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This is an extended version of the column that appeared in today's Exchange Daily

Broadband – How big are the benefits?

A high-speed fibre access network will transform the economy. With the goal posts now shifted from FTTN to FTTP, it becomes even more important to know if the benefits justify the $43bn needed to get there.

There is good reason to get excited about the NBN. Broadband communications promises to be an important transforming technology generating large economic benefits. Like steam and electricity, broadband communications is a General Purpose Technology (GPT) because it transforms economic relations, enhances productivity and enables new services and markets[1].

The Government's discussion paper released with its new NBN policy says only that *"a recent study has suggested that widespread access to and use of high speed broadband would expand economic activity by approximately 1.4 per cent of GDP after five years"*[2] But, it is relying on a press release as the study is not publicly available. This study and another recent study both underestimate benefits.

Local studies

The CIE published a report in June 2008 for the Competitive Carriers Coalition[3]. Its focus was on the cost of capital (WACC) sought by Telstra and did not contain estimates of national benefits as such. However, in November some inkling of its estimates appeared in the four page press release referred to above[4].

More recently, Telstra revealed that it had commissioned Access Economics (AE) to do an NBN cost-benefit study[5] and although its focus was on different roll-out scenarios, it estimates some of the national benefits.

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[1] A GPT has the following three characteristics: (a) *Pervasiveness*: It spreads to most sectors. That is why impacts should be measured at a higher level than the firm or individual sectors. Only higher levels of aggregation capture the externalities or spill-over impacts that arise at firm and sector levels, (b) *Improvement*: GPTs get better and better, lowering the costs to users and (c) *Innovation spawning*: GPTs make it easier to invent and produce new products or processes. That is, they allow us not only to do things better but to do better things. New possibilities are created and specialisation raises productivity.

[2] NBN: Regulatory Reform for 21st Century Broadband, April 2009

[3] CIE The Telstra Return on a National FTTN Network – Community Impacts, June 2008

[4] Centre for International Economics *Impact of Genuine Broadband for Australia*, November 2008. The full study has not been publicly released and the identity of the client is unknown.

[5] Access Economics, *Impacts of a high speed national broadband network*, March 2009 available at http://www.nowwearetalking.com.au/news/impacts-of-a-national-high-speed-broadband-network-125

As noted above, GPTs are game-changing. But it is difficult to anticipate how new technologies will be used or how the benefits will be generated. The AE study provides the following taxonomy of benefits but estimates only the first two:

- the costs of constructing the NBN networks;
- improvements in firm-level multifactor productivity (MFP), that is, in the productive capacity of labour and capital employed by firms, including through the better organisation of these resources;
- the introduction of an array of new services associated with high speed broadband;
- 'network' benefits whereby individuals and businesses are able to more effectively communicate remotely with the widespread adoption of High Speed Broad Band (HSBB) technologies; and
- improved convenience and choice for consumers who will be able to undertake various tasks (such as shopping, banking or planning holidays) over the network.

AE does not say what multiplier effects are applied to the $12.5bn investment it assumes for the NBN.

Both the CIE and AE focus their attention on the "productivity shock" of the NBN on each sector in the economy. They are not alone. Many studies of the economic impact of new technology focus on either labour productivity (usually output per hour worked) or MFP (which is a catch-all for about half the improvements in labour productivity which are harder to explain). Labour productivity is highly correlated with the growth in per capita GDP so it is an important metric for wealth creation and is the sum of the growth in capital per worker (capital deepening) and the growth in MFP.

