3G mobile networks in emerging markets: The importance of timely investment and adoption

Prepared for the GSM Association

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1 Executive summary

1.1 The enclosed report has been prepared for the GSM Association by LECG. The main goal of this report is to outline the “order of magnitude” of the likely benefits to major emerging economies from the timely adoption of 3G mobile technologies. By assessing the significance of the potential benefits to societies from timely and intensive adoption of 3G mobile technologies (in particular, the rapid diffusion of mobile broadband), we argue that government policies that lead to delays in the investment process can cause substantial economic loss, exceeding several billion dollars for delays of two to three years.

1.2 The report has three segments: (a) we compute the consumer benefits from 3G adoption, (b) we provide estimates of increased output from investment in 3G networks, and (c) we calculate the consequences (in terms of reduced output) of a modest delay (two years) in roll-out of 3G networks. Our focus is mainly on China and India in these calculations.

Calculation of benefits

1.3 Our calculations show that the potential consumer benefits of 3G adoption are very significant, likely to approach or exceed tens of billions of dollars per annum in key markets such as India and China. Additionally, the impact of GDP from both the direct and short-term stimulus provided by increased investment in 3G networks, and the longer-term productivity gains from the increased use of mobile broadband technologies are likely to be very significant. For example, we calculate that the Net Present Value (NPV) of the current and future economic benefits from Chinese operators’ proposed investment of $59 billion is likely to exceed $110 billion. Given the high level of interest in the Chinese and Indian economies, we place a particular focus on these two markets.

Calculation of consumer welfare gains

1.4 We calculate that based on established econometric methods for computing consumer welfare gains, consumers in large emerging markets such as China and India have realised economic gains from the introduction of 2G mobile services (measured in terms of “consumer surplus”) that are comfortably in the $6 billion to $10 billion range (using conservative assumptions) at nominal exchange rates for India, and between $37 billion and $59 billion for China. Converted into purchasing power terms, these annual consumer welfare gains are in the range of $15 billion to $30 billion (for India) and $68 billion to $107 billion for China.[1]

1.5 These consumer welfare gains from the introduction of a previous generation of mobile technologies are likely to provide some guidance as to the potential gains from the introduction of 3G technology. Using available data on 3G diffusion in established markets, and utilising information on falling handset and device prices, as well as projections by operators and industry experts, we show that it is possible that revenues from 3G and related services might in a range equivalent to between 20% and 60% of current industry revenues, within five years of introduction. If this is the case, then the consumer benefits from 3G adoption are also likely to be in the billions of dollars annually within five years of adoption, and when considered on a purchasing power basis, are likely to approach or exceed $8 billion per year in India, and significantly higher than that in China. We believe that similar to previous generations of telecommunications technologies, there are likely to be significant positive externalities from 3G adoption. *One important reason for our belief is the crucial role of mobile broadband in countries with historically under-developed fixed-line telephony sectors.*

Economic return from investment

1.6 The consumer welfare gains that we refer to above are separate from gains in economic output, or GDP. In order to calculate the increased long-term economic output (or more precisely, the present value of the increased long-term economic output) from 3G network investment, we use an "investment multiplier" that utilises evidence on the return to society and the wider economy from investment in valuable infrastructure. Past econometric studies of telecommunications investment, for example, suggest that (the present value of) the long term increase in economic output from an additional $1 of telecommunications network investment has been in the range of $2 to $4. While we do not assert that all telecommunications investment projects yield similar returns, or that all telecommunications investment is valuable and efficient, these past studies provide some idea of the "typical" returns from investment in telecommunications networks. Applying these typical returns to the likely investment schedules in China and India suggests that the total economic returns from 3G investment in these markets have a present value of tens of billions of dollars, likely exceeding $100 billion in the

[1] This difference between India and China is driven by the fact that mobile penetration in China is significantly higher than in India, as are mobile industry revenues.

Chinese case.[2] These calculations of economic benefit refer to both the direct and indirect effects of the investment. The "direct" effect of the investment is the short-term stimulus to spending that is caused by the investment, while the indirect effect is the effect of the technology on longer-term productivity and efficiency.

Consequences of delay

1.7 Both the consumer welfare gains and the GDP gains described above are very significant. They suggest to us that the potential costs of a delay in introducing services or in making the investment are also very significant. It might be argued that since the telecommunications industry is characterised by rapid technological progress, countries that fail to adopt 3G technology immediately could actually benefit by either (a) the fact that they adopt the technology at a later date when prices are lower as are investment costs, or (b) the possibility that they leapfrog to a newer better technology. We argue that such reasoning cannot be applied to the present instance of 3G adoption in emerging economies.

1.8 Firstly, the relevant technology is now at a relatively mature stage, with the continuing development of devices and applications that make mobile broadband access an ever more viable substitute to fixed-line broadband access. The increasing maturity and state of development of 3G-based services such as mobile broadband and data services means that future mobile voice, data and broadband solutions are likely to *evolve* from the current solutions. Thus countries where consumers, businesses and operators are intensive and enthusiastic adopters of the current technology are likely to be at an advantage in reaping early benefits from adopting and putting the next generation of mobile broadband technologies to creative and productive use.

1.9 There is growing evidence that countries in which businesses (and the public sector) invest in complementary assets (worker training and "user skills") and are willing to transform their organisational structures to make the most of new technology are likely to benefit the most from a given level of investment in new technologies. However, delaying the adoption of the new technology also delays the investment in these complementary factors, which in turn adversely affects not just

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[2] When we refer to the "present value" of increased output from investment in telecommunications networks, this is what we are describing: suppose that $1 invested in the telecommunications network gives $1 of benefit today, and $1 per year of benefit for the next nine years. Benefits earned today are valued more highly than benefits earned in the future, and the more distant the benefits are in time, the less valuable they are today. If we apply an annual discount rate of 10 percent, then the "present value" of the benefit stream from the investment described above is

the benefit that a country can get from the existing technology but also the benefits that can be obtained from the next generation of the technology. [3]

1.10 Secondly, a non-trivial portion of the existing mobile telephony subscriber base is willing to pay for and adapt 3G handsets and services at existing prices. Forcing a delay onto this consumer segment means that the entire potential consumer welfare gain accruing to these "early adopters" will be lost. The other consumers —those who would not have adopted at today's prices— are in exactly the same situation as prior to the regulatory delay, since the price declines are unrelated to country-specific regulatory factors that might be responsible for causing the delay. Thus one set of consumers would likely lose, whereas another set of consumers would be no better off than before.[4]

1.11 Thirdly, in a present value calculation, the further off in the future that benefits are realised, the lower is their value. Even from the private perspective of profit-maximising firms that might benefit from the fact that their inputs are likely to get cheaper over time, delays may well prove to be counter-productive, remembering that the delay also means that the firm forgoes the additional revenues it would have expected to realise from its investment. If one uses telecom firms' opportunity cost of capital as a basis for discounting cash flows, then the discount rate might be 10% or even 15%, one can readily see that delays in being able to offer service may not be optimal from the firm's private perspective, even though some costs be declining.

