

# Impacts of a national high-speed broadband network

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Report by Access Economics Pty Limited for  
**Telstra Corporation Limited**



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## Executive Summary

This report explores and quantifies the economic importance of expanding the coverage of high-speed broadband (HSBB) to the Australian economy under a range of different scenarios. Using the latest literature, economic data, coverage maps and subscriber numbers, the current and future impact of broadband has been modelled for the period from 2009 to 2020.

The rapid evolution in information and communications technologies (ICTs) over the recent decades has transformed societies and economies throughout the globe. The latest and perhaps most far-reaching phase in this transformation is underway with the rollout of HSBB in most developed and many developing economies.

The net benefits to flow from the rollout of HSBB will depend on the timing, scope and precise technological specifications of the investments. Telstra has commissioned Access Economics to assess the economic impact of various options for HSBB for Australia.

The Australian Government is currently evaluating tenders for funding for a National Broadband Network (NBN). The proposed NBN would represent an important, but far from the sole, investment in a broader suite of investments in HSBB in Australia. Indeed, competing or complementary networks have already been established, especially in city centres, and additional investment in both wired and wireless technologies is underway. Accordingly, the research in this report should be viewed as assessing the impact of future investments in HSBB including possible investments under the NBN. It is not narrowly dependent on future decisions to be taken on the NBN.

HSBB will affect economic performance through a variety of influences including:

- the costs of constructing expanded HSBB 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 HSBB;
- 'network' benefits whereby individuals and businesses are able to more effectively communicate remotely with the widespread adoption of 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.

The assessment of the magnitude of the economic impact of HSBB is made especially difficult by:

- the newness of rollout of the technology;
- the fact that the impact is diffuse, affecting activities in virtually all areas of the economy; and
- the complications involved in disentangling the additional benefits that accrue from HSBB from the existing communications networks, including the existing patchwork of broadband services.

Nevertheless, estimates of economic impact of at least some of the channels involved can be derived from various partial studies of the rollout of various forms of broadband

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internationally as well as lessons from analysing the effect of investment in ICT over the past two decades. Indeed, one of the main themes emerging from the empirical literature on the role played by ICT is that the boost to productivity has been sizeable while the effects have been spread out over an extended period.<sup>1</sup>

In light of the inherent difficulties involved in identifying and quantifying the various economic effects of HSBB, the estimates derived in this report should be regarded as providing preliminary estimates of the magnitude of key aspects of the total economic impact as well as providing evidence on the relative size of the net benefits that may accrue from different rollout options.

### **Estimation of the net benefits from HSBB**

The analysis uses a general equilibrium model of the Australian economy that has been modified for the purpose. The analysis only evaluates the first two of the economic influences cited above, that is, it evaluates the net economic benefits that flow from the direct capital costs of the infrastructure investment and the direct effects of HSBB on productivity of each sector in the economy. Accordingly, the results are likely to understate the total net benefits to the extent that, *inter alia*, network effects and the improvement in convenience and choice for consumers are excluded from the analysis.

The primary direct effect of HSBB is one of bandwidth, allowing businesses and households to access a faster data service than would otherwise be possible. From this direct effect, productivity improvements are unlocked.

To understand and quantify what this direct effect on bandwidth will be under different scenarios, detailed spatial modelling has been conducted, bringing together likely coverage maps, technical constraints, cost considerations and the location of demand by high-speed broadband customers of different types. A combination of the productivity estimates of HSBB from other studies, and the coverage implications of specific HSBB coverage network possibilities in Australia, were combined to estimate productivity impacts of the rollout.

The direct impacts on productivity for each sector have been constructed using evidence drawn from research into aspects of the impact of the introduction of various ICTs including the impact of the Internet and low-speed broadband networks. This research provides useful information that has been used to inform the estimates of the direct productivity impacts of high-speed broadband for different sectors of the economy.

Finally, the direct sectoral productivity gains arising from broadband use, along with the costs associated with the construction of the infrastructure, were then fed into the general equilibrium model to estimate the macroeconomic impacts.

The precise form that Australia's HSBB is likely to take is yet to be fully determined and those specifics can have a material effect on the economic benefits to accrue. Three aspects of the rollout may be especially important, namely:

- the time period over which the rollout occurs;

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<sup>1</sup> ACIL Tasman (2004)

- which parts of the country first receive HSBB. In particular, the speed with which the benefits from HSBB may build will depend on whether the investments are made in the more densely populated parts of the country first; and
- the quality of the technologies employed. The quality of the services being provided can be viewed as being a combination of speed and reliability and will be affected by the technologies used, the distance to nodes, the capacity of the 'core' and amount of competing traffic. Thus, achieving a minimum speed of, say, 12 or 50 Mbps can translate into quite a different level of service on a consistent basis depending on the various dimensions of the network. Also, currently, telecommunications is subject to higher ('carrier-grade') standards of reliability while Internet based technologies have been built on a 'best-efforts' standard. If something akin to a carrier-grade standard is to be achieved for HSBB, significant capital expenditures will be required in upgrading the existing network including investment in the Customer Area Network (CAN) rehabilitation.

Six scenarios along with a reference case have been considered in order to assess the impact of specific aspects of an expanded HSBB infrastructure. These scenarios have been informed in part by the parameters set out in the Government's current tender for its NBN.

As noted above, HSBB has been rolled out in pockets of Australia, especially in densely populated areas, and some continuation of this could be expected without significant changes in approach by Government or industry. However, without major investment decisions being taken, the rate at which this rollout occurs is set to slow due to emerging industry constraints, including the need to upgrade parts of the 'core' of the network.

The economic benefits to flow from HSBB will depend, in part, on the state of the economy at the time of the investment. The net benefits will be lower if the economy is operating near capacity than if there are under-utilised resources in the economy. Normally, general equilibrium analysis assumes that the economy is operating near capacity and accordingly most of the results presented below adopt this assumption.

However, with the Australian economy slowing and forecast to continue to weaken, it is likely that an early rollout of HSBB would occur at a time when resources, especially labour resources, are not being fully utilised and the rollout could provide additional stimulus. Accordingly, the final scenario considers the net economic benefits under the assumption that additional labour resources are readily available.

Against this background, the scenarios considered are:

- **The Reference Case:** An estimate of what would happen to Australian broadband rollout over the projection period, and resulting bandwidth changes, without a quantum decision to upgrade the infrastructure such as through the NBN.
- **Scenario 1 – Carrier Grade:** Assumes rollout of the network commences in 2009, completed by 2016, with rollout of 12 Mbps + services ultimately to 90% of the population serviced by a VDSL based fibre to the node network. Deployment is 'inside-out', starting from the highest population density areas currently without service and progressively serving areas in descending population density order until the 90% coverage is reached by 2016. Service is carrier grade with full CAN rehabilitation allowing for greater service reliability and enhanced applications.

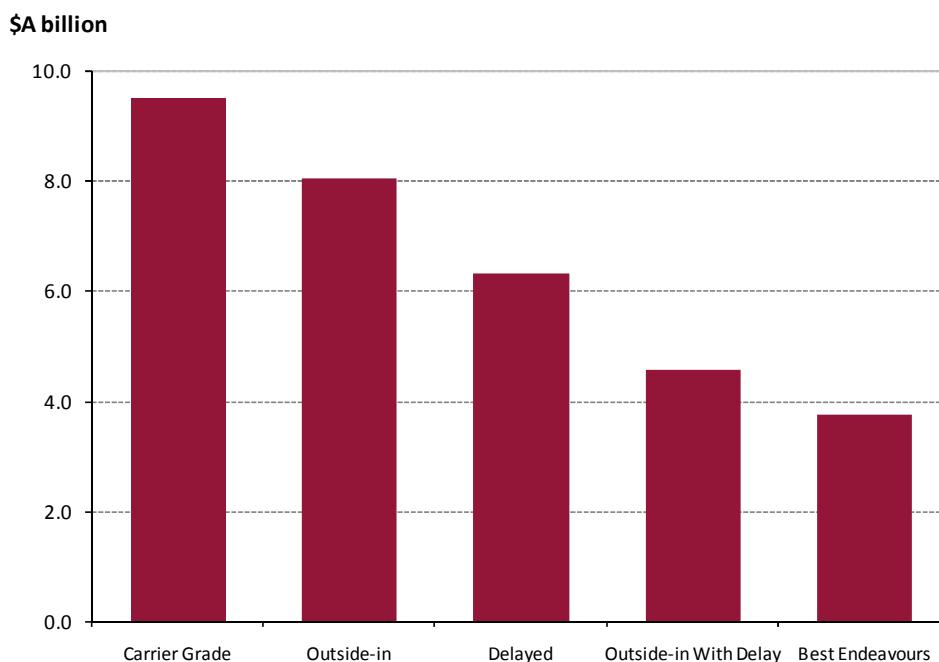
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- **Scenario 2 – ‘Outside-in’ Deployment:** The same as for Scenario 1, but the deployment pattern from Scenario 1 is reversed.
  - **Scenario 3 – Delayed Introduction:** The same as for Scenario 1, but with a 2-year delay on commencement, meaning that rollout commences in 2011 and is not finished until 2018.
  - **Scenario 4 – ‘Outside-in’ Deployment with Delay:** The same as for Scenario 1, but with both an ‘outside-in’ deployment pattern (the lowest population density areas below the 90% coverage threshold served first, the most densely populated areas without coverage served last) and a 2 year delay to the rollout commencement and completion.
  - **Scenario 5 – ‘Best Endeavours’ Reliability:** Similar to Scenario 4 (delayed and ‘outside-in’ deployment pattern), however at completion the network reaches 98% of the population (instead of the 90% of the other options) due to an additional (though costly) wireless component. In this scenario, there is no CAN rehabilitation and hence service reliability is less than for the other scenarios and there is less potential for enhanced applications.
  - **Adjusted Scenario 1 – Carrier Grade in a time of higher unemployment:** Based on Scenario 1 but with the assumption that the labour market adjustments due to HSBB deployment occur through an increase in employment rather than real wages, simulating the effect of the network being built in a time of rising and higher unemployment.

The key results for the first five of these scenarios are presented in Chart I. They show that, compared with the reference case, the net present value (NPV) of the economic benefits from the Carrier Grade option with inside-out deployment (Scenario 1) is approximately \$A 9.5 billion.<sup>2</sup>

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<sup>2</sup> The NPV calculations are based on the period from 2008 to 2020 and assume a real discount rate of 7.0%.

**Chart I: NPV of GDP Impacts – 2008 to 2020\***



(\*) Expressed in 2008 dollars.

An alternative way of interpreting the results is to compare the scenarios against each other, rather than against the reference case. A comparison of the Carrier Grade option and the Outside-in option indicates that the net cost to the Australian economy of an outside-in deployment pattern is \$1.4 billion over the period 2009-2020. This represents a 16% decline in the positive economic contribution of HSBB.

Additionally, the cost to the Australian economy of a two year delay in extending the coverage of HSBB is \$3.2 billion over the period 2009-2020. This represents a 34% decline in the positive economic contribution of HSBB.

A comparison of the Carrier Grade option and the Outside-in With Delay option suggests that the cost to the Australian economy of *both* a two year delay and an outside-in deployment pattern is \$4.9 billion over the period 2009-2020. This represents a 52% decline in the positive economic contribution of HSBB.

A comparison of the Carrier Grade option and the Best Endeavours option indicates that the cost to the Australian economy of also adopting a lower quality network build design along with a two year delay and an outside-in deployment pattern is \$5.7 billion over the period 2009-2020. This represents a 60% decline in the positive economic contribution of HSBB.

### **Estimating the stimulus in an economy with unemployed resources**

The above results are from a modelling baseline that assumes the economy is already operating near capacity and resources need to be drawn from other productive activities to rollout the HSBB. In these circumstances, wage rates are bid up and employment is increased by a moderate amount through inducing people into the workforce. Most of the response in

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the labour market for Scenarios 1 to 5 is through higher real wages rather than increased employment levels.

