to the fact that the underlying technology has progressed in the 3 years since. The users who started using the technology in 2007 would still have been able to avail of the improvements in networks and handsets that has happened between 2007 and 2010. Indeed, some business users might already have started developing service offerings that could have, and would have, evolved as network capabilities improved. Particularly in sectors such as content and software development, such businesses must now compete with foreign competitors who have developed more experience and are farther down the “learning curve” in terms of their understanding of the technology, consumer tastes and appropriate business models.

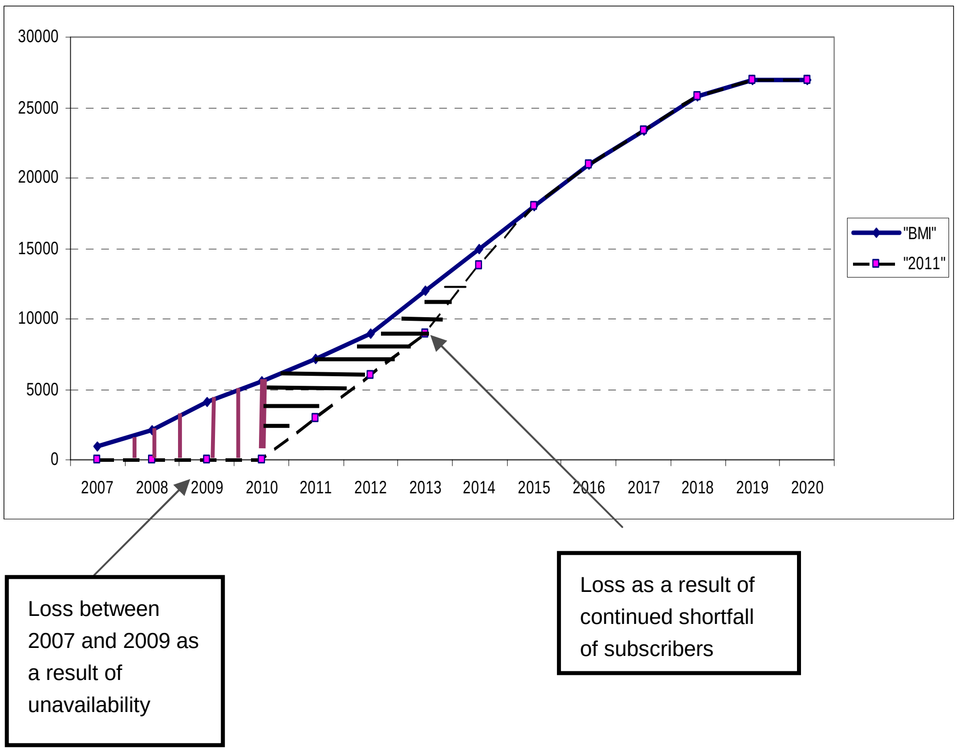
6.3 We first present the implications of the delay in adoption in Thailand in terms of lost consumer benefit. This “lost consumer benefit” has two dimensions to it: (a) the benefit foregone between 2007-2009 by consumers who would have used the

[34] Source: BMI Forecast, obtained from ITU Regulatory News-log, August 23rd,2006.

service at that time, but were unable to because of its general unavailability, and (b) the fact that under the “delayed adoption” scenario penetration might be lower than it would have been had services been launched in 2007 for a number of years after launch. For instance, penetration might already have reached 10% by 2010, had services been launched early in 2007.