Table 1: Australian Productivity Trends (% pa)

	1965-1969	1969-1974	1974-1982	1982-1989	1989-1994	1994-1999	1999-2004		1965-2008
MFP	1.2	1.6	1.0	0.8	1.0	2.3	1.1		1.1
Capital deepening	1.3	1.3	1.1	0.2	1.2	1.0	1.1		1.1
Labour productivity	2.5	2.9	2.1	1.0	2.2	3.3	2.2		2.2
Output	5.1	4.6	2.1	4.1	1.7	4.6	3.1		3.3
Inputs:									
Capital + labour	3.9	2.9	1.1	3.3	0.7	2.2	2.0		2.2
Capital services	5.9	5.1	3.3	3.7	2.6	3.7	3.4		3.9
Hours worked	2.5	1.6	0.0	3.1	-0.4	1.2	0.9		1.1

Source: Productivity Commission using ABS data

Table 1 shows these data for Australia[6]. Note that output growth is the sum of the growth in labour productivity and growth in hours worked. The studies considered below

[6] www.pc.gov.au/research/productivity/estimates-trends/trends Output is defined here by the ABS as value added in the 'market sector' and excludes General Gov't, Health, Education, Business and Property

speculate about how much growth in MFP and labour productivity will be enhanced by the NBN.

First Assume the Answer:

MFP may be a key benefit from the NBN but neither the CIE nor AE estimate it using their models. For the CIE *"a key input to the analysis is the extent of any productivity gains*" (my emphasis). AE does the same. Both use complex models mainly to work out scenario relativities (eg WACC or roll-out scenarios) and the distribution of impacts by industry or geography. In each case, the size of the benefit pie is hostage to the productivity assumptions borrowed from other studies.

The closest recent GPT analogue to the NBN is the broader class of Information and Communication Technologies (ICTs). Both the CIE and AE draw on studies of the impacts of ICT for their own NBN productivity impact assumptions.

The CIE quotes the Productivity Commission as finding that ICT investment generated a MFP growth of 0.15 to 0.2% pa over the 1990s. This is about one fifth of the MFP growth seen recently. Adopting 0.2% pa, the CIE believes that for the NBN *"it would be reasonable to expect a MFP gain of around 1 full percent over the medium term (say 5 to 6 years)"*

AE assumes a smaller gain in productivity than the CIE. It concludes from its own review of the literature that: *"economy-wide multifactor productivity levels would be around 1.1 per cent higher in an Australian economy with HSBB available everywhere relative to an Australian economy without any HSBB* (high speed broad band) *after ten years. That is, the average annual growth rates in productivity would be around 0.1 percentage points a year higher in a complete HSBB world compared with a situation where only, say, dial-up was available "* (my emphasis added).

The base-line for AE is not dial-up but 70% HSBB coverage (increasing to 90% with the NBN). Its Carrier-Grade NBN Scenario assumes around 0.05% pa extra MFP growth relative to the base-line; based on my inferences from their report[7]. AE says that the base-line scenario has 25% lower productivity; which would make the base line just 0.038% pa. The sum of these is 0.088% pa; slightly less than 0.1% pa because we are not starting with dial-up; there was 38% HSBB coverage in 2008. Note that even relative to dial-up, 0.1% pa is still only half what was assumed by the CIE[8] and only one tenth of MFP growth in Table 1 – not much of a GPT!

Sanity checks

Services, Other Personal Services, and Ownership of Dwellings. The periods are productivity cycles defined by the ABS.

[7] Table 3.2 in its report, which shows productivity shocks by 15 sectors over the 12 years to 2020, has only 15 of the 180 cells with 0.1% or more. The 0.05% was estimated in a simple spreadsheet model.

[8] If the CIE's reference point is not dial-up, Access Economics is even more conservative.

Steam was one of the first GPTs. James Watt invented the steam engine in 1769 and the first railway operated in 1830. But high pressure steam was the real breakthrough and it did not get deployed until after 1850. Nick Crafts, an economic historian at Warwick University, says that steam added 0.2% pa to labour productivity between 1830 and 1850 and 0.4% pa between 1850 and 1870 and 0.3% pa between 1870 and 1910[9]. Note that it took a very long time before James Watt's breakthrough had any significant effect on labour productivity growth. This long lag reflected the time it took to improve the technology so that steam power became cost effective and the relatively limited extent to which the cost of steam power fell − in 1910 it was about 1/8th of the 1760 level.