In light of this recent weakening in the economy and the likelihood that unemployment will continue to rise, the assumption that the resources needed for the HSBB would all be employed elsewhere without the rollout proceeding is problematic. Rather, in an economy operating at less than full employment, the investment in the HSBB will act to stimulate economic activity and – either directly or indirectly – reduce the level of unemployment. In these circumstances, much of the labour market adjustment will be felt through increased employment levels rather than higher real wages.

In order to capture the effect of the rollout in an economy with idle resources, Adjusted Scenario 1 estimates the effects of the Carrier Grade option (Scenario 1) but with the additional assumption that labour is readily available at the prevailing level of real wages. This results in additional productive resources returning to the economy – that is, additional stimulus – and a noticeably larger increase on economic activity:

- The net present value of the benefits is estimated to be \$21.0 billion, more than double the \$9.5 billion for the Carrier Grade option.
- The benefits are realised in the form of higher employment. In the initial construction phase, employment increases by 0.36 per cent in 2010 (compared to only 0.12 per cent in the Carrier Grade option):
  - This corresponds to approximately 31,000 full-time equivalent jobs in 2010.

The assumption that labour is available without any changes to real wages at all may not be strictly met even if there is a high level of unemployment. Nevertheless, this scenario highlights how the benefits from the HSBB rollout would be of even greater value in times of a weaker economy characterised by higher unemployment.

### **Key conclusions**

There are several key conclusions arising from this analysis:

- The newness of the development of HSBB combined with the diffuse nature of its benefits means that any assessment of the net economic benefits to be garnered from the expansion will be subject to a large degree of uncertainty. The timing of the impacts is particularly difficult to assess. Greater confidence attaches to the relative size of the net benefits across the various scenarios.
- All of the scenarios modelled have a positive NPV over the reference case, meaning that the benefits outweigh the costs in all cases. In other words, the expansion of coverage of HSBB in any of its forms is an economically beneficial project to be pursuing when compared to the option of doing nothing.
- The Carrier Grade option has the greatest NPV, despite its higher construction cost. The additional cost of this network is more than compensated for by its greater aggregate benefits.
- Importantly, the positive economic benefits increase the faster the continued rollout of HSBB occurs, and the more it is first directed to the most densely populated areas of the economy not yet serviced by HSBB. Furthermore, these benefits also increase with a

higher grade of service, for example a carrier grade service with full CAN rehabilitation, despite the higher costs of providing these quality services.

- The positive economic benefits will be noticeably greater in times of a weak economy and higher unemployment, and they will be realised in different ways. In particular, more of the benefits will accrue through a boost to employment rather than in the form of higher real wages.
- The benefits captured in this modelling are likely to understate the overall long-term gains. In particular, some of the beneficial impacts on households cannot be reliably quantified, especially as they relate to household convenience, entertainment value and time savings, nor can the network benefits that flow from faster bandwidth in creating a more interactive society be measured.



## 1 Background

Access Economics was commissioned by Telstra Corporation Limited to undertake an analysis of the economic impact of the rollout of a high-speed broadband (HSBB) network across Australia, reaching some 90% of the Australian population. It is expected that there will be significant economic and social benefits of providing internet access at speeds of 12 Megabits per second (Mbps) or higher to a large proportion of the population.

The Australian Government is currently evaluating tenders for funding for a National Broadband Network (NBN). The proposed NBN would represent an important investment in HSBB although this should be seen as part of a broader suite of investments in HSBB in Australia. Indeed, competing or complementary networks have already been established, especially in city centres, and additional investment in both wired and wireless technologies is underway. Accordingly, this report assesses the impact of future investments in HSBB including possible investments under the NBN.

This report makes use of past literature regarding the productivity and other economic benefits of both 'traditional' broadband and high-speed broadband networks to determine productivity impacts of such a rollout, primarily for businesses. This is combined with spatial modelling that considers the timing and geographical pattern of construction of a high-speed network, as well as a series of estimates about demand and timing of adoption of the technology by different industries.

Access Economics' Computable General Equilibrium Model (AE-GEM) is used to convert these estimates of rollout patterns, cost, adoption rates and productivity impacts into an overall figure for the economic impact of a high-speed broadband rollout to the Australian economy. A series of scenarios are quantified, in order to assess how the results vary when some of the assumptions are altered, particularly with regards to timing and rollout patterns.

The structure of the report is as follows:

- The remainder of Section 1 details the scope of the economic analysis in this report, including what potential impacts are not considered.
- Section 2 outlines the scenario design, including the different scenarios estimated, and details of the spatial modelling.
- Section 3 provides a review of the available literature considering qualitative and quantitative productivity and economic impacts of different types of broadband, leading into a discussion of the literature-based productivity shocks used in the modelling and the way it integrates with the spatial modelling.
- Section 4 details the direct impacts of the HSBB scenarios, primarily in terms of coverage, cost and service take up.
- Section 5 discusses the results of the CGE modelling, including comparisons between the various scenarios.
- Section 6 provides some concluding observations.

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## 1.1 The scope of the analysis

The introduction of a national HSBB network will affect many dimensions of the operation of businesses as well as the daily activities of individuals (for example, shopping and banking). Many of the effects will only become evident over a period of years, even decades. Accordingly, it is not possible to fully articulate all possible channels through which HSBB may affect economic performance.

Consequently, this modelling exercise does not pretend to capture all of the value of either HSBB or, more specifically, the NBN. It is important to note the specific economic influences that have been measured by the quantitative methodologies employed in this analysis, and the limitations of the approach.

Estimates of the direct productivity impacts at the sectoral and whole-of-economy level can be assessed and incorporated into the full modelling analysis. An example of a direct effect is the time saving to a business as a result of HSBB adoption. All other variables remaining the same, the business can then either produce more output for the same cost, or produce the same output for reduced cost.

More complex general equilibrium models can also capture flow-on effects; that is, effects experienced by others who are linked through the economic system to those facing the direct impacts. To continue the above example, where a business experiences time saving and a resulting productivity improvement due to HSBB adoption, given cost competition and where multiple businesses within an industry have received (or have the potential to receive) HSBB, the customers of this industry will benefit in the form of lower prices. This benefit to customers is a flow-on impact.

Accordingly, the initial productivity effect to the industry consuming the HSBB (that is, the change that drove the subsequent impacts) is considered the 'shock', along with the effects of the construction of the network itself. Impacts of this sort are well captured in a productivity analysis and CGE modelling based framework, as used in this project.

In contrast, other types of effects will be very difficult to reliably quantify. One such effect, relating to the accuracy of the productivity impacts used, relates to what is known as the 'network effect', whereby the marginal benefit to each user of a technology such as HSBB increases with each additional user. As a simple example to illustrate the network effect, a lone broadband user in a world of narrowband users would not benefit from their broadband access to the same extent as a broadband user in a world of many broadband users. As the broadband market grows, the possibilities for broadband users also grow, as broadband specific applications and content are progressively developed. Furthermore, there will be more users with the ability to share two (or more) way communication applications, requiring HSBB from all ends. The aggregate productivity impacts are not a linear function of adoption, as our approach here implicitly assumes.

Another more general impact of HSBB, indeed digital information transfer in general, is undoubtedly its role in knowledge transfer and the decision-making processes in our societies. Through the instant and inexpensive transfer of digital data, information has become cheaper, deeper and more accessible and useable than ever before. Thanks to networks and the Internet, the marginal social cost of accessing and using information becomes close to zero. Not only is access seamless and largely costless in a marginal sense, one person's use of digital

information via broadband does not generally limit the possibility of another from also using it, unlike, for example, a book from a library or a seat in a public conference.

Furthermore, any individual connected to the Internet from virtually anywhere can now access a mass of information with minimal searching, and the higher the bandwidth, the greater the amount of easily accessible information. Just as the price of a million instructions per second (MIPS), or of other units of information, has fallen by a factor of thousands over recent decades, relative to a piece of manufacturing equipment, so too has the cost of transferring that information.

When relative prices change in these proportions, we need to be cautious about interpretations of aggregates that must use such pricing weights. As Negroponete (1995) explains, bits and bytes have replaced atoms as the medium for information exchange and dissemination. While many of the benefits of using ICT can be captured by an economic model, such as the cost savings to businesses in general, the overall impact of a more knowledgeable society inevitably involves some non-measurable effects. The relevance of this is illustrated in the changing, and indeed critical, role of knowledge in today's society.

The new information age may also impact upon lifestyle, whereby individuals turn away from the use of some physical goods towards essentially free information goods. Household and business locational decisions may also change through, for example, the increasing telecommuting possibilities that HSBB can facilitate. The resultant benefits to overall economic welfare of such social and environmental impacts of altered locational decisions are not captured in a CGE framework.

Similarly, other benefits not readily expressed in monetary terms and hence not fully captured in the CGE framework include the additional choice that HSBB affords individuals as well as the improved convenience that digitally delivered services provide in delivering a variety of services such as financial transactions or some forms of entertainment. In short, measures of productivity and GDP, as used in this project, are useful but necessarily incomplete measures of all items of value, and fall short of the idealistic economic notion of aggregation of everyone's individual well-being (utility). Accordingly, to the extent that benefits associated with network effects, choice and convenience have not been captured in this modelling, the potential benefits from the establishment of HSBB throughout society are likely to be understated, particularly over longer time periods.

In summary, this report attempts to quantify the following impacts of HSBB:

- the costs of constructing expanded HSBB networks;
- the improvement in productivity that results from being able to convey data (in its various forms) more cheaply, rapidly and in much larger amounts; and
- the flow-on economic effects.

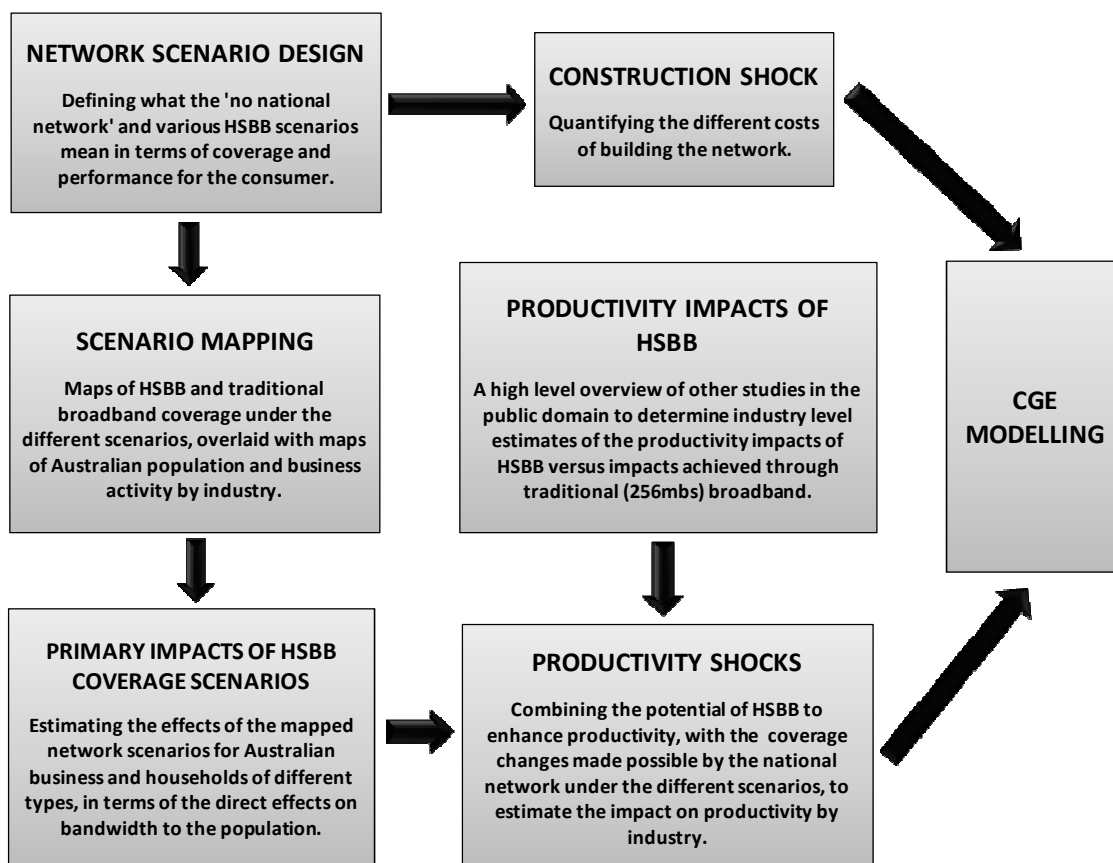
## 2 Approach

Our approach to modelling the potential impacts of a national HSBB network on the Australian economy involves a general scenario design task, a review of the literature on the productivity impacts of ICT and broadband technologies, followed by three discrete modelling tasks. The specific steps involved are as follows:

- Scenario design – quantifying what the potential HSBB scenarios mean in terms of key market parameters such as performance and coverage.
- Scenario mapping – articulating how the HSBB scenarios affect costs and demand by households and businesses over time.
- Quantifying and describing the direct impacts on business productivity and capital costs involved in setting up the network. In the first instance, this involves a general literature review of the impacts of ICT and broadband technologies on productivity, leading to specific estimates on the impacts of HSBB. When combined with the scenario mapping, this provides the basis for productivity estimates for the various scenarios modelled.
- Estimating the flow-on and overall economic impacts of the cost of the network and direct impacts on business productivity on key economic variables such as GDP, employment, investment and trade.