$6.81. That is, the value of the benefit stream is equivalent to being paid $6.81 today.

[3] Examples of academic studies providing some evidence of the importance of investment in complementary assets and of the importance of organisational change are Susanto Basu, John G. Fernald, Nicholas Oulton and Sylaja Srinivasan, "The case of the Missing Productivity Growth: Or, Does Information Technology Explain Why Productivity Accelerated in the US but not the UK", NBER Working Paper 10010 (2003), Brynjolfsson, Erik and Lorin M.Hitt, "Beyond Computation: Information Technology, Organizational Transformation and Business Performance", *Journal of Economic Perspectives*, 2000: Volume 3.

[4] One can consider the following example of two consumers: an early adopter and a late adopter. The early adopter is willing to pay more than the prevalent price for obtaining a 3G handset and getting mobile broadband service; the late adopter waits until the price falls to at least 10 percent below its current level. Suppose that the price two years hence is likely to be 10 percent lower than today owing primarily to the evolution of the industry. Should the government delay the adoption of the technology by two years in anticipation of this price decline? The early adopter loses all the consumer surplus (the difference between the price and the adopter's actual willingness-to-pay) for the first two years. The late adopter does not lose or gain from the delay. One can add in complicating factors such as contracts that lock in the early adopter and temporarily limit this early adopter's ability to benefit from price declines; one can also consider producer surplus, taking into account falling investment costs. However, in a Net Present Value calculation factoring in long-term benefit streams, it seems unlikely that under any realistic assumptions about price declines, appropriate private and social discount rates, and even the actual length of lock-ins, that social surplus would be higher as a result of the delay. The answer would be different if the delay in itself caused lower prices or lower investment costs, but this is not the case.

1.12 Table ES-1 summarises the basic calculations that we have performed for consumer surplus and GDP benefit for China and India, as well as the costs of a two-year delay (relative to 2009) in rolling out 3G services in these two countries:

Table ES-1: Summary of findings

Type of Benefit (US $ terms)	Exchange rate	China	India
Consumer welfare effect in 2015	Market	$17 billion	$3 billion
Consumer welfare effect in 2015	PPP[5]	$32 billion	$8 billion
GDP benefit from 3G network investment (NPV)	Market	$114 billion	$36 billion
GDP benefit from 3G network investment (NPV)	PPP	$211 billion	$95 billion
Type of Loss (US $ terms)		**China**	**India**
Lost GDP from investment delay of two years	Market	$20 billion	$6 billion
Lost GDP from investment delay of two years	PPP	$37 billion	$16 billion

1.13 The calculations above are based upon the announced investment of $59 billion for China over the next three years, and a hypothetical investment of $20 billion in India over the next five years. In the remainder of the report, we spell out the basis for our calculations and our belief that 3G network investment is likely to have a significant positive externality effect in emerging economies. We begin by describing the basis for our consumer welfare calculations and then proceed to describing the calculations that we used for our projections of the increased GDP from network investment. We then discuss the costs of delaying such valuable investment, and the considerations for regulatory policy-makers who wish to foster an environment which promotes timely investment and adoption. Throughout this report, we emphasise the key role of 3G (and its successors) not just as part of the mobile telephony industry, but also as a key means of getting “broadband to the masses” in emerging economies.

2 Calculation of consumer welfare gains

Conceptual basis for calculating consumer welfare gain

2.1 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.

2.2 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

2.3 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

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[5] PPP = Purchasing Power Parity. Purchasing power parity reflects the fact that the purchasing power of $1 is significantly more than the purchasing power of $1 in the United States. In our calculations, the purchasing power exchange rate for India is roughly 2.68 times the “market rate”, for China 1.85 times the market rate. These ratios have been computed by dividing purchasing power parity GDP by GDP valued at exchange rates prevalent in 2007, and reported in *the CIA World Factbook.*

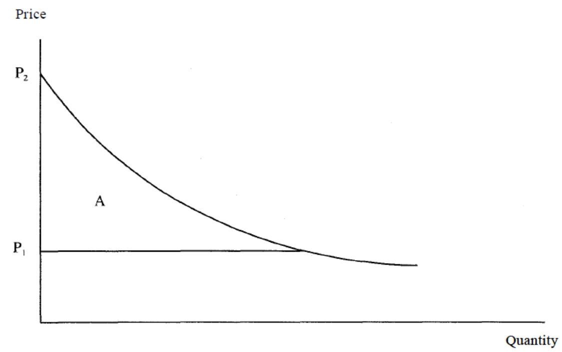
and the costs of regulatory policies that seriously delayed the introduction of these new services.

2.4 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.

2.5 Figure 1 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.[6]

[6] 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 1: Consumer welfare gain from a new good (from Hausman(1997))[7]



Applicability to valuation of 3G

2.6 It might be pointed out that the compensating variation methodology outlined above is applicable to valuation of new services or products, and thus should not be applied to the valuation of consumer benefits from 3G. Two points need to be made here.

2.7 First, 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. [8]

2.8 Second, the rollout of 3G networks will provide consumers with more than just a few additional features that are not inherent in existing 2G networks. The promise of mobile broadband services in the emerging economies is very substantial, given the under-development and limited prospects for fixed-line broadband deployment in the near and medium-term. Thus at least in the emerging world, the significant additional value that consumers derive from 3G networks will be related to the mobile broadband capabilities of these networks; in this sense, 3G services are

[7] 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 Telecommunications Economics*, edited by M.E.Cave, et al., (2002: Elsevier Publishers, Amsterdam).

[8] Specifically the valuation methodology has two important facets that are of relevance here: first, if used an "expenditure function approach" allows us to incorporate changes in the prices of other goods into the welfare calculations, and secondly, it uses a "representative consumer" approach which implies that all products that are available continue to be purchased. Hausman adds that only when the older product is withdrawn altogether do "significant complications arise."

substantially "new." We discuss the importance of mobiles as a means of providing broadband access in significant detail subsequently.

Quantification of welfare gains

2.9 In order to quantify the welfare gains from the introduction of 3G services, we begin by quantifying the annual welfare gains from existing (very predominantly 2G) mobile services in key emerging economies. We then show that based on reasonable estimates about the penetration rates that 3G is likely to achieve, we can calculate the welfare gains that are likely to accrue within about five years of introducing such services, using the welfare gains from 2G to guide our calculations.