Table 2: Steam's Contribution to UK Labour Productivity

	1800-30	1830-50	1850-70	1870-1910
Steam - Capital deepening	0.02	0.16	0.2	0.15
- MFP growth	0	0.04	0.21	0.16
- Labour productivity	0.02	0.2	0.41	0.31
Total - MFP growth	0.4	0.5		0.2
- Labour productivity	0.5	1.2		0.9

Source: Crafts, 2004 (Tables 1 and 6)

From Table 2, when steam got going it contributed about a third and half of labour and MFP growth respectively.

The extra 0.2% pa MFP growth is similar to the 0.2% assumed by the CIE but it is too conservative to equate the NBN with steam: *"The impact of ICT on the rate of productivity growth exceeded that of steam in any period even at the time of the so-called Solow productivity paradox while since the mid-1990s the MFP growth contribution in the US has been about 3 times the peak of steam in the UK. These results may suggest that society is getting better at rapid exploitation of general purpose technologies which might reflect more investment in human capital, greater government support for R & D, superior scientific knowledge and/or better capital markets"* (Crafts).

Also, the CIE reports the OECD as saying that broadband will replicate and even exceed the economic gains from use of previous GPTs including ICT at large.

A recent study by LECG[10], concludes that there is evidence that each additional 1% penetration in broadband lines will increase productivity by 0.1% points pa. In 2008 the fixed broadband line penetration rate was 23.3% in Australia[11]. So, if we take the 90% coverage by 2016 forecast by AE and assume, say, 75% take-up[12] then the fixed line

[9] Crafts, N. (2004), *Steam as a General Purpose Technology: a Growth Accounting Perspective*, Economic Journal, 114, 338-351

[10] LECG *Economic Impact of Broadband: An Empirical Study*, February 2009 available at www.connectivityscorecard.org

[11] ABS Cat. 8153.0 reports 5.7m broadband lines of which households are 4.9m and both include 0.8m wireless lines relative to 21m population. Including mobile broadband, the penetration rate is 27.1%.

[12] Access Economics says coverage will be 90% and business adoption will be 90% but does not make it clear what it assumes for households.

penetration will be 67.5% for an average annual increase from 2008 of 5.52%. Applying the LECG productivity factor to this increase leads to an increase in MFP growth of 0.55% pa which is ten times larger than assumed by AE and about three times larger than assumed by the CIE.

The LECG estimate is based on regression analysis of international data on broadband penetration and its economic impacts. A more commonly used approach is "growth accounting"[13]; which is the framework used in Table 1 above.

Table 3 below shows growth accounting estimates of the impact of ICTs in the US[14]. Since Australia has a much smaller IT producing sector than the US, the 0.55% pa derived from the LECG study may be around the limit of what we should expect. It is also about half of recent MFP growth in Table 1 so it is a significant (GPT-like?) change.

Table 3: Contributions to Growth in US Labour Productivity (% pa)

	1973-1995	1995-2000	2000-2006
MFP			
- IT sector	0.28	0.75	0.51
- Other	0.15	0.38	1.17
Capital deepening			
- IT sector	0.46	1.11	0.61
- Other	0.30	0.02	0.24
Labour quality	0.27	0.26	0.34
Total = labour productivity	1.47	2.51	2.86
Memo: Total IT	0.74	1.84	1.12

Source: Oliner et al, 2007

Access Economics mentions a number of studies that it has examined for inspiration. It seems to give special consideration to the Crandall[15] and ACIL Tasman[16] studies, which breakdown productivity impacts by sector, because these can be used to inform its own multi-sector model.

[13] Conventional studies of economic growth stem from the growth accounting framework pioneered by Solow. This approach is based on the economic assumptions of perfectly competitive markets and constant returns to scale in production. The first permits labour and capital inputs to be added as each are paid their marginal product. The second means that returns to inputs should sum to the value of output. With this framework, there is an unexplained gap (the "Solow residual", "MFP" or "technological progress") between output growth and the weighted increase in labour and capital inputs.