These steps, and the way they relate, are illustrated below.

**Figure 2.1: Modelling the economic impacts**



## 2.1 Scenario design

Overall six HSBB scenarios are considered, each reflecting possible network design, timing, cost and quality parameters. In addition, a reference case where the HSBB network does not proceed as proposed – a ‘no national HSBB network’ – scenario is considered.

The six HSBB scenarios are designed to explore the impacts of decisions over the speed and coverage of the roll-out, the quality of the infrastructure being provided and economic circumstances that prevail at the time of the rollout. The scenarios considered are:

- **Scenario 1 – Carrier Grade:**
  - Rollout of the network commences in 2009.
  - Completion of the rollout is in 2016, with rollout of 12Mbps and services spreading ultimately to 90 per cent of the population serviced by a VDSL based fibre to the node network.
  - Deployment is ‘inside out’, starting from the highest population density areas currently without service and progressively serving areas in descending population density order until 90 per cent coverage is reached by 2016.
  - Service is carrier grade with full Customer Area Network (CAN) rehabilitation allowing for greater service reliability and enhanced applications.
- **Scenario 2 – ‘Outside-in’ Deployment:**
  - The same as for Scenario 1, but the deployment pattern from Scenario 1 is reversed (that is, ‘outside in’ deployment).
- **Scenario 3 – Delayed Introduction:**
  - The same as for Scenario 1, but with a 2-year delay on commencement, meaning that rollout commences in 2011 and is not finished until 2018.
- **Scenario 4 – ‘Outside-in’ Deployment with Delay:**
  - The same as for Scenario 1, but with *both* an ‘outside in’ deployment pattern and a 2 year delay to the rollout commencement and completion.
- **Scenario 5 – ‘Best Endeavours’ Reliability:**
  - Similar to Scenario 4 (delayed and ‘outside in’ deployment pattern), however at completion the network reaches 98 per cent of the population (instead of the 90 per cent of the other options) due to an additional wireless component.
  - There is no Customer Area Network (CAN) rehabilitation, hence service reliability is less than for the other scenarios and there is less potential for enhanced applications. As a result, take up rates of HSBB are 10 per cent lower and marginal productivity gains are 25 per cent lower than in Scenario 1.
- **Adjusted Scenario 1 – Carrier Grade in a time of higher unemployment:**
  - Based on Scenario 1 but with the assumption that the labour market adjustments due to HSBB deployment occur through an increase in employment rather than real wages, simulating the effect of the network being built in a time of rising and higher unemployment.

The scenarios have been designed to illustrate the dimensions of the likely net economic benefits under varying circumstances but the precise details of each is subject to judgement on

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key inputs to the modelling. Of particular relevance is the treatment of the quality of the infrastructure as illustrated in the difference between the 'Carrier Grade' and 'Best Endeavours' options (Scenarios 1 and 5 respectively). The ability to deliver HSBB at sufficient speed and reliability throughout the day will be dependent, *inter alia*, on the number and locations of nodes, the infrastructure used in rolling out the services to a broader base and the investment in upgrading – and continuing to upgrade – the existing network (including the rehabilitation of the CAN).

The 'Best Endeavours' option depicts an approach that would deliver basic broadband services but without ensuring a reliable service. The option can be viewed, for example, as meeting the minimum standards set out in the NBN. The option could be delivered at a lower cost than the Carrier Grade option but the reduced quality would translate into lower gains in productivity and reduced take-up rates. Some innovative services that may be associated with Carrier Grade quality would be less common without the CAN rehabilitation and associated deployment of technologies such as packet switching that comes with the deployment of a higher 'quality' national HSBB network.

(The precise assumptions used to depict that 'Best Endeavours' option involve lowering the post-2008 takeup rate of HSBB by 10 per cent and the productivity gains by 25 per cent. In addition, this scenario incorporates a wireless component to the national HSBB network, taking high-speed coverage from the 90 per cent achieved with VDSL FTTN network to 98 per cent, but with the inferior quality aspects included. The scenario includes a cost saving associated with no CAN rehabilitation, and less customer cutover expenses (a direct function of fewer customer numbers), but includes an additional wireless component with associated costs.)

## 2.2 The reference case

The development of a reference case (or counterfactual) is a critical component in assessing the impact of a national HSBB network, as proposed. The reference case provides a profile of economic activity in the absence of the HSBB network investment. It is impossible to determine the economic impact of the proposed HSBB network without an estimate of what the economy would look like in its absence. This means that a further scenario must be modelled; a scenario reflecting what is likely to happen if the HSBB network does not go ahead as planned.

Even without the national HSBB network scenarios modelled here, technologies will continue to advance, broadband and more limited HSBB infrastructure will continue to be deployed, prices for the same product would continue to fall beyond where they are currently at and take up rates would continue to increase, just as they have done so in the past. Competitive forces and innovation, along with other government policies, will continue to drive rollout of higher speed broadband than the prevailing level, as they have for many years and as they do across many other industries, even in the absence of this specific program aimed at expanding the HSBB network.

However, in the absence of a national HSBB network as planned, developments will be at a slower pace and some developments, such as the open access nature of the network, may not be achieved at all in the foreseeable future. For the economic modelling to be an accurate reflection of the likely impacts, the scenario design therefore must also include credible forecasts about not just what will happen with the national HSBB network as proposed, but also what would happen in the absence of such a network.

In determining the reference case, two estimates are derived. Firstly, the situation where no further investment in faster bandwidth technology takes place and speeds remain at 2008 levels is considered; secondly, a case where existing trends in speed and investment continue through to 2018 is estimated. Note that this is not a linear path; bandwidth to the population has been increasing at an exponential rate since data service first began to emerge. However, it is understood that the industry is facing technological constraints that make a continuation of past trends in bandwidth increase unlikely in the absence of an initiative along the lines of a national HSBB network.

The modelling presented below adopts a midway path for coverage between these alternatives. That is, the reference case assumes that, without explicit action to expand the national HSBB network, technology and bandwidth would continue to increase but at a noticeably greatly reduced rate than trends seen over the past few years because of the emerging industry constraints. This scenario is discussed in Section 4.1 (identified as the solid red line on Chart 4.2).

As previously noted, the reference case also includes 25 per cent lower productivity and 10 per cent lower take up for those receiving service from the forthcoming network, reflecting the absence of the service quality that comes through CAN rehabilitation.

Conceptually, this 'no national HSBB network' scenario becomes crucial in the economic modelling; it is the scenario or base case against which the other scenarios are compared, otherwise known as the reference case scenario. The comparison of the various HSBB scenarios against the 'no national HSBB network scenario' is used to define the national HSBB network's potential impacts.

### 2.3 Scenario mapping, cost and coverage modelling

Scenario mapping links the conceptual scenarios outlined above to their eventual economic impacts. This depends on each scenario's ability, over time, to supply HSBB broadband to customers who demand it and hence unlock the potential productivity gains that HSBB has to offer (as identified in Section 3).

Each of the coverage scenarios have been mapped, using geographical information system (GIS), to provide a basis for analysing the coverage impacts of the different HSBB scenarios. As much as possible, this exercise reflects the location of existing telecommunication services, the technical limitations facing future supply, and the likely location of customer demand. The specific steps involved in developing these maps, and using them to calculate HSBB cost and coverage implications for different industries of the economy, are summarised in the six steps set out below:

1. **Current (2008) broadband and HSBB coverage.** GIS data on telephone exchanges, telephone exchange boundaries, ADSL and ADSL 2+ status have been used to map available broadband speeds across Australia. The key assumption here is that, for exchanges currently enabled with ADSL2+ (of which there are 1404 out of a total of 5069 exchanges), those within 2.5 km (1.8 km radial distance) are assumed to already have access to at least 12Mbps broadband services. This represents approximately 38 per cent of the population and a slightly higher proportion of total businesses. Some of the same areas covered by ADSL 2+ also have fibre coverage, another source of current 12Mbps+ broadband. These areas with existing coverage, and the households and businesses they contain, are not directly affected by any of the future HSBB network

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scenarios in a coverage sense, with the future HSBB networks primarily directed at areas currently without existing coverage.

2. **Future (2016) HSBB network coverage.** Population densities throughout Australia were mapped using Australian Bureau of Statistics (ABS) collector districts (38,081 such areas throughout Australia). The population density of each of these was ranked from the most to the least dense. The population density yielding the 90<sup>th</sup> percentile was calculated – in other words, the area whose population density is such that 90 per cent of the population live in a more densely populated area. Areas within that 90<sup>th</sup> percentile become, in our modelling context, the areas *eventually* covered once the national HSBB network is complete (by 2016) under Scenarios 1 to 4. The remaining 10 per cent (the least densely populated areas of the country) do not receive coverage within the projection period.

This implicitly assumes that the only variable driving future coverage is population density, when in reality the cost of serving different areas is also an important consideration that could not be dynamically modelled here. Areas falling within that 90<sup>th</sup> percentile within each telephone exchange boundary were mapped and aggregated. The total area within each telephone exchange area that falls within the 90<sup>th</sup> percentile was then calculated. This becomes the ‘national HSBB network area’ of each telephone exchange area. All areas of some exchanges are part of the ‘national HSBB network area’, some parts of others, while the most remote and sparsely populated exchanges do not have any areas falling within the 90<sup>th</sup> percentile.

The same approach is adopted under the Best Endeavours option (Scenario 5), where wireless extends coverage to 98 per cent, but the 98<sup>th</sup> percentile in this scenario becomes the key threshold.

3. **Deployment pattern (2009 to 2016).** Population densities within the national HSBB network area of each telephone exchange area were calculated (taking into account those areas where, as mentioned above, that coverage extends to only part of an exchange area). Based on this figure, exchange areas throughout Australia are then ranked, once again from highest population density to lowest. In the ‘inside out’ deployment pattern, the exchange areas with the highest population density (within their national HSBB network area) are enabled first. This order is reversed in the ‘outside in’ deployment pattern.