Estimates of annual welfare gains from existing mobile services

2.10 Table 1 provides estimates of the annual welfare gain in 2007 in key emerging economies from mobile (very predominantly 2G) services. We have performed these calculations for three different values of the price elasticity parameter[9], and thus have

Table 1: Consumer welfare gains from 2G mobile telephony

Country	Elasticity	CV at Market Ex Rates	CV at PP Ex Rates
India	0.5	$10,312,632	$27,669,867
India	0.7	$7,366,166	$19,764,192
India	0.8	$6,445,395	$17,293,667
Brazil	0.5	$23,760,783	$28,969,603
Brazil	0.7	$16,971,988	$20,692,574
Brazil	0.8	$14,850,490	$18,106,003
China	0.5	$59,616,188	$110,289,948
China	0.7	$42,582,991	$78,778,533
China	0.8	$37,260,117	$68,931,216
Mexico	0.5	$15,985,495	$22,069,214
Mexico	0.7	$11,418,211	$15,763,724
Mexico	0.8	$9,990,934	$13,793,258
South Africa	0.5	$9,894,772	$16,689,182
South Africa	0.7	$7,067,694	$11,920,844
South Africa	0.8	$6,184,232	$10,430,738

2.11 Table 1 demonstrates that the consumer benefits from 2G adoption have been very significant. In the larger emerging economies, *annual* consumer welfare gains

9 Here when we refer to price it is in the sense of an "all-in" price or "total ownership cost" on an annualised basis.

(measured in purchasing power parity terms) derived from existing mobile telephony services are in the range of $10 billion to $100 billion or more, depending on which country we are looking at and what assumptions regarding elasticity we make.

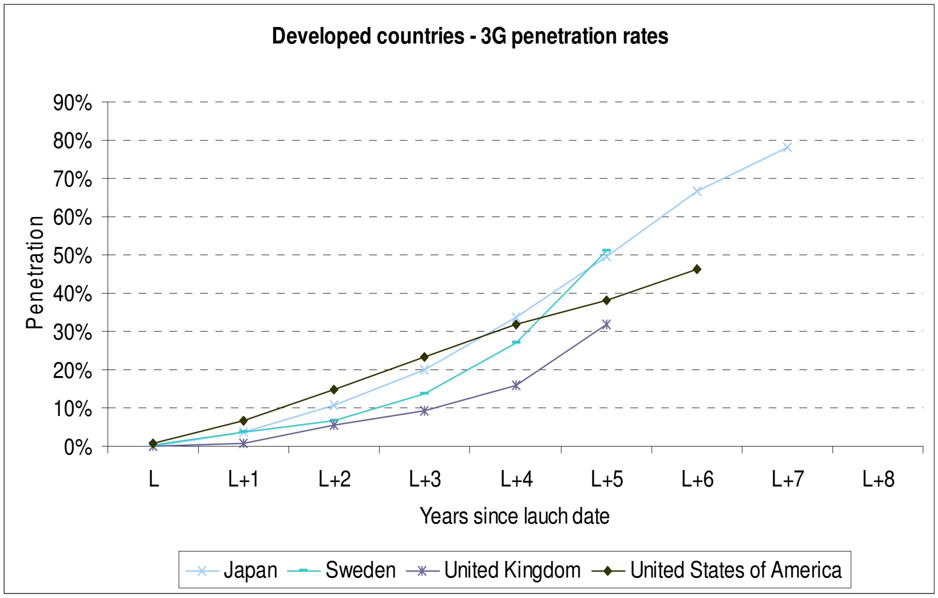
2.12 Do these calculations provide at least a starting point for calculating the potential consumer benefits from 3G adoption? At an intuitive level, can we expect the benefits from 3G within the medium-term to be anything like as large as the benefits from 2G? We believe that even though it will take some time before 3G adoption reaches the level of current 2G adoption in key emerging economies, there is a reasonable basis for predicting that within five years, 3G revenues could approach between 20% and 50% of *current revenues* from 2G services. We base this belief on:

- the fact that 3G diffusion has been relatively rapid even in mature markets where 3G was introduced arguably before the applications, devices and services for which it was truly useful were fully developed;
- the further fact that in developing countries, there is likely to be significant latent demand for the types of mobile broadband functionality that 3G networks can provide, meaning that although the income and even skills constraints that govern the ultimate penetration rate of 3G technologies in emerging markets are much tighter than in developed markets, there is still a significant chunk of consumers for whom the incremental benefits of 3G subscriptions are arguably more substantial than they are for most consumer groups in the developed markets;
- the fact that 3G handsets and other devices that enable mobile broadband access are getting cheaper, especially when one considers the fact that more features are available for the same price.

Experience from mature markets

2.13 In some key mature markets that we have examined, there are now about 30 to 80 3G subscribers per 100 population. This is about five years or so after the launch of commercial 3G services. (Commercial services have been available since late 2001 in Japan, where the penetration rate of 3G is now about 80 subscribers per 100 population).

Figure 2: 3G adoption in mature markets



2.14 Thus 3G technology has diffused relatively quickly in mature markets. However, it should be kept in mind that there were several factors that caused slow initial adoption of 3G in many markets:

- The telecoms recession of 2001-03 left many mobile operators in Europe in poor financial condition, and unable to invest sufficiently in 3G networks which led to delayed rollout of services;
- Operators had difficulty defining the precise services and applications that they could market using 3G technology. For instance, Hutchison 3G in the UK initially promoted "video calling" rather than mobile data services as its main selling point;
- There were significant doubts raised about the attractiveness of mobile broadband and data services because of the limitations of handsets and the features and software these handsets supported. Recently, however, there have been significant innovations both in the mobile handset space and in the computing space, innovations that have greatly enhanced the ability of mobile networks to compete with fixed networks as broadband access platforms.

The potential for mobile broadband in emerging markets

2.15 The niche for mobile broadband in the developing world is made clear by several facts. As Table 2 below shows, there is likely to be significant latent demand for personal Internet access. In India, for example, the ratio of Internet users to Internet subscribers far exceeds the ratio in developed markets such as the United States and United Kingdom. Two major barriers to the spread of Internet subscribership have been:

- The limited ability of fixed-line networks to facilitate mass market broadband access. According to a report by BDA Connect (BDA) for the Confederation of Indian Industry (CII), current fixed broadband infrastructure can only facilitate 9 million connections[10];
- The high price of personal computers relative to average incomes in developing nations. There were fewer than 3 personal computers for every 100 individuals in India, compared to 80 or more in Sweden, the UK and USA.

Table 2: PCs and internet use in 2006/07, selected countries

Country	PC per 100 Inhabitants	Internet Users per 100 Inhabitants	Fixed Broadband per 100 Inhabitants	Ratio of Internet Users to Fixed BB
China	5.60	15.81	3.85	4.11
India	2.76	6.79	0.21	33.04
Japan		68.27	20.61	3.31
Sweden	88.20	76.97	27.44	2.80
UK	81.21	63.16	21.71	2.91
USA	79.89	69.83	20.11	3.47

Source: ITU World Telecommunications Indicators 2008.

2.16 Mobile networks have proven demonstrably easier to expand in the developing world than have fixed-line networks. Mobile voice penetration greatly exceeds the fixed voice penetration (by factors of 10 to 1 or more) in many developing markets. Thus to the extent that low broadband penetration is caused by inadequate infrastructure availability, mobile broadband networks are an effective solution to relieve these infrastructure constraints.