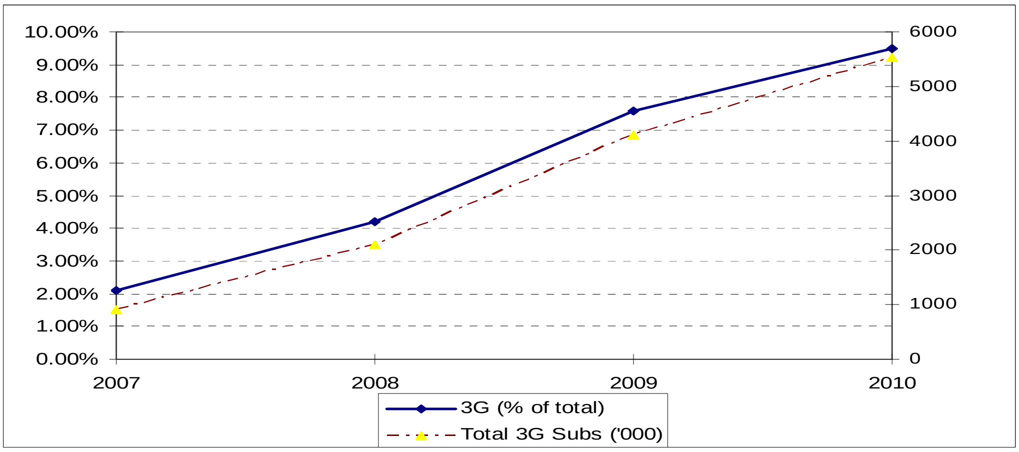
6.4 Figure 10 demonstrates (in a purely illustrative way) the consumer harm as a result of delayed adoption. The blue line above extrapolates from the subscriber forecasts being made by BMI as of 2006, while the dashed line below (that meets the blue line in 2015) is a hypothetical diffusion curve for a situation in which services are launched in 2010. The diagram illustrates the fact that the “harm” when considered in terms of aggregate consumer benefit persists even after the original problem of unavailability is resolved. Similar analytics can be applied when one thinks about the “total economic return” style of analysis.

Figure 10: Illustration of economic harm from delayed adoption



6.5 We next present a calculation of the cumulative surplus foregone by consumers in Thailand as a result of 3G services being substantially unavailable between 2007 and 2009. The calculation is based upon the 2006 forecasts of subscriber numbers made by BMI. The forecasts for subscriber numbers and the proportion of subscribers who switch over to 3G are presented in Figure 11 below.

Figure 11: Initial forecasts for 3G uptake in Thailand



6.6 We assume that in real terms ARPU per 3G subscriber would have been around $200 per year during this period. Table 7 below shows the calculations that in Net Present Value terms (assuming a social discount rate of 5%), the lost consumer benefit ranges from $630 million to $1.26 billion.

Table 7: Potential consumer benefit, 2007-2009 (000s of $)

			CV under varying elasticity assumptions		
	Subscribers	ARPU	*0.5*	*0.8*	*1*
2007	900	$200	$180,000	$112,500	$90,000
2008	2100	$200	$420,000	$262,500	$210,000
2009	4100	$200	$820,000	$512,500	$410,000
NPV			$1,260,728	$787,955	$630,364

6.7 While it is difficult to be determinative about subscriber numbers, revenue streams and elasticity, the overall conclusion that we can draw is that the potential consumer benefit that could have been gained from the introduction of 3G services in the 2007-2009 timeframe is very significant. Indeed, the calculations show that the value of the benefits foregone by Thai consumers and businesses as a result of not being able to access such services over the 2007-2009 is very likely over $500 million and quite likely in the region of $1 billion.

6.8 This estimate of consumer loss is, however, a lower bound. One could quite reasonably take account of the adoption dynamics depicted in Figure 10, and calculate the loss associated with having lower adoption (relative to the situation in which 3G services were introduced in 2007) for several years after the introduction of 3G services in 2010.

6.9 One can also use the perspective of the "total economic return" methodology to estimate the economic harm from not having had 3G services in place. This can be seen through a comparison of the total economic return from a given investment plan made in 2007, and the same investment plan implemented with a three-year delay. The economic loss is the difference in the total economic return (which is an NPV calculation) between the two scenarios. It can be shown that using the multiplier of 2.35 and the discount rate of 10%, the total economic return is reduced by over $2 billion. This is based on a comparison between a five-year investment programme with an annual investment outlay of $1 billion commencing in 2007, against a five-year investment programme with the same (real) outlay commencing in 2010.

Conclusion on delay

6.10 It may have been viable to introduce 3G services in Thailand in 2007. However, for many reasons, the actual introduction of services has been delayed significantly. This delay has been socially costly. Whether looked at through the lens of the consumer benefit calculation or through the total economic return calculation, the lost value to society from not having been able to use 3G services is likely to be in the region of $1 billion or perhaps even significantly above.