4. **Capital expenditures on the HSBB network over time.** A key deployment pattern assumption is that a constant number of exchanges are enabled each year over the deployment period. The enablement of each exchange is assumed to have a fixed cost component (associated with exchange upgrades and backhaul costs) and a variable cost component. The variable costs reflect the area – and hence fibre length and number of associated nodes – that must be covered to provide high-speed broadband to the national HSBB network area of each exchange area. There is also a component of costs related to customer cutovers and CAN rehabilitation related to the number of customers covered by each node, a function of the assumed take up rate.

The cost of wireless is assumed to be a function of the area that the wireless service has to cover in each exchange area. Because the total costs of enabling each exchange varies, the national HSBB network costs over time also vary, even through the rate of exchange enablement is constant. The costs over time also vary between the two deployment scenarios, because the Outside-in option involves deployment to the less densely populated, and hence more expensive, exchanges first.

5. **The direct impact of the HSBB network on bandwidth per head over time.** The Outside-in option sees less of the population covered early than the Carrier Grade ('inside-out') option, but the marginal benefit to those covered will tend to be greater because the national HSBB network service will tend to be replacing a slower service. Conversely, the Carrier Grade option sees more of the population covered earlier, but the marginal benefit to those covered will tend to be less because of the already existing fast services in the densely populated areas. In other words, as is identified in Section 4, the Outside-in option brings bigger benefits sooner to a fewer number, whereas the Carrier Grade option brings smaller benefits to a bigger number early.
6. **Direct impact on industry.** The impact upon business and industry through the different deployment patterns will also be very different, due to the different locations of Australian businesses of different industries. The location of all employment by industry has been mapped throughout Australia, and overlaid with the HSBB coverage scenarios and the reference case scenario, over time, to calculate the specific coverage implications facing each industry throughout the life of a national HSBB network out to 2020.

## 2.4 Productivity impacts of the HSBB network

The productivity estimates used in this modelling relies on the projections of a series of rollout patterns, adoption rates by industry, and the underlying potential for HSBB to enhance productivity above and beyond a slower bandwidth alternative. The approach to estimating the productivity impacts, detailed in Section 3, is based upon the available literature considering gains in productivity from usage of ICTs, particularly broadband and high-speed broadband. These estimates are then combined with the specific coverage implications of the different HSBB network scenarios to produce productivity shocks for each scenario. These are then used as inputs for the CGE modelling.

## 2.5 CGE modelling

The economy-wide modelling is undertaken using Access Economics' in-house general equilibrium model, AE-RGEM (Access Economics' Regional General Equilibrium Model). Models such as AE-RGEM are a widely accepted tool for estimating the direct *and* indirect impacts of policy changes or other economic shocks.

The model is primarily based on input-output or social accounting matrices as a means of describing how economies are linked through production, consumption, trade and investment flows. For example, the model incorporates:

- direct linkages between industries and countries through purchases and sales of each other's goods and services; and
- indirect linkages through mechanisms such as the collective competition for available resources, such as labour, that operates in an economy-wide or global context.

A more detailed discussion of the specifications of AE-RGEM can be found at Appendix A. More detail on the coverage and cost modelling providing inputs into the GE model can also be found in Appendix A.

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## 3 Literature review and productivity impacts

The economic impacts of broadband estimated in this report are a function of anticipated rollout patterns, adoption rates by industry, and the productivity impacts of this adoption. As emphasised above, the newness of the technologies and the fact that the benefits are likely to flow gradually over an extended period means that the productivity impacts in particular are subject to considerable uncertainty. The purpose of this section is to outline the approach adopted to construct those productivity estimates that are then fed into the CGE model.

Given the forward-looking nature of this work, the productivity estimates are necessarily obtained from reviewing estimates reported in the literature for related investments in Australia and around the globe. In particular, the gains in productivity from usage of information and communication technologies (ICTs), particularly broadband and high-speed broadband, as estimated in the literature, are reviewed in this section. Following the broad literature review, exploring the underlying potential of HSBB to enhance business productivity, we identify how our specific HSBB network scenarios can unlock some of that potential. The productivity inputs used in the CGE modelling are summarised at the end of this section.

### 3.1 ICT overview

The linkages between productivity growth and usage of ICTs — of which broadband is among the most recent examples — are complex. The difficulty in disentangling the effects meant that early studies into the impact of ICT investments on productivity growth struggled to identify the strength of these links, especially using traditional growth accounting methods.

However, with further investigation and, especially, richer data covering longer time periods, the positive contributions became clearer. Firm-level studies, in particular, highlighted ways in which the technology has led to operational improvements and efficiencies.

The evidence for Australia of its strong and rapid uptake of ICTs, of which broadband is part, has been evaluated and summarised in a series of reports prepared by the Productivity Commission (eg in Productivity Commission 2004). In the transition to a more competitive, open and flexible economy in the 1990s, Australian businesses found greater imperative to take up the opportunities provided by ICTs and other technologies. These technologies contribute to productivity growth through a process of ‘capital deepening’, whereby workers gain access to more and better quality equipment, improving output for the same quantity of labour input.

While it is still early days, broadband appears to be the element of ICT with potentially the single biggest impact on the economy in the last 20 years. Broadband networks play a critical function in the transfer of data and information and have already become an important facilitator of the knowledge economy. They are particularly important for data-intensive service industries such as the finance and business services sectors.

The scope for broadband to act as an enabler of structural change and productivity growth in the economy potentially expands as adoption of the technology increases and it affects an increasing number of sectors and activities. Greater bandwidth effectively increases the range of activities that can be undertaken online. Indeed, emerging broadband applications across the education and health sectors highlight the potential for the technology to transform service delivery in human service areas.

## 3.2 Economic impacts of broadband

### 3.2.1 Qualitative impacts

The OECD Ministerial Background Report (2008) considers the economic impacts of broadband in a qualitative nature. The initial impacts arise from the rollout of the technology itself, which is then followed by the benefits of broadband as a general purpose technology enabler. Broadband is a technological improvement with the capacity to fundamentally change how and where economic activity is organised.

Among these enabling impacts of broadband are increased productivity through use of Internet Protocol (IP) telecommunications; significant portions of public infrastructure including sewage systems; and transportation logistics. In addition, there are increasing benefits from e-government and other services. Broadband is also noted as facilitating increased globalisation of services, as broadband makes it easier for consumers to purchase goods from a producer who is not in the same location as themselves, thereby increasing competition in some markets.

The OECD identifies three ways in which productivity benefits from the use of ICT filter through the economy:

- through the ICT producing sector;
- through ICT investment in ICT-using sectors; and
- through complementary factors, such as the organisation of capital, firm organisation, and ability to better utilise the skills of human capital.

The OECD report notes a time lag in the productivity gains for most firms, as the benefit does not flow from merely the construction of the network; rather it relies upon the adoption of both the technology and improved business practices to harness these benefits.

As Australia does not produce a lot of the ICT equipment, productivity benefits to Australian businesses are broadly expected to lie in the latter two channels, although there will be some gains to the ICT producing sector through the construction of a HSBB network. The majority of benefits to Australia are expected to flow from the complementary factors as business practices improve to maximise the benefits of the technology after it is adopted. However, such gains generally take some time to evolve. Firms typically need to restructure their operations, train workers, and modify management systems before the full range of gains can be realised. Because of this, there is often broad variation across firms and sectors in both the timing and magnitude of these benefits.

Broadband has the potential to create significant supply chain management improvements (DCITA 2007). For example, the advent of “just-in-time” inventory management in recent years has been greatly facilitated by improvements in communications technologies. This trend is set to be further improved by HSBB technologies with richer information – including video – allowing improved accuracy in orders as well as reinforcing the reduced need for paper transactions, the automation of the processes, and integration of dispatch and distribution data along the supply chain. These improvements make supply chain procedures more reliable, and have efficiency savings for employees and enable the end retailer to reduce inventories, saving them on storage costs.

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One area expected to produce sizeable benefits to businesses through improved human capital management is tele-working, where an individual does not work in a typical office, but works remotely, connecting to the office via the internet. This provides travel time and cost savings to the worker, and provides flexibility for those who may be unable to work from an office full-time such as parents, those in regional and rural communities, or people with disabilities (DCITA 2007). In addition, such flexibility can lead to reduced stress and more productive workers.

Varian *et al* (2002) highlight four key benefits of the internet to businesses: the reduction in transaction costs from improved ability to locate and purchase supplies; improved efficiency of producing and delivering goods and services; improved effectiveness of dealing with consumers; and enhanced competition in some markets. These factors come under the third of the OECD's benefit types, and so are not immediate impacts of HSBB adoption, but rather longer-term flow-on effects that result from organisational changes.

Broadband also has scope to promote more robust competition by effectively expanding markets across regions and countries, including international trade in services that were previously untradeable. In these ways, broadband has the ability to deliver growth and productivity benefits throughout the economy.

### **3.2.2 Quantitative impacts**

Quantification of the productivity benefits of broadband is a difficult task. As Professor Robert Solow famously quipped, "you can see the computer age everywhere but in the productivity statistics" (Solow 1987). The effects of all ICT technologies, including broadband, on productivity growth have been difficult to quantify, and the research experiences in preparing this report match closely with those of Holt and Jamison (2008), finding a paucity of quantitative research. A number of reasons have been offered to explain the difficulties in quantifying the economic impact of broadband, including the relatively recent development of broadband, its rapidly evolving nature and the difficulties in effectively disentangling the impact of broadband from ICTs more generally (OECD 2008).

The few attempts to model the economic impact of broadband have adopted a variety of measures of 'broadband' technologies depending on the particular circumstances under investigation. There is no universal definition of what speed and other qualities constitute a 'broadband' internet connection, as opposed to a 'narrowband' connection. Rather, the term broadband generically indicates a faster download speed, with more packets of information passed down a connection than in a narrowband setup.

Most studies that consider the experience in the United States have adopted the Federal Communications Commission (FCC) standard definition of download speeds above 200 Kbits per second (Kbps). Australian studies are less clear on the definition adopted, although the ABS defines 'broadband' as download speeds above 256Kbps.

There is even less consensus as to what constitutes 'high-speed' broadband compared with 'standard' broadband. A definition of 10 Megabits per second (Mbps) has previously been adopted (Allen Consulting Group 2003), while a study of broadband in Scotland employs a definition of 'second-generation broadband' requiring speeds of at least 5Mbps (SQW 2007).

### **‘Traditional’ Broadband**

Of the past studies into the productivity impacts of broadband, it is generally the more recent studies that produce more reliable results, by virtue of having a greater range and depth of data on which to develop estimates. Table 3.1 provides a summary of the main literature considered in the preparation of this report, with a detailed discussion of some of the more reliable and useful studies below. At this point in their development, *all* the empirical studies are subject to significant shortcomings.

Investigators have a choice of exploring the benefits of broadband through a comparison across regions or countries – ‘cross-sectional’ studies – or by examining changes over time. In either case, the challenge is to isolate the impact of broadband on various economic indicators from the myriad of other influences on economic performance. The precision of the estimates tends to improve as the number of data points increases.

Given the newness of the rollout of broadband technologies, cross-sectional studies tend to have more relevant observations than do time series studies and thus provide a stronger basis for estimating economic impacts. This approach has been used by Crandall *et al* (2007) who conducted a cross-sectional analysis of US data in order to estimate the productivity impacts of broadband. Looking at the impact of broadband, the effects of broadband penetration on output and employment are estimated using state level data from all US states except Hawaii and Alaska over the period 2003-2005.

This study argues that the difficulties encountered by the early investigations into the effects of ICTs on productivity reflected the fact that the impact of ICTs was not apparent in productivity statistics as initially ICT represented only a small share of total capital stock, and because it is a general purpose technology that is used by business in many different ways. However, over the course of the 1990s the impact on productivity growth became more apparent. The authors argue that such a trend is also likely to be seen in studies into broadband, especially as broadband’s pervasive but indirect effects diffuse through the economy.