2.17 To the extent that expensive hardware is another major constraint on the spread of broadband in developing markets, developments in mobile devices and computing are likely to alleviate this constraint in coming years. First, mobile handset prices

[10] See BDA Connect and Confederation of Indian Industry (CII), "Wireless India: Catalyzing the Next Wave in Economic Growth", available at http://cii.in/menu_content.php?menu_id=696

have generally been falling. Second, mobile handset terminals have undergone a major increase in functionality during the past few years. Figures 3 and 4 capture both of these aspects of mobile handsets. The BDA-CII report also provides significant discussion of handset functionalities and pricing points. It points out that entry-level 3G phones costing less than $100 are imminently available. Given the rate of technological innovation in the industry, one can expect that within five years, very sophisticated phones might be available at "entry-level" prices of US $100 or less.

2.18 There are also other devices coming on the market that are designed to foster cheap access to broadband. As has been widely publicised, the Massachusetts Institute of Technology has developed a low-cost laptop priced at $100. Tata has recently introduced a $20 laptop for the Indian market. While the viability of these devices is yet unclear, they represent the beginnings of a computing solution to the "device" or "access" problem for Internet access in developing markets.

2.19 Thus it appears likely that whether through subscribers who use their mobile handset as a primary Internet access device, or through subscribers who use a combination of the mobile handset and laptops equipped with 3G cards, 3G networks are likely to play a major role in expanding broadband access in emerging markets. Indeed, in mature markets 3G networks are already playing a major role in expanding the market among "late adopters."[11] Given the lack of fixed-line alternatives in emerging markets, there is every reason to believe that the niche for 3G services in emerging markets is even clearer.

2.20 Finally it is worth emphasising that 3G technologies have several advantages over alternative platforms for wireless broadband access, largely because they are backwards compatible with existing wireless voice and data networks currently in service (GSM and CDMA).

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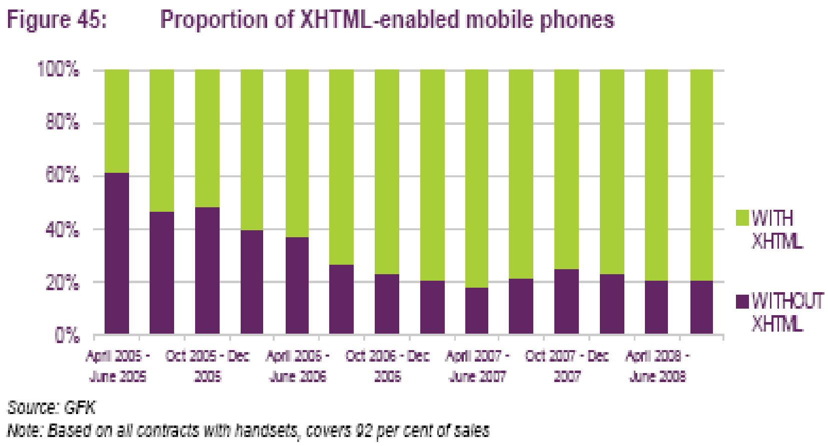
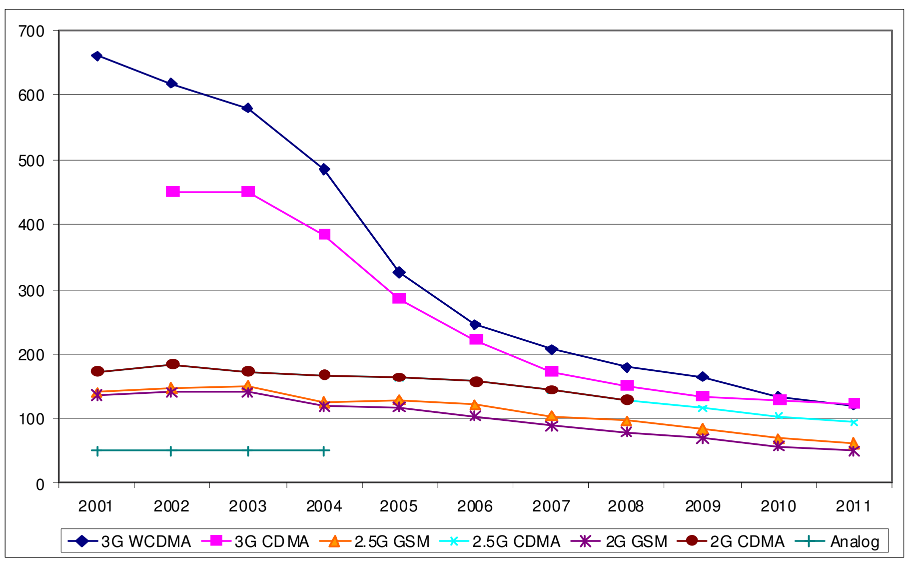
[11] See "Mobile Broadband USB Modems Take off in Europe", Pete Nuthall, Forrester Research, July 22nd, 2008: http://www.forrester.com/Research/Document/Excerpt/0,7211,44577,00.html, arguing that mobile broadband technology is now a serious competitor to fixed-line broadband technology. Juniper Networks 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.

Figure 3: Increasing handset functionality



Source: "Mobile Citizens, Mobile Consumers", Ofcom, August 2008.

Figure 4: Average selling price for handsets (ASP)



Source: LECG analysis of data from Strategy Analytics and Yankee Group.

Prognosis for 3G adoption in emerging markets

2.21 The evidence on adoption rates from mature markets suggests that there were roughly 30 to 50 3G subscribers per 100 population within about five years of introduction of services (the proportion is over 80 per 100 population currently in Japan, but this is some seven years of introduction). Since penetration rates in most of these markets are roughly 100 percent (or 100 subscribers per 100 population), roughly 30 to 50 percent of the existing subscriber base had adopted 3G within a roughly five year period of introduction.

2.22 In emerging markets, it could be argued that the income constraints facing consumers are more significant than in the developed markets. Further, factors such as lower skills levels and literacy levels, and a lack of development of complementary infrastructure, would suggest that there is less aggregate demand for broadband services and 3G services than in developed markets. In other words, one should not expect that 3G penetration in China or India will reach the levels (30 per 100 population to 50 per 100 population) observed in mature markets about five years after launch.

2.23 However, these important differences in incomes and skills are also reflected in current mobile penetration rates. Thus the mobile penetration rate in India is 30 per 100 population, or about 30% of the levels of the developed markets discussed above. As compared to this penetration rate, however, the penetration rate of broadband (broadband subscribers per 100 population) in India is under 0.5, or just 3% (at best) of the broadband penetration achieved in the developed markets in Table 2. Thus there are likely to be a significant number of current mobile subscribers in countries such as India who do not subscriber to broadband services, but potentially could do so as incomes grow and current issues with accessing broadband such as the high cost of PCs and the unavailability of sufficient network infrastructure are resolved. As mentioned above, the introduction of 3G mobile networks is likely to be the most effective way of increasing network reach and boosting the availability of relatively affordable access devices.