6.11 Over the relevant period, 2007-2009, 3G technology had already matured significantly. Operators in other nations were already implementing business models that took advantage of the capabilities of 3G networks, while handsets had evolved significantly since the early 2000s. During the same period, there was significant pent-up demand for broadband Internet in Thailand, which could at least partially have been sated by 3G services. Had 3G services been available over the period from 2007 to 2009, this might have permitted Thai operators, content developers and businesses to experiment with new ways of bringing services and products to consumers. This would have left them perhaps even better placed to take full advantage of continuing evolution in network and handset capabilities. Instead, it is quite likely that some of the innovation that may have happened in Thailand has instead happened in other Asian countries, which have a lead in using the technology and innovating along the 3G platform, a lead that could prove difficult to eradicate.

6.12 There may be some circumstances in which early adoption proves not to be a good thing. Most usually, this happens when a technology is in its early stage, and there is considerable rivalry between emerging standards and protocols. A good example of this is the home-video-recording industry in the mid-to-late 1970s, when there was a battle between the Betamax and VHS platforms for ascendancy in the market. Public policy that consciously pushed for adopting one or the other standard would have proved significantly misguided, as it could have resulted in being "locked in" with the "wrong" technology. This was clearly not the case with WCDMA/HSPA, especially given that the technological developments of the past 3-4 years are evolutionary ones.

6.13 Indeed, the United States provides an example of how unnecessary regulatory-imposed delays in allowing for commercialisation of a service can have significant long-term consequences. Cellular telephone service could have been introduced in the United States in the 1970s, before it was introduced in countries such as Japan and Sweden. However, Hausman (2000) argues that the Federal Communications Commission (FCC) unnecessarily held up the introduction of services until the mid-1980s, after they had already been introduced in other nations. It may well have been the case that had the United States introduced the technology in the 1970s, the country could have taken the lead in the cellular field. In reality, it was not until the very late 2000s that the US market came to be seen as being at the leading edge of mobile technology.

7 Some conclusions for regulatory policy

7.1 The mobile telephone industry in emerging markets in Asia, Africa and Latin America has achieved what the regulated, state-owned fixed-line sector never achieved. It has brought affordable telephony and even some data services to the mass of people in these countries. It has done so with much less regulation and with much less state guidance than the fixed-line industry. Economics has a term called "general purpose technology" (GPT) for technological innovations that affect entire economies and transform the way that business and life are conducted. Mobile telephony is the general purpose technology of the last two decades in most of the developing world.

7.2 In the developed world, broadband technology is the dominant GPT. Current innovation, whether it is innovation in the way businesses organise themselves, how they serve customers, or even innovation in the physical products that are brought to market, is substantially linked to the Internet and to broadband. However, to date, broadband in the developed world has been substantially driven by fixed technologies such as cable and ADSL. This is changing, however, and among late adopters in the developed world and for many consumers in the developing world, mobile networks are likely to play a major role in closing the broadband gap. Given the potential importance of mobile broadband in facilitating innovation and economic growth, public policy in a nation like Thailand has a significant interest in ensuring that there are minimal impediments placed in the path of investment in advanced mobile networks in Thailand.

7.3 While we think that the appropriate regulatory framework should place maximum reliance on market forces, regulation and public policy do have an important role to play in setting the rules of the game. In the mobile world, the most basic requirement of regulation is to allocate spectrum property rights in the most economically efficient manner.

7.4 There is a near-consensus among economists (if not always among industry participants) that the most efficient and transparent method of allocating spectrum is via an auction process. While there have been criticisms of some auctions (e.g., the UK 3G auction in 2000) for various reasons related to the design of those auctions, one assumes and hopes that the NTC and private firms will seek appropriate economic advice about how to structure the auction process and their own responses to it.

7.5 In the Thai context, the auction process offers the chance for operators such as DTAC to own their spectrum, and promises an end to the BOT regime that has thus far characterised competition in the Thai telecommunications industry. Under the BOT regime, revenue-sharing arrangements are a potential source of contention between operators and their state-owned "host." The combination of uncertainty around the political situation in Thailand, the timing and nature of the spectrum auction process, and the uncertainties and disputes around the revenue-sharing issue can all be argued to have had at least a somewhat negative impact on incentives to invest in new networks.