[14] Oliner S, Sichel D and Stiroh K *Explaining a Productive Decade*, Federal Reserve Board, August 2007

[15] Crandall R, Lehr W, Litan R *The Effects of Broadband Deployment on Output and Employment: A Cross-Sectional Analysis of US Data*, 2007

[16] ACIL Tasman *Economic Impacts of Broadband Adoption in Victoria*, prepared for Multimedia Victoria, Melbourne, June 2004

The Crandall econometric study found that a 1% increase in fixed broadband penetration increased US non-farm output by 0.46%[17]. And, given the AE projection of an average increase in penetration of 5.52% mentioned above, this implies Australian non-farm GDP could be 2.5% higher in ten years with the NBN. But AE estimate that GDP will be just 0.6% higher.

The ACIL Tasman study used by AE assumes average labour productivity growth of 0.23% pa. Without any growth in capital deepening, the increase in MFP growth would be the same and much higher than assumed by AE. The ACIL Tasman study also says that the Victorian economy could be 5.3% to 9.5% higher with broadband after ten years. At least, the latter agrees with AE's conclusion that if there is slack in the economy, the benefits could double.

The bottom line

The NPV of AE's 0.6% higher GDP Carrier Grade Scenario is $25bn, which looks conservative relative to the CIE estimate that the NBN would raise GDP by 1.4% after only 5-6 years; which has an NPV of $33bn (or $101bn extrapolated over ten years).

If productivity benefits are nearer the 0.5% pa discussed above, the NPV of increased GDP could be $182bn[18]. While this looks promising, the range of estimates suggests that more work needs to be done to get a clearer picture of the benefits we can expect from the NBN.

JdR 9 April 2009

[17] The study did not try to estimate productivity impacts because consistent capital stock data across states was not available.

[18] From Table 1, MFP has been around 1.1% pa but this could grow to 1.6% pa with the NBN using the 0.55% pa boost to MFP based on the LECG study and AE coverage assumptions. Assuming the contribution from capital deepening remains around 1.1% pa leads to labour productivity growth of 2.7% pa. Output growth is equal to the sum of growth in labour productivity and hours worked. Assuming hours worked continue to grow long term at around 1% pa (we shall get over the emerging recession) leads to GDP growth of 3.8% pa. This is about 0.5% pa higher than trend and leads to GDP around 4.5% higher in 2018 than without the NBN.

Post-script: Approximations may be flawed but the benefits are there

The analysis above assumes that AE's coverage assumptions are based on population. But it seems more reasonable to interpret these as based on households. This note explains why and what it means for the benefits of the NBN.

The reason for this re-interpretation is that few households need more than one fixed broadband connection. Assuming 90% population coverage exceeds this requirement. If instead we assume that AE's 90% NBN coverage refers to households (which may be what it intended) and 75% take-up, then we get 67.5% household penetration which we have to convert to population penetration to apply the LECG algorithm.

Assume 8m households and 21m population in 2016. Then, we have 5.4m household fixed broadband connections (76.5% x 8m) which we scale up by 4.9/4.1 (the ratio of total to household fixed broadband lines in 2008) to get 6.45m total fixed broadband lines. Dividing by 21m gives 30.7% population penetration.

Household take-up could be as much as 100%. In this case, the population penetration becomes 41% instead of 30.7%.

Fixed broadband population penetration in 2008 was 23.3%. So, averaging the increase over 8 years and applying the LECG factor gives either 0.09% or 0.22% pa increase in productivity for 75% and 100% household take-up respectively.

The higher take-up assumption leads to a productivity increase similar to that found by the CIE; but based on an empirically estimated relationship between broadband and productivity.

These back-of-the-envelope estimates probably understate the benefits of broadband. As with telephony before it, there will be strong network effects as fixed broadband becomes ubiquitous. The above estimates are based on either the experience of ICTs generally (CIE and AE) while broadband will have larger transformational impacts or the early experience of broadband adoption (LECG) before penetration has passed any "tipping point" that will cause a surge in benefits that will come with ubiquity.

Further estimation of fixed broadband benefits using the approaches described above is not likely to be useful. But there are "bottom-up" approaches (see the UK Broadband Stakeholder Group reports) which should be considered. Any analysis would also have to look at the interplay of fixed and mobile broadband.

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