2.24 By about 2015, the McKinsey Global Institute predicts that some 4% of Indian households will have (real) incomes of 500,000 rupees or more, with another 22.1% having incomes of between 200,000 and 500,000 Rupees. Thus the total proportion of Indian households earning 200,000 rupees or above by 2015 is forecast to be around 26%. On a population basis, accounting for the fact that richer households in India may be slightly smaller than poorer ones, this represents some 200 million or more of the population living in households with “middle class” income levels. With a 3G penetration rate of 50 per 100 among this segment of the population alone, India would achieve 100 million 3G subscribers by 2015.[12] In the Chinese case, given the higher income levels, one would expect significantly more 3G

[12] Source: McKinsey Global Institute, “The Bird of Gold—The Rise of India’s Consumer Market”, 2006.

subscribers in a shorter period of time: *e.g.,* leading Chinese mobile operators expect that about 30% of *existing subscribers* in that market would switch to 3G within three years.[13]

2.25 In summary, the adoption rates experienced in mature markets may provide a reasonable basis for assessing likely adoption rates in emerging markets, provided one controls for the fact that a significant proportion of the population in certain countries is too constrained in income and education levels to afford any type of mobile or Internet service. One should instead think in terms of the "*addressable market*", those who may be able to potentially afford 3G services either at today's prices or at prices that may prevail in the near future.

2.26 There is no science to defining what this addressable market might be. For example, one might reasonably define members of households with incomes above 200,000 Indian rupees as the "addressable market." In purchasing power terms, such households would have incomes of US $15,000 or more, and could potentially afford 3G services, especially if prices fall. Based on such a definition, this addressable market would be 26% of all Indian households.

2.27 Alternatively one could use the base of existing mobile subscribers (about 30 per 100 population) to define the addressable market. Both definitions would seem to point to an addressable market of somewhere around 25 to 30 percent of the population in India. For China, the addressable market might be between 45 and 50 percent of the population based on current mobile penetration rates. We thus adopt the existing mobile subscriber base as defining the bounds of the total addressable market for 3G handsets and services.

2.28 Taking into account various factors that would point towards relatively faster adoption of 3G in emerging economies, such as maturing technology, lower-priced handsets, the absence of fixed broadband alternatives, and the development of lower-cost alternatives to current computing devices, the experience of developed nations can provide a conservative guidance as to the adoption rate for 3G services in emerging markets.

Conclusion on 3G adoption rates

2.29 Based on the experience of mature markets as shown in Figure 2 and on the many mitigating factors that we have discussed, we assume that between 20% and 40%

[13] Source: "China enters the 3G wireless era", www.telecommagazine.com, 9 January 2009.

of existing subscribers in emerging markets such as China and India may switch to 3G services within a five-year time frame.

Calculations of potential consumer welfare gains from 3G

2.30 We show below the "compensating variation" calculation showing how much consumers can gain from the adoption of 3G technologies five years after initial service is introduced. In order to make this calculation, we assume that "real" (inflation-adjusted) revenue per subscriber (ARPU) for 3G services (accounting for inflation) is between 1 and 1.5 times the ARPU for current 2G services.[14] This implies that real (inflation-adjusted) revenues from 3G are between 20 and 60 percent of current revenues from 2G services. This yields the consumer welfare calculation in the table below, for different assumed values of the elasticity parameter. The calculations below represent the potential welfare gains in 2015 if service was launched at the beginning of 2010.

Table 3: Potential consumer welfare gains from 3G in 2015 (Nominal exchange rate), $ 000s[15]

	Elasticity	20% of Current Revenue	40% of Current Revenue	60% of Current Revenue
India	0.5	$2,062,526	$4,125,053	$6,187,579
	0.7	$1,473,233	$2,946,466	$4,419,699
	0.8	$1,289,079	$2,578,158	$3,867,237
China	0.5	$11,923,238	$23,846,475	$35,769,713
	0.7	$8,516,598	$17,033,197	$25,549,795
	0.8	$7,452,024	$14,904,047	$22,356,071

14 Higher ARPU might lead to lower switching rates to 3G. The extent to which the two effects (higher price and lower penetration) offset each other would depend on the cross-price elasticity of demand between 2G and 3G services.

15 Note: Current industry revenue in India is estimated at US $10.6 billion, and in China at US $ 59.6 billion. Source: Wireless Intelligence.

2.31 Table 4 shows the consumer welfare valuation expressed in purchasing power terms:

Table 4: Potential consumer welfare gains from 3G in 2015 (PPP exchange rate), $ 000s[16]

	Elasticity	20% of Current Revenue	40% of Current Revenue	60% of Current Revenue
India	0.5	$5,533,973	$11,067,947	$16,601,920
	0.7	$3,952,838	$7,905,676	$11,858,514
	0.8	$3,458,733	$6,917,467	$10,376,200
China	0.5	$22,057,990	$44,115,979	$66,173,969
	0.7	$15,755,707	$31,511,414	$47,267,120
	0.8	$13,786,243	$27,572,487	$41,358,730

Note: Shading indicates central scenario used in Table ES-1.

2.32 Based on these valuations, the annual consumer welfare gain from 3G services will range from between $3.5 billion and $16.6 billion in India, and $13.8 billion to $66 billion in China, sensitive to the exact assumptions one makes about the rate at which consumers switch to 3G services, and the effective price of these 3G services.

2.33 Clearly this is a wide range, but the point here is simple: annual consumer gains from 3G services are likely to be very significant, under even the most conservative scenarios. *To put matters in perspective, if the number of 3G subscribers in India reaches 100m or so, an annual consumer welfare gain of $8 billion (in PPP terms) is akin to an increase in each subscriber's purchasing power of $80 annually.*

Given the significance of these annual welfare gains, delays to 3G investment might also prove costly to society. We will discuss the impact of delayed investment in Section 5.

3 GDP Impact of investment: Key concepts

3.1 We next turn to a complementary method for calculating the potential economic impact of 3G networks. This method utilises information about the planned level of investment in 3G infrastructure, and applies a "multiplier" effect to the investment

[16] Note: Current industry revenue in India is estimated at US $10.6 billion, and in China at US $ 59.6 billion. Source: Wireless Intelligence.

made in 3G networks in order to quantify the overall economic impact (the "total economic return") from the investment. This total economic return can be interpreted as an increase in national income or GDP, and is a mixture of private benefits (e.g., profits to investors in mobile network operators) and public returns (benefits to society such as increased productivity). It should be emphasised that in economics, consumer welfare calculations are not included in GDP.

Basic concept

3.2 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

3.3 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.

3.4 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.

3.5 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.

3.6 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 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

3.7 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.

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

3.9 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

3.10 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

3.11 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 5: 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 (ρ/r) for N = ∞
= I(ρ/r).(0.86) for N = 20; r = 10%
= I(ρ/r).(0.78) for N = 15; r = 10%
= I(ρ/r).(0.63) for N = 10; r = 10%

4 GDP impact of investment: Practical application

4.1 In this section, we demonstrate how the concepts from the previous section can be applied to estimate a sensible range for the total economic return to China from the proposed investment by Chinese mobile operators of $59 billion over three years.