Crandall *et al* control for a number of factors that will influence productivity performance including taxes, education level and wages. Their measure of broadband take-up is the number of broadband lines per capita. Using regression analysis, they find consistently positive effects on both employment and output at the State level as well positive effects for all but one of fourteen 2-digit industry sectors examined.<sup>3</sup> The estimated impacts for employment were, for the most part, statistically significant while those for output were consistently positive but not statistically so. Among the results, they found that, for the period 2003-2005, an increase of 0.01 lines per capita – an increase of around 10 per cent – resulted in an increase of 0.46% in output in the non-farm private sector.

As with all of the studies at this point, the Crandall *et al* results are best viewed as providing very preliminary estimates of the impacts. The study does not have data that are sufficiently rich on which to base robust econometric techniques. Indeed, the techniques employed can be criticised for ignoring some potentially important econometric problems.<sup>4</sup> Also, as noted

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<sup>3</sup> The one sector where the effects were negative was arts, entertainment and recreation although all of the estimates were not statistically significant.

<sup>4</sup> For example, the techniques employed do not permit an assessment of whether higher levels of broadband take-up produce improved economic outcomes or are the result of those better economic

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above, the study is based on a definition of broadband involving much lower speed than those currently being considered in Australia.

Connected Nation Inc. (2008) considered the economic impact of increased broadband access and adoption in Kentucky that arose as a result of the ConnectKentucky initiative, which brought together partners in the public and private sectors to foster both the supply of and demand for broadband. When compared to projections of what broadband uptake in Kentucky was expected to have looked like without the initiative, it was found that broadband adoption was 7 percentage points higher than otherwise would have been the case. The estimated economic impacts for Kentucky totalled \$1.59 billion annually, and when similar results were applied across the whole of the US, the economic impact was estimated at \$134 billion annually.

This study provides an indication of the size and types of benefits attainable through widespread broadband adoption, including health care improvements, time savings, travel savings and wages from jobs created or saved. However, the overall accuracy of the final results is less clear, as the study relies upon self-reported estimates, from a sample size of less than 200 respondents. Whether these results would be replicated across the entire US population, or even the whole of Kentucky, is uncertain.

Although Varian *et al* (2002) do not, strictly speaking, consider the impact of broadband, but rather the internet, this study provides some key pointers about the impacts of ICT. This study looks back at the estimated productivity impact of internet business solutions in the US and the three largest European economies (France, UK and Germany) over the period 1996-2000, and also makes projected productivity impacts for 2001-2010.

Overall the impact from 1996-2000 in the US is estimated as an annual gain in productivity growth rates of 0.17% and in the big three European countries as 0.017%, while the forecasts for 2001-2010 are 0.43% for the US and 0.11% for the European countries. The benefits in the US are higher as internet uptake took place earlier in the US. The differences between the US and Europe appear to reflect the fact that the relative size of the ICT producing sector is much larger in the United States than it is in Europe. (A common theme in many of the studies looking at the impact of ICT on economy-wide productivity is the role played by higher productivity in the ICT-producing sector itself.)

This evidence also implies that the impacts on productivity in Australia are likely to be lower than those in the United States because Australia will not benefit as much from productivity improvements in the production of the technology. Rather, the benefits will be concentrated on the use of the technologies to improve efficiency in business (Perham 2002).

A MICUS (2008) study into the impact of broadband on productivity in the EU considers the problem in two steps. Firstly, the impact of broadband on productivity is analysed at the company level on the basis of experiences such as case studies from Cornwall and Piedmont and previous analyses of statistical datasets in the USA, UK and Europe. Secondly, the macro-economic impact of broadband on productivity is evaluated by multiplying the figure obtained at the company level in the general case with the indicator on the adoption of online services among European companies.

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conditions. Greenstein and McDevitt (2009) also criticise the Crandall *et al* study for a range of simplifying assumptions that have been made in order to make the exercise tractable.

Although the methodology of the MICUS study is at points obtuse, the results of the study appear comparable with other contemporary results. Overall, the use of online services generates an average annual productivity improvement of 0.29% across the EU27, with higher benefits in the services (0.32%) and business services (0.58%) sectors, and lower benefits in the manufacturing (0.14%) sector.

### **High-speed broadband impacts**

Studies on the specific impact of HSBB are even scarcer than those considering 'traditional' broadband, as the newness of the technology means it has yet to be widely introduced and there has been less time to observe impacts. As a result, most attempts at quantifying the impacts are forward-looking forecasts, rather than observation-based estimates.

Determining the productivity gains from HSBB is further complicated by the fact that HSBB is typically a next step beyond broadband, rather than moving from no internet to internet. As a result, the benefits of many basic internet functions, such as text-based emailing and basic internet banking, should realistically be incorporated into a reference case, rather than counted as benefits of HSBB. Instead, the benefits of HSBB are focused around functions which are unfeasible at lower speeds, including video conferencing and many e-learning capabilities.

Allen Consulting (2003) conducted an analysis of the impact of the implementation of 'true' broadband in south-east Queensland, considering speeds of 10Mbps. The rollout considered would cover 50% of dwellings in Queensland, with rollout over the period 2004-2008. The report utilises the Monash Multi-Region Forecasting (MMRF) model, and details of the methodology are scant. Overall, however, in a vertically integrated model it is forecast that broadband of 10Mbps would increase Gross State Product (GSP) by \$4.2 billion over 15 years, and create an average 1,630 jobs in a typical year.

Although the literature has progressed towards a deeper understanding of the productivity impacts of broadband technologies, it remains difficult to make strong conclusions about the impact on the Australian economy. Nevertheless the aforementioned literature allows for orders of magnitude estimates.



**Table 3.1: Literature summary**

Study	Technology	Methodology	Result
Connected Nation 2008	Broadband (200Kbps)	Impact of increased broadband access and adoption in Kentucky from ConnectKentucky initiative, using self-reported health care improvements, time and travel savings, and wages from jobs created or saved. These results are applied across the USA to determine the potential gain of a national initiative.	Kentucky economic impact of \$1.59 billion per year; USA economic impact of \$134 billion per year.
Stiroh 2002	ICT generally	Regression analysis of the US productivity revival, and analysis of whether this is linked to ICT use.	Value-added productivity 1995-2000 1.0 percentage points higher than that of 1987-1995, study indicates that ICT is a leading candidate as a catalyst, but unable to quantify
Crandall <i>et al</i> 2007	Broadband (200Kbps)	Cross-sectional analysis of US data to estimate the productivity impacts of broadband in the medium-term. Regression analysis from the 'first 48 states' in the US	Finds an increase of 0.01 broadband lines per head of population associated with a 0.46% increase in output in the non-farm private sector
MICUS 2008	Broadband (speed unclear)	Analyses impact on productivity at company level and macro level, for the implementation of e-business practices and improvements arising from business services outsourcing over the period 2004-2006	Average annual productivity improvement of 0.27% in the EU27, higher in services (0.32%) and business services (0.58%), lower in manufacturing (0.14%)
Varian <i>et al</i> 2002	Internet generally	Methodology unclear, measures productivity impact of internet business solutions in the US and the three largest European economies (France, UK and Germany) over 1996-2000, with projections for 2001-2010.	1996-2000 average annual gains of 0.17% in US and 0.017% in European big three, 2001-2010 forecasts of 0.43% p.a. for the US and 0.11% p.a. for the European countries
Gillett <i>et al</i> 2006	Broadband (200Kbps)	Econometric regression analyses of cross-sectional/time-series data at state level and zip-code level, based on broadband penetration in the US over 1998-2002	Those areas where mass-market broadband was available before December 1999 experienced more rapid growth in employment, business numbers, and business in IT-intensive sectors
Allen Consulting 2003	True broadband (10Mbps)	Impact of a rollout over south-east Queensland over 2004-2008, covering 50% of Queensland dwellings, using Monash Multi-Region Forecasting (MMRF)	Increased GSP of \$4.2 billion over 15 years, 1,630 jobs additional per year
Crandall <i>et al</i> 2003	Ubiquitous broadband (speed unclear)	Impact of broadband at penetration similar to standard telephony services by 2021 (95.3% of population), and impact of high-speed broadband over 2003-2021, with penetration of 78.5% of households by 2021	Widespread penetration results in increased GDP of \$9.5 billion per year through 2003 to 2010; high-speed broadband results in further benefits of \$4.9 billion over 2003 to 2021
New Zealand Institute 2007, 2008	High-speed broadband (10Mbps)	Methodology unclear, benefits are estimated by improved productivity of digital media and storage and manipulation of data, health care and education savings, and remote working, with FTTP to 75% of the population by 2018	Impact of 0.26% on GDP, with gain of \$2.7-\$4.4 billion per year



### 3.2.3 Sectoral productivity impacts

As noted previously, the implementation of HSBB will not uniformly affect all economic sectors, with those sectors that are more ICT-intensive expected to receive greater benefits than sectors which are more labour-intensive. Other individual sectors may also be uniquely impacted by potential uses that are not applicable elsewhere. Studies which consider shocks by individual sector, therefore, are considered here in order to determine how productivity shocks might vary across economic sectors.

ACIL Tasman (2004) conducted a study which is not dissimilar to the present work, quantifying the economic impact of broadband (256Kbps) on the Victorian economy over 2004-2015. This study highlights key assumptions required in order to estimate the economic impact of broadband:

- impact on productivity and how impacts change over time;
- availability of broadband;
- rate of adoption of broadband; and
- what the economy would look like without broadband (that is, the reference case).

The productivity shock in this report of broadband adoption is 0.23 per cent across the whole economy. Sectoral breakdowns are used, and each sector is estimated as either an early, mid or late adopter of broadband technologies. In the conservative scenario estimated, broadband is estimated to make an average annual contribution to Victoria's economy of 0.47 per cent.

The results of Crandall *et al* (2007) for the whole economy have been detailed above. This study also provides estimates of the impacts for 14 two-digit sectors to break the results down by economic sector and provide a useful check on the Australian results as summarised in ACIL Tasman (2004). Crandall *et al* reported estimated impacts on GDP ranging from a slightly negative result for the Arts, Entertainment and Recreation sector (-0.032) through to a high productivity impact for the Finance and Insurance sector (1.900). Typically, office-type service sector jobs are those with greater benefits, including Real Estate and Management of Companies and Enterprises, with smaller gains for such fields as Information, Professional Scientific and Technical Services, and Manufacturing.

DCITA (2007) note a particular productivity gain from broadband is the ability to share digital content more easily, with video-based digital content considerably more operable with high-speed services. This is noted in the report as particularly beneficial for international collaborative activities, with benefits in film, animation, special effects and electronic games. For this reason it is a productivity benefit that is most applicable to the Cultural and Recreational Services sector.

Another area with unique gains from HSBB is education. DCITA (2007) notes that it is remote students in particular who gain the most from e-learning. Australia's School of the Air for children in remote communities utilises satellite broadband to provide services to students, who use laptops to work collaboratively through such features as a virtual whiteboard. It has been suggested, however, that higher speeds (at least 2Mbps) are required to fully harness the benefits of e-learning than are currently available in the areas where these students live.

Access Economics (2003) estimates the total net benefit of broadband rollout to all major regional hospitals in Australia at \$190 million over 2003-2013. These benefits arise from the

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ability to provide services, particularly services that require face-to-face contact such as the provision of imaging services, to those in remote areas of Australia from larger, more central locations through use of video conferencing and similar technology. This reduces travel and time costs for both patients and specialists, saving patients from travel for what may be unnecessary procedures, and enabling specialists to see a larger number of patients in the same amount of time. Many of these services, because they require high quality and reliable video technology, cannot be operated at basic broadband speeds.

### 3.3 Productivity impacts

The literature detailed above has informed the productivity shocks used for quantifying the economic impact of broadband in the current report. In this case, 'high-speed broadband' is the technology under consideration, defined as download speeds of at least 12Mbps.