7.6 To appreciate this further consider the significant commercial risks that are faced by an investor in telecommunications networks. These networks are characterised by a high degree of "sunk" resources— most of the physical assets in the network are useful only in the context in which they are deployed. The cost of investing in these assets is a sunk cost, because the assets have primary economic value only if the network is operational. Thus the telecommunications business is not one where it is possible for firms to easily mitigate their risks. In the language of economics, exit from this business is not costly. To commit to large sunk investments, potential investors must either expect a very high return on investment or sufficient certainty around the ability to recover on sunk costs.

7.7 In a “normal” market situation firms that have successfully bid for spectrum have significant freedom in terms of how they own and operate that spectrum. The BOT system, however, brings bringing many additional parties to the table (the “host operator” and the Thai government) – this raises significant uncertainties related to the allocation of risks and returns between different parties, disputes between parties, and the possibility of opportunistic behaviour by one or more of the parties. BOT schemes are common in sectors such as transportation, which is a sector in which the government remains a primary investor, and financing costs are very high. In those sectors, BOT offers a way to reduce financing costs and perhaps to achieve greater operational efficiencies. However, in mobile telecommunications, despite the significant risks we discussed above, the industry has been propelled by private-sector firms, and complex arrangements such as BOT are probably unnecessary and may well serve to reduce incentives to invest and innovate.

7.8 The spectrum licensing that is currently under discussion in Thailand thus offers a significant opportunity to resolve uncertainty and to effectively “restructure” the industry along more market-oriented and competitive lines. Particularly in the medium and long-term, the social benefit of implementing a successful transparent spectrum auction in a timely way is very significant. Conversely, the lost social benefit from further delays and failures to resolve uncertainty can also be significant.

8 Appendix 1: Derivation of total economic return methodology

This appendix describes the estimation of the numerical value of the total economic rate of return for telecommunications infrastructure investments derived from empirical results reported in the economic literature of the impact of telecommunications infrastructure investments. On the basis of that literature, we estimate a total economic rate of return in the range of 30-60% for telecommunications investment.

Roeller-Waverman

The leading, state-of-the art empirical article on the impact of telecom on GDP is still Röller and Waverman (2001), (hereafter 'RW').[35] We will first show how to back out an estimate of the total economic or public rate of return to a dollar invested in telecom (specifically, in main lines). This study pertained to mainline telecommunications deployment in the OECD in the 1970-1990 period, but provides significant evidence as to the range in which one can expect to find the average social return on telecommunications investment.

We compute a range of estimates, which depend on two things:

a) the value of the elasticity of GDP with respect to the telecom measure, as reported in the published empirical studies. (RW present estimates from specifications with and without country fixed effects, and with and without an interaction term that allows the effect to depend on the initial level of penetration.)

b) Cost per main line used for the calculation. We will use three alternative costs here: $1,000, $1,500 and $2,000, as representative of the range of costs per line observed internationally for telecommunications networks.

The RW study reports empirical estimates of the elasticity[36] of GDP to the telecom penetration rate. To convert this elasticity estimate to the required information (namely, the total economic rate of return), it is necessary to make some reasonable economic assumptions about the relationship between the

[35] Röller, Lars-Hendrik and Leonard Waverman (2001), 'Telecommunications Infrastructure and Economic Development: A Simultaneous Approach', *American Economic Review*, Sept 2001.

[36] Elasticity is a widely-used economic measure of the responsiveness of one variable (the endogenous variable) to changes in another variable (the exogenous variable). It is defined as the percentage change in the endogenous variable divided by the percentage change in the exogenous variable.

various variables of interest. In particular, we consider a Cobb Douglas (log linear) production function relating the level of GDP to the telecom penetration rate, P, and other variables, X:

$$(1) \qquad Q = P^{\alpha} X^{\beta}$$

The Cobb-Douglas production function is the most widely used approach in empirical studies, largely because of its flexibility and general application. It has the virtue that we can include as many other determinants in the vector X as we want, and as such the model used is extremely general. Penetration is defined as the number of lines per capita, or P=L/B where L is the number of lines and B is the population. The parameter α is the elasticity of Q with respect to P – i.e., the percentage change in the level of GDP from a one percent change in the penetration rate. This parameter (or a variant) is the value estimated in the earlier studies.