Evidence on the social returns to telecom investment

4.2 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.[17] 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

[17] Roeller, Lars-H and Leonard Waverman, "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach", *American Economic Review*, September 2001.

and GDP. In their study, telecommunications penetration is the measure of the useful telecommunications capital stock in a country.

4.3 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

4.4 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.

4.5 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 %[18] 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."[19] These results indicate a very large difference between financial and economic returns and that the Commission

[18] 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).

[19] 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.

considers the economic and social benefits sufficiently valuable to offset the financial losses that result from these projects.

4.6 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).

4.7 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.”[20]

4.8 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.[21]

Applicability of literature to 3G investment in emerging economies

4.9 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?

4.10 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;

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

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

- The potential for 3G services to significantly reduce spectrum constraints in the 2G sector, thus allowing lower-cost 2G options to emerge (particularly in India), and thus expanding basic voice connectivity to a significant section of the population currently lacking such access;[22]
- The relatively low cost and scale-ability of mobile networks compared to their fixed line counterparts.

4.11 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.[23]

Cost of capital and multipliers

4.12 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).

Calculations for China

4.13 The Chinese mobile operators plan to invest $58.5 billion in 3G networks over the next three years. (Source: Reuters, January 26th, 2009). We assume that this investment is made in three equal lumps, the first one of which is assumed to be completed by the end of 2009, and the last of which is completed by the end of 2011. Tables 5 and 6 show the economic returns from this investment project, evaluated first at market exchange rates and secondly at purchasing power exchange rates.

[22] See the BDA-CII report, at p. 13, where it is argued that 3G may prove to be an effective way of relieving capacity constraints on 2G networks.

[23] 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.

Table 5: Economic return from 3G investment, market exchange rates

	2009	2010	2011
Investment ($ billions)	$19.5	$19.5	$19.5
Discount rate	10%		
NPV of Investment ($ billions)	$48.5		
Multiplier	2.35		
Total Economic Return (NPV of gains in GDP, $ billion)	$113.96		

Table 6: Economic return from 3G investment, PPP exchange rates

	2009	2010	2011
Investment ($ billions, PPP rates)	36.1	36.1	36.1
Discount rate	10%		
NPV of Investment ($ billions, PPP)	$89.7		
Multiplier	2.35		
Total Economic Return (NPV of gains in GDP, $ billion at PPP rates)	$210.83		

Implications of calculations

4.14 Two things should be stressed here. First, the total economic return is calculated as a Net Present Value. Thus what is being computed is the present value of all current and future, direct and indirect, public and private economic gains from the investment project. This total economic return should not be interpreted as saying that GDP will increase by $113.96 billion instantaneously (at market exchange rates).

4.15 Secondly, the NPV calculation is inherently a valuation calculation. In other words, what lump sum payment, made today, would Chinese society accept in lieu of the current and future benefits from the proposed 3G investment? Equivalently, the value of the 3G investment is similar to a project that yields $113.96 billion of benefits today (or $210 billion in purchasing power terms). This is still over 2% of China's current GDP.

Jobs: another way of looking at the value of the project

4.16 In some countries, national statistical offices provide detailed Input-Output multipliers that relate increases in spending (such as capital spending) by one sector to additional job creation in that sector and all other sectors connected to it. Thus Criterion Economics calculates that every additional $1 million invested in telecommunications in the U.S., creates about 18 new jobs. Since worker productivity and the structure of the economy in China are so different than in the United States, it would be problematic to apply this U.S. multiplier to China. However, the cumulative investment of $58.5 billion over the next three years would, using the U.S. multiplier, create more than 1 million additional jobs. The likelihood is that in China, the job creation potential is several multiples of the U.S. figure, given much lower levels of worker productivity. In any case, the point is that the job creation potential of such a large investment, with so many spill-over effects into the wider economy, is huge.[24]

4.17 As an illustration of how large the employment effect in China relative to the United States might be, a project worth $114 billion would, at current average levels of worker productivity in China (GDP per worker is around $6000 at market exchange rates), create 19 million jobs. Again we are not making a specific statement about how many jobs would be created by the proposed investment in mobile networks. Rather we are stating that the value of the project is akin to that of another project that creates 19 million jobs. In other words, policy-makers should be as eager to promote investment in 3G networks as they would be in a project that created 19 million new jobs immediately.

Calculations for India

4.18 Although no firm details of investment plans are as yet available for India, we have assumed an investment of $20 billion in 3G networks, made over a five-year period, in equal instalments. The BDA-CII report on Wireless India suggests that about $20 billion of additional GDP will be generated by direct increased investment and revenues in Advanced Wireless Services (AWS) in India "within the first decade of introduction." It estimates that the total economic benefit to India would be about $70 billion over this time period.[25] These calculations appear to be done in market exchange rate terms.

4.19 Applying our multiplier of about 2.35 to India, we obtain the following calculations:

[24] See Criterion Economics, "The Effects of Ubiquitous Broadband Adoption on Jobs, Investment and the U.S. Economy", September 2003.

[25] See BDA-CII report, at Section 2.6, p. 22.

Table 7: Total economic returns from 3G investment in India (market exchange rates)

	2009	2010	2011	2012	2013
Investment ($ billions)	4.0	4.0	4.0	4.0	4.0
Discount rate	10%				
NPV of Investment ($ billions)	$15.2				
Multiplier	2.35				
Total Economic Return (NPV of gains in GDP, $ billion)	$35.63				

4.20 Similarly, it can be calculated that the PPP value from a $20 billion investment in AWS in India ($53.6 billion in PPP terms) is $95 billion.

Reasonableness of calculations

4.21 To put our calculations into perspective, other estimates of the impact of AWS and fixed broadband services provide similar, if not higher, estimates of the impact of investment. For example, Criterion Economics applies a multiplier of 2.89 to estimate the GDP impact of increased investment in broadband services in the United States, compared to the multiplier of 2.35 that we use. The multiplier that they use is derived in a fundamentally different way from our multiplier. However, in practical terms their multiplier would imply that the investment proposed by Chinese operators would have (in market exchange rates) an impact (in NPV terms) of $140.5 billion, compared to the $113.96 billion that we obtain.

4.22 Similarly the BDA-CII report for India obtains benefits of $70 billion from an investment of $20 billion or less (although this is not expressed in present value terms). However, as with the Criterion Economics estimates, the BDA-CII estimates suggest a very large aggregate economic impact of AWS services, arguably significantly larger than we have calculated.

4.23 Recent evidence submitted before the House of Representatives Appropriations Committee in the United States claims that "for every dollar invested in broadband, the economy sees a ten-fold return on that investment."[26]

[26] U.S. House of Representative, Committee on Appropriations, Press Release, January 15th, 2009.