The majority of benefits arising from HSBB are expected to be from those types of internet functions that are not feasible at lower speeds, for example, videoconferencing, VoIP phone services, and accessible e-learning services, while the benefits considered under many of the studies above, such as email, are already available in Australia under narrowband or basic broadband technologies. The limited and only indirectly comparable international empirical experience means that productivity shocks must be estimated based on figures that are not directly comparable.

The literature surveyed above provides an imprecise sense of the scale of the productivity benefits that may flow from the rollout of HSBB. Unfortunately, at this point, there are insufficient data to estimate the precise impact and hence any estimate will be subject to a good deal of uncertainty.

For the purpose of this project, and based on Access Economics' assessment of the imperfect empirical evidence available, it has been assumed 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 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. Access Economics views this estimate as being conservative, especially since many of the indirect effects are not being captured as discussed earlier.

A number of steps are then needed to translate this estimate into a profile for productivity increases over time and across sectors allowing for the fact that some HSBB is available in the reference case.

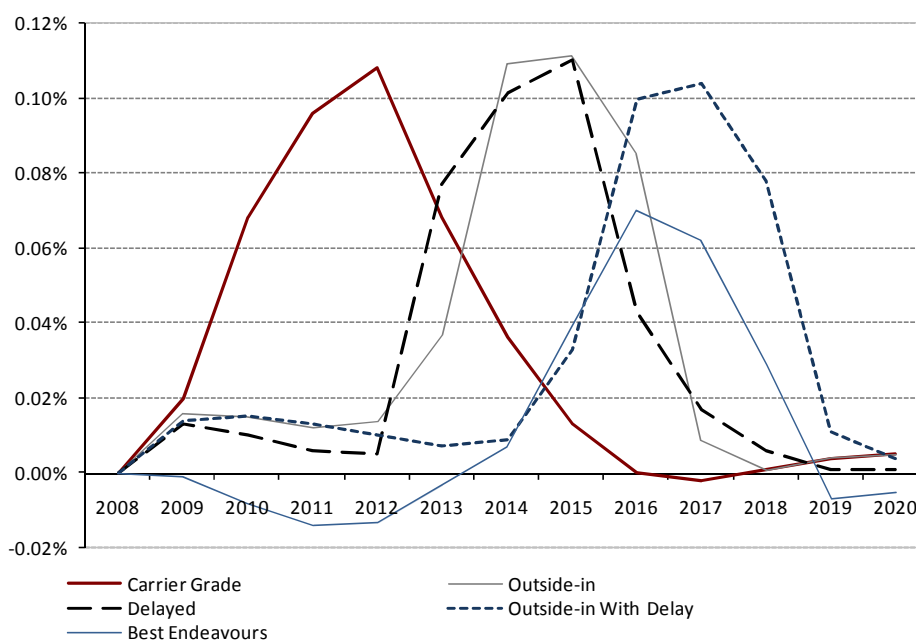
The profile of the assumed productivity shocks to each industry within the economy are not linear over the ten years. Instead, they are assumed to ramp up as the network is built, and those firms which stand to gain the most from adoption (and therefore are more inclined to adopt the technology) take up HSBB almost as soon as coverage is available. The benefits would then gradually ramp down after the network is constructed as those sectors with smaller potential benefits adopt the technology. In this way, the productivity benefits are closely linked to adoption of the service, itself a function of the underlying willingness to adopt combined with service availability (coverage).

Hence, integral to the productivity gains are the timing and eventual nature of the deployment of a national HSBB network. Unlike a general exercise measuring the impacts of HSBB *per se*

(comparing a world with HSBB and a world without), the more focussed question here is the specific impacts of different HSBB coverage scenarios versus a world with less, but still some, HSBB coverage. In other words, we are modelling the impacts of specific infrastructure projects, as distinct from a general technology, whereby the infrastructure provide more of the population with high speed broadband, or bring forward the time in which they will get it.

Chart 3.1 shows the differences in the annual productivity shocks over time, combining both the underlying potential for industries to benefit, and the extent to which the NBN unlocks this potential by providing more of the population with high-speed broadband at any point in time compared to the reference case. The peak productivity shock is in 2012, the fourth year of rollout for a network with construction commencing in 2009. At this point, a large proportion of the infrastructure has been installed, while those firms which stand to gain the most will have largely adopted high-speed broadband. Continued productivity gains are eventually and largely exhausted by 2020, as the rate of development in the reference case by then would be similar to the various HSBB scenarios modelled. As discussed in Section 5 however, this does not mean that the gains to that point are lost to the economy.

**Chart 3.1: Overall productivity shock, 2008-2020**



Once all-of-economy shocks are estimated, the shocks are reduced to a sectoral level. Central estimates for the shock by sector are informed primarily by the studies from ACIL Tasman (2004) and Crandall *et al* (2007), both of which make productivity estimates of simple broadband. These results are matched as best as possible to ANZSIC 1-digit sectoral codes, in line with the GE model used to quantify the impacts. Following this, the mean of the relevant shocks from the two studies are taken, to provide initial sectoral shock figures.

Based on other qualitative information concerning the possible applications of these technologies in different sectors of the economy, and the ICT intensity of given industries, some of these initial sectoral shock figures are adjusted upwards or downwards, as required. For example, the shock to the Health and Community Services sector has been adjusted upwards due to the large number of health applications for video conferencing, in the form of

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remote health care provision that saves patients and doctors alike in terms of time as well as unnecessary procedures (Access Economics 2003). In contrast, the estimate for Finance and Insurance Services has been adjusted downwards somewhat as many of the benefits to this sector, such as online banking and the ability to conduct transactions such as the purchase and sale of shares, are attainable at existing broadband speeds.

The productivity shocks by sector used for the Carrier Grade scenario are presented in Table 3.2. For most sectors, the pattern of productivity shocks closely matches that of the whole economy, peaking in 2012, however the anticipated late adopting sector of Agriculture, Forestry and Fishing does not see peak benefits until 2013.

Those sectors with higher productivity shocks tend to be IT-intensive and particularly office-based services, such as Finance and Insurance Services and Property and Business Services, which due to their previous experience with the internet and broadband technologies are likely to be rapid adopters of the technology. The ability to conduct instantaneous transactions are of significant benefit to such industries, with faster speeds enhancing the comparative advantage of these sectors in conducting transactions on an individual's behalf relative to them carrying such services out themselves. Similarly, communications services, which can be increasingly operated over the internet with HSBB through services such as VoIP and video conferencing, rather than through more traditional means, are also anticipated to have higher than average productivity shock.

The ability to reduce search costs plays a role in the large shocks in other sectors. The ability to search for products online and conduct transactions online, as noted previously, means information that compares pricing on a range of goods and services can be found relatively quickly. This effectively increases competition in the market, and for this reason productivity gains in Accommodation, Cafes and Restaurants, as well as Wholesale and Retail Trade, are expected to be slightly higher than the average productivity shock.

Sectors which are forecast to experience a relatively low productivity shock can be attributed to two types: non-ICT intensive sectors; and sectors that experience a substitute effect away from them.

Non-ICT intensive sectors tend to be those which are relatively labour-intensive and use only limited ICT technology. Such sectors are typically likely to be later adopters of HSBB, although there are some specific areas of some sectors, such as e-health applications for the Health and Community Services sector, that are likely to introduce the technology sooner. Overall, however, the Agriculture, Forestry and Fishing sector and Mining sector, both of which are dependent upon labour and heavy machinery rather than computer and internet technologies, experience lower productivity gains from the technology being fundamentally less useful to them.

Certain services that would be readily accessible through HSBB will also compete with existing non-ICT services, which may result in a sizeable shift away from these services. In particular, HSBB will make the downloading of movies, music and other entertainment services a viable alternative for many households, who may then choose to acquire such products online rather than going to the movies or seeking alternatives such as theatre. This counters the productivity gains from international collaboration which utilises broadband technology. For this reason the productivity shock to Cultural and Recreational Services is relatively low.

Once again, they are then converted to HSBB specific shocks for use in this project by considering the coverage implications for each sector of the various HSBB scenarios compared to the reference case. The shocks used for the Carrier Grade option (Scenario 1), as inputs to the CGE model, are identified below.



**Table 3.2: Productivity shocks by sector, Carrier Grade option\***

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, forestry and fishing	0.000	0.001	0.009	0.018	0.028	0.029	0.023	0.017	0.009	0.008	0.019	0.026	0.030
Mining	0.000	0.007	0.032	0.052	0.057	0.039	0.018	0.011	-0.008	-0.010	-0.008	0.005	0.004
Manufacturing	0.000	0.010	0.053	0.078	0.087	0.047	0.017	-0.002	-0.009	-0.008	-0.002	0.001	0.003
Electricity, gas and water supply	0.000	0.010	0.060	0.098	0.113	0.075	0.029	0.008	-0.011	0.003	0.004	0.010	0.006
Construction	0.000	0.008	0.059	0.090	0.103	0.059	0.023	-0.002	-0.013	-0.012	-0.005	-0.001	0.002
Wholesale trade	0.000	0.015	0.067	0.095	0.102	0.052	0.019	-0.001	-0.009	-0.010	-0.004	0.000	0.004
Retail trade	0.000	0.012	0.063	0.094	0.106	0.062	0.026	0.001	-0.012	-0.012	-0.004	0.002	0.006
Accommodation, cafes and restaurants	0.000	0.011	0.057	0.086	0.103	0.066	0.036	0.012	-0.003	-0.004	0.004	0.013	0.018
Transport and storage	0.000	0.015	0.084	0.126	0.138	0.080	0.031	-0.001	-0.019	-0.019	-0.004	0.003	0.008
Communication services	0.000	0.017	0.085	0.118	0.126	0.064	0.023	-0.003	-0.016	-0.015	-0.004	0.004	0.009
Finance and insurance services	0.000	0.031	0.112	0.153	0.162	0.083	0.030	-0.003	-0.017	-0.016	-0.010	-0.005	0.000
Property and business services	0.000	0.026	0.110	0.154	0.166	0.084	0.030	-0.005	-0.017	-0.017	-0.009	-0.005	0.000
Health and community services	0.000	0.011	0.051	0.072	0.082	0.044	0.016	-0.005	-0.011	-0.009	-0.004	-0.002	0.000
Cultural and recreational services	0.000	0.006	0.023	0.033	0.036	0.019	0.007	-0.001	-0.004	-0.004	-0.002	-0.001	0.001
Personal and other services	0.000	0.011	0.050	0.074	0.084	0.049	0.022	0.002	-0.005	-0.005	-0.002	0.001	0.003

(\*) Expressed as a percentage.