A complication is that in their calculations RW use a penetration figure P' defined as P' = P/(.7 – P),where the 0.7 figure represents the highest penetration rate in their sample. P' can thus be thought of as the actual penetration rate relative to the highest penetration rate. The use of such "rescaled" or "normalised" variables is common in econometric modelling. They estimate

$$(1') \qquad Q = P'^{\alpha} X^{\beta}$$

It can be shown that the total economic rate of return to an additional line (including depreciation) is the same as the marginal product of an additional line. From the empirical econometric estimate of α provided by RW, we can express this marginal product of penetration as

$$(2) \qquad \partial Q/\partial P' = \alpha \, Q/P'$$

We want to get the marginal product of a dollar investment (in main lines), $\partial Q/\partial I$, which is

$$(3) \qquad \partial Q/\partial I = (\partial Q/\partial L)\, \partial L/\partial I = (\partial Q/\partial P'.\ \partial P'/\partial P.\ \partial P/\partial L).\ \partial L/\partial I$$

We have:

$\partial Q/\partial P' = \alpha\ Q/P' = \alpha\ Q\ (.7 – P)/P$
$\partial P'/\partial P = .7/(.7 - P)^2$
$\partial P/\partial L = 1/B$, since P=L/B
$\partial L/\partial I =$ the number of lines that can be financed with one dollar, which is one divided by the cost of a line = 1/c.

This gives the expression for the total economic rate of return to such a dollar investment in telecom:

(4) $\partial Q/\partial I = \alpha\ Q\ (.7 – P)/P\ .\ (.7/(.7 - P)^2)\ .\ 1/B\ .\ 1/c = (\alpha\ Q/L)/c\ .\ (.7/(.7 - P))$
i.e., $\boldsymbol{\partial Q/\partial I = (\alpha\ Q/L)/c\ .\ F}$
Where $\boldsymbol{F = (.7/(.7 - P))}$

To compute this, we use the empirically-estimated elasticity for α from RW, and evaluate the marginal product in (3) using OECD-wide data on GDP and the number of lines, and the beginning penetration rate P (thus the data are chosen for 1970, the beginning year of the RW study). As pointed out earlier, we do this for alternative estimates of α and for the cost per line, c.

Results

RW get three different sets of estimates of α (all of which are highly statistically significant):

- Using a specification that does not include any fixed country effects (Model 1 in Table 3, p. 918), they get $\alpha = 0.154$
- Using a specification that includes fixed country effects (Model 2 in Table 3), RW get $\alpha' = 0.045$.
- Using a specification that includes fixed country effects and also allows the elasticity of GDP with respect to penetration to be different in countries with low (< 20%), medium (20-40%) and high (> 40%) penetration (Model 3 in Table 3), they get:

  For low penetration, $\alpha = 0.034$.
  For medium penetration, $\alpha = 0.044$
  For high penetration $\alpha = 0.074$.

We use the fixed effects estimate (which is the one that RW recommend), namely $\alpha = 0.045$, as the baseline value, but we also include computed rates of return corresponding to a lower bound of 0.034.

As a sample calculation, we use 1970 data for the entire OECD, GDP = \$2.4 trillion, L = 142.7 million, cost per line of \$1000 and penetration rate of P =

20.0%.[37] Using the lower bound estimate for the α parameter, we obtain a social rate of return of 41%. Using the 0.045 value for α, we obtain a social rate of return of 55%. Similar (actually, higher) rates of return can be obtained if we calibrated the calculation to 1990. Using different assumptions on cost per line, i.e., that the cost is $1500 per line, we obtain a rate of return that is lower. Across a range of assumptions, we tend to obtain rates of return generally in the 30% to 60% range. Again, it should be remembered that these calculations are simply to set a sensible range for the average social return on telecommunications investment projects. We have no specific evidence of social rates of return for mobile broadband investment in Thailand, but our calculations are based on the supposition that these social rates of return might reasonably be in the same range as social rates of return for past waves of transformative telecommunications investment. Our purpose here is to simply to establish some reasonable bounds for that range, which we find to be 30% to 60%. As discussed in Section 5 of this report, this range is also consistent with evidence from social returns on other types of infrastructure and innovation investments.

[37] ITU World Telecommunications Indicators 2008.