5 Adverse impact of policies that delay investment

Why delays are costly

5.1 Delays to the proposed investment programmes are costly from two perspectives. First, from a consumer perspective they delay the date at which consumers can enjoy the benefits from new products and services. During the period of the delay, consumers lose the entire "consumer surplus" that they might otherwise have enjoyed as a result of the new products or services. For instance, if 3G services were introduced in India currently, current handset prices may make them affordable only to more affluent sections of the population—say the top 10% or 15% of households. However, as we have researched, "like-for-like" handset prices are likely to fall for the next few years. If 3G services were delayed until handsets became more generally affordable would this still hurt overall consumer welfare.

5.2 The reason is simple: those consumers who would have been able to afford 3G handsets at prevailing prices will not be able to subscribe to 3G services. Since the decline in handset prices is largely determined by conditions in the overall international handset market and by the declining costs of the electronics that go into the handset, these prices would have declined at the same rate independent of when or whether 3G services are available in India. Thus those consumers who cannot afford 3G services currently are no better off as a result of the delay in launching services, while the entire consumer surplus (the difference between the prevalent price for a good or service and a given consumers' willingness to pay for that good or service) for those who would have been able to afford service are foregone.[27]

5.3 The second reason that delays are costly has to do with the state of development of the global 3G and mobile broadband platforms. If 3G mobile technology were untested and untried, and there was no large global installed base for the technology, then "early adoption" of 3G could have downsides. For example, a country that pushed an early adoption policy might find itself locked into the wrong technology, as more cost-efficient and commercially viable alternatives become available. In the case of the major 3G platforms (WCDMA and CDMA 2000 EV-DO, and their variants), however, there is already a large global installed base. With the exception of WiMax, all next-generation technologies (i.e., 4G technologies) can be expected to evolve from the current 3G technologies. The applications and devices required to utilise the potential of 3G networks already exist, and further innovation in developing these applications and devices is in the pipeline.

5.4 For instance, in the early days of consumer home video in the 1970s, there was uncertainty about whether Betamax or VHS would emerge as the preferred recording format. Both were early-stage technologies, and eventually VHS emerged as the preferred format for home recording and viewing. A firm that invested heavily in Betamax before establishing the market demand for that product would have suffered commercially as a result. However, there is no analogy between a firm that invested in Betamax and a country that seeks to promote investment in 3G networks. 3G technologies are not early-stage. In fact, given the size of the current global installed base, manufacturers of network equipment, application developers, and handset manufacturers are all arguably far better positioned to exploit economies of scale in pushing out new networks, applications and devices than they were five years ago, when 3G networks were being introduced in Europe and North America.

5.5 Given that telecommunications networks are "general purpose technologies" which are useful to a wide swathe of economic actors, the costs to society from delaying adoption of a proven and useful standard are substantial. Since 3G technology is likely to provide a cost-efficient and viable broadband solution in many emerging economies, delaying the introduction of this technology will delay the development of applications and services that use broadband, and will at least partially deter firms from investing in the skills and organisational changes that are required to make the most of the opportunities that broadband offers.

5.6 Online commerce offers an example: firms might be able to use mobile broadband platforms to reach consumer segments online to sell services such as banking services or mobile entertainment services. However, if there were significant uncertainties about whether and when mobile broadband networks would become available, then the firms that might have invested in developing online commerce platforms may well defer their investment.

[27] It may be possible that some of the early adopters are locked into paying high prices by long-term contracts, and are thus unable to benefit from the falling price of handsets and services. However, these "lock-ins" are temporary and unlikely to weigh heavily in a calculation of cumulative consumer surplus over several years.

5.7 By contrast, firms operating in countries that offer a more certain regulatory environment, would go ahead and develop applications and services, some of which may prove commercially successful. When 4G technologies emerge, these firms would be well positioned to exploit these yet more powerful technologies to their fullest extent. They would already have significant market experience, they would have invested in workers with the skills to develop the right types of products and services, and they would have a significant base of consumers who are used to the idea of online commerce platforms. Thus countries that are quick to adapt 3G technology today are likely to benefit from being well down the "learning curve" for mobile broadband and data usage — both in terms of having firms that realise the potential of such technologies, and consumers who use these technologies — by the time even more powerful mobile solutions become available.

5.8 Given that the transition from 3G to 4G and future wireless platforms is likely to be evolutionary, there would appear to be very limited opportunities for countries that are persistently late adopters of current generation technologies to "leap frog" and become innovators and leaders in the next generation of technologies.

5.9 In simple terms, delayed introduction of 3G services is not good when evaluated from either the perspective of consumer welfare or from the perspective of reduced economic output. In the next section, we quantify the impact of a two-year delay on our total economic return calculations, mainly to illustrate the point that the economic losses from such delays are significant.

Significance of delayed investment

Impact on total economic return calculations

5.10 It is straightforward to calculate the impact of a delay in investing in 3G networks on the total economic returns that we estimated in the previous section. One might see society as having two options: an "invest now" option and a "delayed investment" option, wherein the same investment takes place but with a two-year delay. The "economic loss" from the delay can be calculated as the difference between the total economic return from the "invest now" option and the "delayed investment" option.

5.11 Here, we assume that all details of the investment projects are unchanged, and that the investments are simply made with a delay of two years. In reality, however, firms do not fund their capital expenditure solely or even primarily from cash. Usually firms have to borrow money from capital markets. A delay to the original investment plan is significant because it delays the cash-flows to investors, and thus reduces the value of the project to investors. In fact, in the current economic situation, funds that are available today may not be available tomorrow, and if they are available, the cost of borrowing may be significantly higher. All of these factors would imply that the actual costs of a two-year investment delay, for example, might be far more significant than implied by a calculation that just looks at the difference in the NPV of the total benefit streams realised from the "invest now" and "invest two years later" scenarios.

Calculation of loss for China and India

5.12 Based on the total economic return calculations for China and India, we estimate that a delay in investment of two years has the following effect:

- Reduces the value of the modelled investment projects by $20 billion in China and $6 billion in India at market exchange rates ($37 billion at PPP exchange rates for China, and $16 billion at PPP exchange rates for India).

5.13 This calculation follows from the simple logic of discounting, using the firms' cost of capital as the appropriate discount rate for the flow of benefits to society from the project.

5.14 The economic loss can be seen from an alternative perspective too, that of job creation. Thus in the Chinese case, the value of the 3G investment project was estimated as being similar to a project that increased GDP by $114 billion (at market exchange rates). Given current levels of worker productivity in China, this type of output would require 19 million additional workers. However, under the delay scenario, the value of the project is reduced to $94 billion in present value terms. This is equivalent to a project that yields about 15.6 million jobs, not 19 million jobs. Thus the delay can be viewed as being as socially damaging to China as a policy that destroys more than 3 million jobs (19 million less 15.6 million). Thus even a delay of "only" two years can be significantly costly in terms of reducing the benefits to society from timely investment n 3G networks.