## 4 The direct impacts of a national HSBB network – CGE model inputs

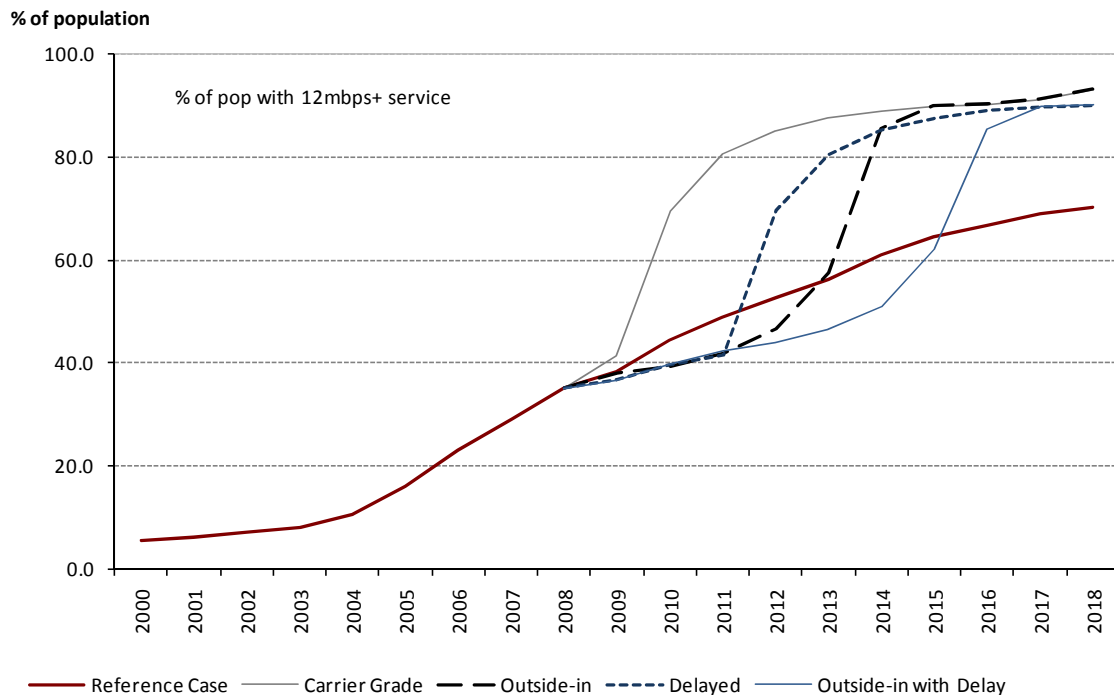
### 4.1 Cost and coverage impacts

The costs associated with the different national HSBB network scenarios reflect the variable costs of fibre, nodes, cabinets, customer cutovers, backhaul and other expenses. Under the Carrier Grade option (Scenario 1), our mapping suggests that a total of 41,000 nodes are required to reach 90 per cent of the population by 2016, and almost 82,000 km of fibre is required to link those nodes. Combined with costs associated with nodes, cabinets, CAN rehabilitation, backhaul and customer cutovers, we estimate that the (non-discounted in 2008 A\$) cost of a national HSBB network is \$12.64 billion. The total cost of the Outside-in, Delayed and Outside-in With Delay options (Scenarios 2, 3 and 4) is essentially the same, though the timing of those costs is different. The equivalent cost for the Best Endeavours option (Scenario 5) is \$11.40 billion, the net result of no expenditure on CAN rehabilitation but more spent on the wireless component extending coverage to 98 per cent.

Costs incurred in the reference case scenario are relevant in the GE modelling sense, as they represent construction of broadband data infrastructure. Under the reference case coverage scenario defined earlier, and given the same unit cost inputs as the HSBB scenarios, we estimate expenditure on data service infrastructure under the reference case scenario would total \$A3.56 billion by 2020. The cost inputs to the CGE model for the different scenarios were net of this reference case cost.

In a coverage sense, the most commonly quoted variable relating to the national HSBB network is the percentage of the population covered by a high speed (12Mbps +) service. This is illustrated below, for our various scenarios:

**Chart 4.1: HSBB network coverage impacts over time**



Note: Best Endeavours scenario is not included on this chart due to its different quality characteristics. It reaches a higher total than the other 4 scenarios (to 98 per cent by 2018), albeit with a delay in proceeding.

Note that, although the above reflects proportional coverage for the population over time, what ultimately matters in our modelling context is the proportional coverage to businesses of different industries over time. Each scenario illustrated above has unique coverage implications for different industries, depending on where the businesses of the industries are located. For example, sectors such as Financial and Insurance Services will receive a higher level of coverage from early in the rollout under an ‘inside-out’ deployment, whereas more regionally based sectors such as Agriculture, Forestry and Fishing or Mining receive smaller shares in early years. In an ‘outside-in’ deployment, however, these sectors receive a higher level of coverage in earlier years, with urban-based sectors catching up only later in the rollout. The coverage results for different industries under the Carrier Grade option (Scenario 1) are identified in Table 4.1. Equivalent coverage implications for each industry have also been calculated.

**Table 4.1: Coverage by industry, Carrier Grade option\***

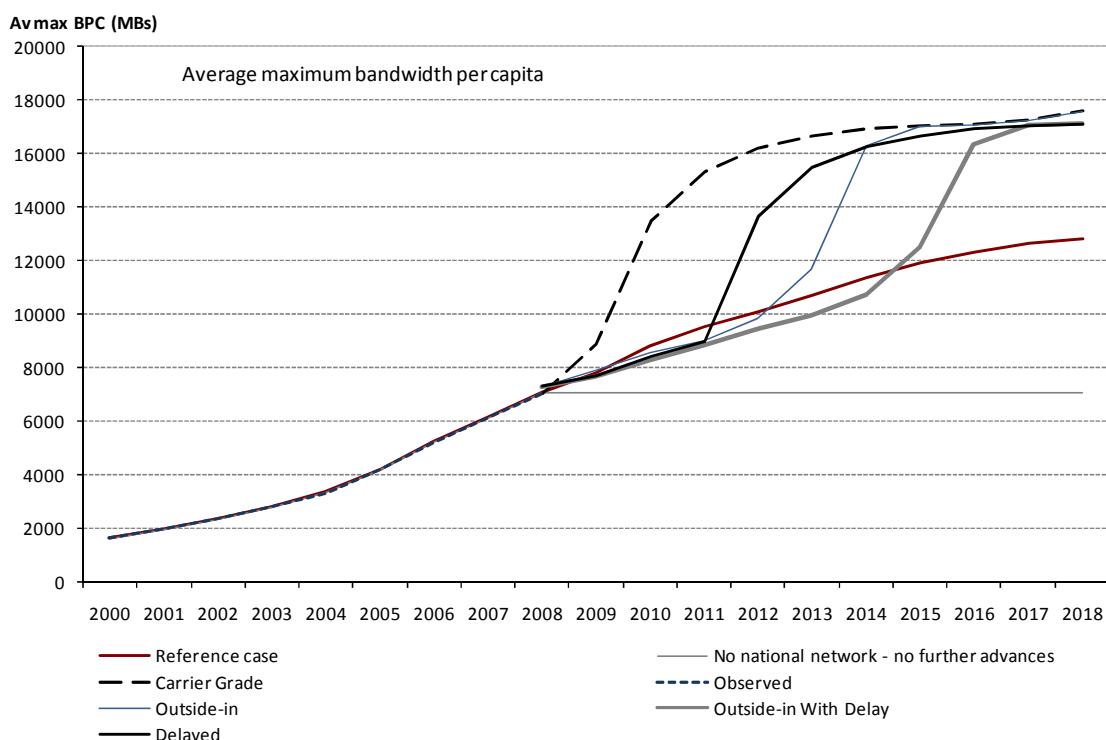
	2009	2010	2011	2012	2013	2014	2015	2016
% of national pop covered	41.3	69.5	80.4	85.1	87.6	89.0	89.8	90.0
Total businesses	46.8	74.0	84.2	88.6	91.1	92.2	92.8	93.1
Agriculture, forestry and fishing	8.5	18.2	26.0	32.4	37.8	41.6	44.8	45.4
Mining	45.2	65.3	74.2	77.6	79.2	80.5	81.8	82.2
Manufacturing	45.1	73.4	83.7	88.3	90.5	91.7	92.4	92.7
Electricity, gas and water supply	39.7	63.9	74.6	80.4	83.5	84.8	86.2	86.5
Construction	38.5	69.3	81.6	87.1	90.0	91.3	92.2	92.5
Wholesale trade	53.4	77.7	85.9	89.5	91.3	92.1	92.7	92.9
Retail trade	45.7	72.0	81.9	86.3	88.8	90.2	90.9	91.2
Accommodation, cafes and restaurants	44.6	65.7	74.2	78.9	81.7	83.6	84.8	85.2

	2009	2010	2011	2012	2013	2014	2015	2016
Transport and storage	44.7	71.7	81.9	86.3	88.5	89.6	90.3	90.6
Communication services	49.5	75.5	83.7	87.4	89.3	90.3	91.0	91.2
Finance and insurance services	65.4	84.8	91.1	93.6	95.0	95.6	95.9	96.0
Property and business services	59.2	81.7	89.3	92.5	94.1	94.8	95.3	95.5
Health and community services	54.8	79.4	87.9	92.4	94.4	95.1	95.4	95.7
Cultural and recreational services	58.0	80.9	88.6	92.1	93.8	94.6	95.0	95.2
Personal and other services	54.4	76.6	85.2	89.6	91.9	93.0	93.6	93.9

(\*) Expressed as a percentage of the employment in each industry with HSBB coverage.

Another way of exploring the impacts of the national HSBB network in terms of its impacts on bandwidth, indeed its most relevant direct impact reflecting its overall purpose, is not just what proportion of the population receive 12Mbps coverage but what is the overall effect on increasing bandwidth to the population as whole. A unit to measure this is the bandwidth per capita, a weighted average measure of the fastest bandwidth service available to the Australian population. It considers the bandwidth situation of all Australians, reflecting that the coverage impacts of the national HSBB network are not just limited to bringing 12Mbps service to those who otherwise would not have it. It includes increases in speed to some households and business below the 12Mbps speed threshold and, in the cases of those close to FTNN cabinets, speeds exceeding 12Mbps. The average maximum bandwidth per capita of the various scenarios is illustrated below.

**Chart 4.2: Average maximum bandwidth per capita**



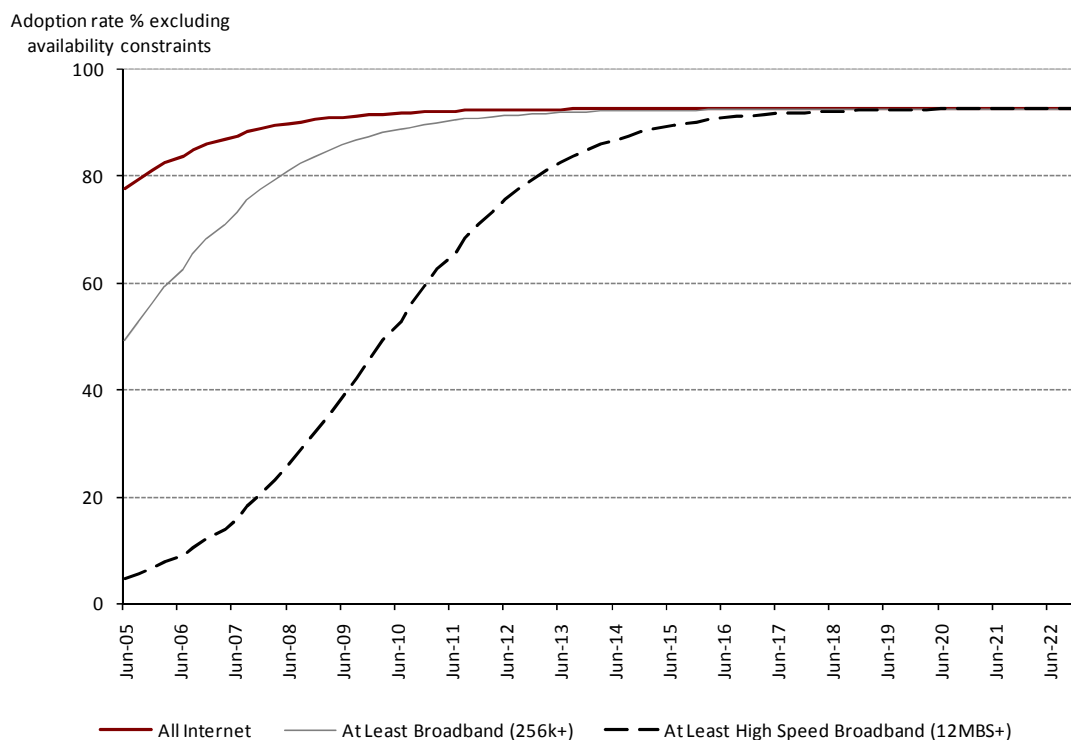
## 4.2 Demand and adoption rates

Coverage does not in and of itself result in productivity gains; it merely makes the technology available. For the potential productivity gains to be harnessed, households and businesses

must adopt the technology, that is, they must subscribe to HSBB services, and these services must be utilised.