Reasonableness of loss calculations

5.15 It might be argued that a delay to 3G investment might simply mean that investors find alternative uses for their money. For instance, the $59 billion currently planned for Chinese 3G investment might be invested in other projects, and thus when calculating the impact of the delays we should account for these alternative earnings (which would serve to reduce the losses). Several points are worth making here:

first, we are assuming that the entire quantum of investment is made, but simply with a delay, rather than accounting for the more complicated reality that the same magnitude of investment and the same level of funding may not be available, or if it is available, the cost of capital may be higher. Second, since capital is internationally mobile, it is unclear whether the capital would be re-invested in China. Thirdly, there is uncertainty about what if any public (as opposed to private) returns such alternative investments might provide.

5.16 Finally, our loss calculation is based simply upon the difference in the timing of benefits. However, it is quite possible that delays to the investment process affect both the *magnitude* and the timing of the benefits to society. For example, diffusion studies for various technologies often find an “s”-shaped diffusion pattern. That is, technologies diffuse slowly at first, until a critical mass of users is reached, at which point diffusion accelerates greatly. This phase of accelerated diffusion persists until “saturation” is reached, at which point the growth rate of diffusion slows down again.

5.17 However, if we are considering the diffusion of a general purpose technology, one should also consider the spill-over effects that such a technology has. Deployment of 3G and mobile broadband networks could spur the development of ancillary industries or allow existing industries to change their ways of doing business. These spill-over developments might only materialise fully when critical mass has been attained. Delayed adoption leads to delayed attainment of critical mass, which may not only delay the realisation of spill-over effects but *reduce or eliminate them altogether.*

5.18 For example, suppose there are critical mass and learning effects involved in the development of software and content tailored to wireless broadband platforms. In this case, would-be developers in countries where adoption of 3G networks is delayed might find that the delay in attaining critical mass eliminates their window of opportunity to compete with international rivals who are further down their learning curves and can rely on critical mass in their existing markets; the domestic firms might find themselves at simply too great a cost disadvantage and thus choose to exit the market. Particularly for an economy such as India that has significant strengths in areas such as software and content, and perhaps the potential to become a world leader in developing content delivered over mobile broadband platforms, the points raised above may, in fact, be economically very relevant.[28]

5.19 Thus while our calculation of loss is simple, it is unclear whether adding more elaborate scenarios would adjust the calculation upwards or downwards.

Policy Implications

5.20 Whichever analytical framework we choose to adopt — consumer welfare analysis or the investment multiplier approach — there is every reason to believe that deployment of 3G services will be highly valuable to societies such as China and India in terms of the consumer welfare benefits or increases in output that they produce. It also seems fairly clear that there are significant benefits involved with timely adoption of services, which in turn requires timely investment and roll-out of infrastructure.

5.21 We think that considerations of consumer welfare and social benefit are relevant considerations for policy-makers to take on board when deciding upon how to allocate spectrum for advanced wireless services. The economics profession tends towards unanimity in favouring the superiority of auctions as a means to allocate spectrum. Thus the key consideration for policy-makers is how to incorporate the social welfare considerations that we have outlined above into the general context of spectrum auctions. We do not advocate replacing auctions with beauty contests, as some industry observers have done. However, we would make the following observations:

- Where spectrum has a value primarily because it is rationed, governments need to reconsider their rationing policies. Thus to the extent that current spectrum is being used in an uneconomic manner — for example, some government bodies may have "free" access to spectrum or there might be existing spectrum reserved for redundant or obsolete purposes — governments should actively consider releasing or reusing such spectrum in

[28] As a potential example, Jerry Hausman cites the fact that the Federal Communications Commission could have allowed for the introduction of cellular mobile services in the United States as early as the mid-1970s. In the event, the FCC's failure to do so meant that commercial services in the United States were not launched until 1983. Much pioneering work in the field of cellular telecommunications was done at AT&T's research facilities in the United States, and it is possible that had the FCC allowed for the introduction of service earlier, the United States might have been able to develop a competitive advantage in mobile telecommunications similar to the competitive

market-oriented ways. This will make more spectrum potentially available for 3G services, and will promote more efficient use of existing spectrum. This will help in the expansion of 3G and 2G services alike;

- Timely and well-defined processes for auctions will send clear signals to potential investors in 3G networks. Such clarity is required at a time of acute financial crisis, as funds currently available to invest in a venture such as a telecoms network that carries a significant element of risk (to the investors) may well be migrated towards investment in "safe haven" assets, and thus not be available in the future. In this context, the Indian government has not helped its cause with the frequent delays and confusion surrounding the auctions process. It would appear that international capital in particular has been reluctant to commit to the Indian auctions process;

- In extraordinary circumstances, such as those that prevail today, it may be worthwhile to reconsider some of the parameters of the auctions process. While economists would normally warn against setting "too low" a reserve price in the auctions process for fear of facilitating collusion among bidders[29], it may be that the danger of collusion needs to be set against the dangers of barriers to entry imposed by the hard liquidity constraints that many operators today face. Again, here it is worthwhile for regulators to consider the benefits to be achieved from securing additional entry in the industry, as this may spur faster deployment of services[30];

- The impact of the spectrum licensing framework on firms' cost of capital also needs to be considered in light of the extraordinary financial constraints that face firms today. While many would argue that spectrum should be treated as a sunk cost, Robert Pindyck argues that the "returns to sunk capital are highly relevant to forward-looking investors." He argues further that a rule that deprives investors of the ability to recoup sunk costs becomes part of the forward-looking analysis for capital not yet sunk.[31] In a similar vein, it is a real

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advantages that it has tended to enjoy in many other IT-related industries.

29 This argument is best expressed in Paul Klemperer, "What Really Matters in Auction Design", *Journal of Economic Perspectives*, Fall 2002.

30 In a similar vein, Hausman has argued that the FCC held up the introduction of voice messaging services in the United States, because it was concerned about the possibility for an integrated AT&T to cross-subsidise other services with its voice messaging offering. However, he adds that the FCC never considered the fundamental comparison between the consumer surplus or consumer welfare gain from the early introduction of voice messaging services (alternatively, the consumer loss from the delay in introducing such services) against the potential loss from reduced competition. Perhaps such a

31 See Pindyck, Robert, "Mandatory Unbundling and Irreversible Investment in Telecommunications Networks", NBER Working Paper 10287, February 2004.

possibility that uncertainties surrounding the licensing and auctions policy framework in a country can affect the forward-looking cost of capital for firms that wish to invest in that country. Similarly, if inefficient current use of spectrum results in an inefficient "scarcity value" being allocated to spectrum, then that raises the barriers to entry and potentially the cost of capital for firms that wish to purchase spectrum.

5.22 These are all relevant factors for policy-makers to consider when thinking about the licensing process for 3G and other spectrum. We cannot pretend that auction design or (more broadly) the design of a socially optimal licensing framework is an analytically easy task. However, there may be greater room for consumer welfare and social benefit considerations to be incorporated into policy-makers' analysis than is currently the case.