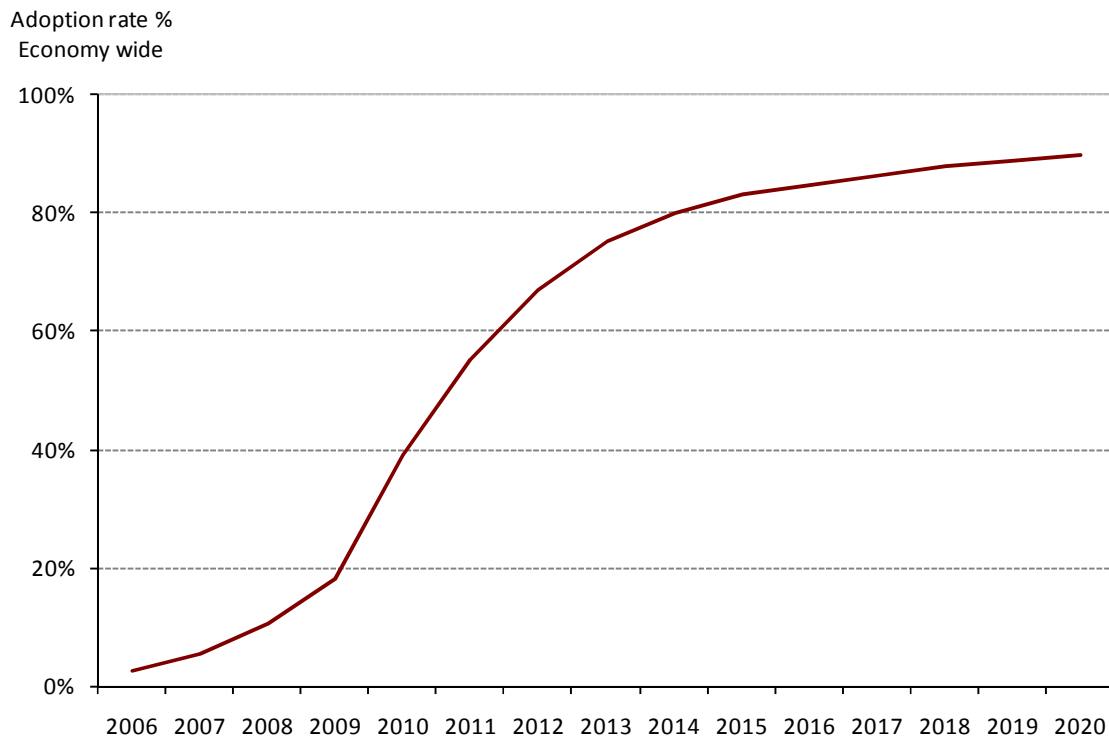
Hence, in order to distribute the estimated potential productivity gains from HSBB over time, we had to combine the coverage over time with a curve reflecting the underlying demand for the service (defined here as the willingness of business to adopt the service irrespective of any coverage constraints). The three curves in Chart 4.3 reflect total business customers for different bandwidth services, excluding coverage constraints. This is conceptually the same thing as customer numbers in areas where the service is available. It is calibrated to reflect recent observations. For example, as of June 2008, 13.26 per cent of all business Internet subscriptions are more than 8Mbps, which represents approximately 12 per cent of all businesses. We conservatively estimate the proportion of these with a 12Mbps service was 10 per cent. Business coverage at the time was approximately 40 per cent, meaning 25 per cent of those who can get a 12Mbps service are demanding it (hence as of June 2008 the blue line is at 25 per cent). The equivalent figure in June 2007 was approximately 15 per cent.

**Chart 4.3: Underlying demand for broadband services excluding availability constraints**



The expected adoption (or take-up) of high-speed services is a multiplication of this proportional demand for the service, and the proportional availability discussed previously. The resulting curve for all businesses is illustrated below in Chart 4.4 for the Carrier Grade option (Scenario 1). Our modelling uses such curves for each industry of the economy, for all the coverage scenarios identified, and for basic broadband services as well.

**Chart 4.4: High-speed broadband adoption rates under Carrier Grade option**



The total economic impact will in reality also vary with the effectiveness of HSBB adoption. A business may adopt the technology but not use it to its full capability, or may partially adopt the technology, or may not be as efficient in their use of the technology as would be theoretically possible with their given level of labour and capital resources. In this study, none of the scenarios varies from any assumptions concerning whether or not broadband is fully utilised. It is assumed that all firms that adopt the technology do so and achieve the full benefits attainable, with these increasing further over time as other firms adopt the technology and network effects are available.

As this model considers economic impacts of a national HSBB network over a period of 10 years, it is necessary to use a discount rate to ensure that all results are presented in current-day value. For this report a discount rate of 7 per cent has been used.

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## 5 Overall economic results

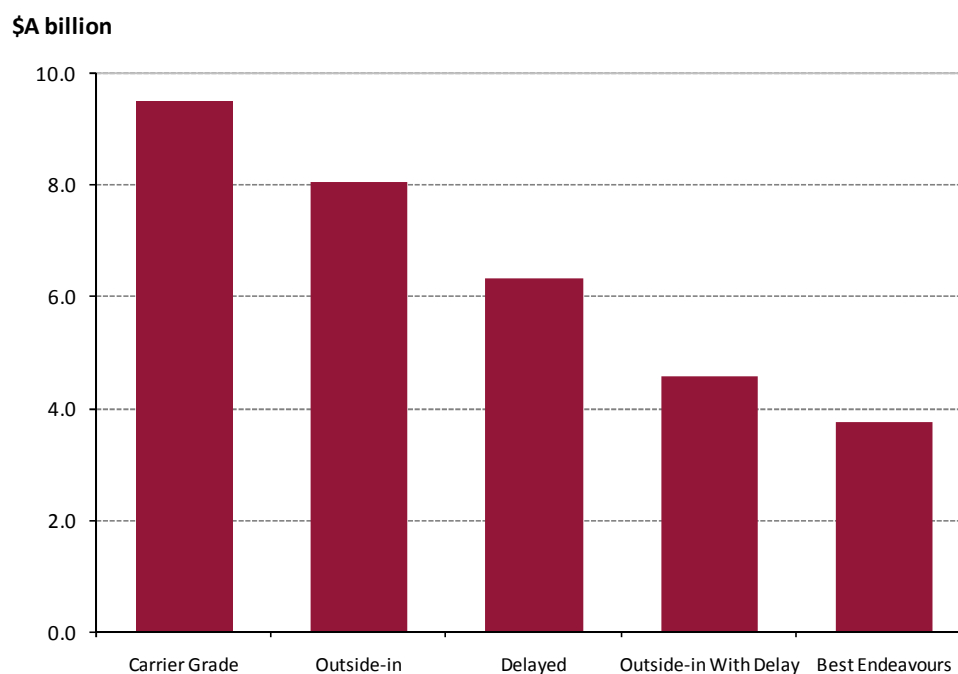
The analysis of the economic impacts of broadband on the Australian economy is presented below in three sections:

- Firstly, a summary of the key results.
- Secondly, an analysis of the impacts of the Carrier Grade option (Scenario 1) compared to the 'no national HSBB network' reference case; a comparison that explores the key question of the impact of the best case scenario national HSBB network.
- Finally, a comparison of the Outside-in, Delayed, Outside-in With Delay and Best Endeavours options (Scenarios 2, 3, 4 and 5) versus the Carrier Grade option (Scenario 1); a comparison that explores both the sensitivity of results to, and the impacts of, altering some key network design and timing assumptions.

### 5.1 Summary

The Net Present Value (NPV) impact of the five scenarios modelled, using a 7 per cent discount rate and compared to the reference case, are illustrated below. The Carrier Grade option (Scenario 1), involving no delay to the national HSBB network and an inside-out deployment pattern, has the greatest impact, in NPV of GDP terms, of approximately A\$9.5 billion.

**Chart 5.1: NPV of GDP Impacts – 2008 to 2020\***

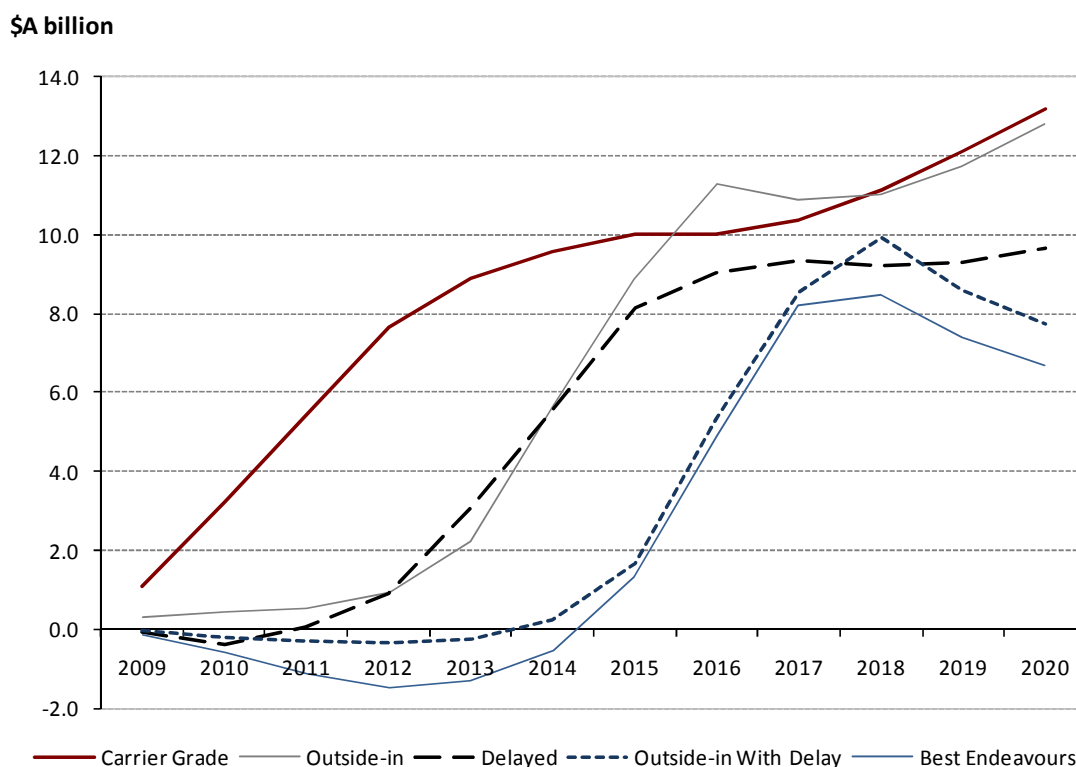


(\*) Expressed in 2008 dollars.

The greater contribution of the Carrier Grade option is primarily due to two factors. Firstly, the magnitude of the impacts on business productivity is higher over a sustained period of time and continuing longer into the future, due to a superior quality of network and its more future-

proof nature. Secondly, the impacts are realised earlier, due to more of the population being served earlier on in the projection period. The effect of discounting future gains ensures that there is a greater net present value of gains experienced earlier on, compared to those experienced later in the projection period. The different timing of the impacts under the different scenarios, measured as proportional impacts on GDP, are illustrated below.

**Chart 5.2: Cumulative GDP impacts over the reference case – 2009 to 2020**



Note: These results are cumulative annual impacts. They are not discounted, hence the total impacts by 2020 are higher for the five scenarios than those reported earlier.

Another way of interpreting the results is to compare the scenarios against each other, rather than against the reference case. Results from this comparison indicate that:

- The net cost to the Australian economy of an outside-in deployment pattern (a comparison of the Carrier Grade and Outside-in options) is \$1.4 billion over the period 2009-2020. This represents a 16 per cent decline in the positive economic contribution of a national HSBB network.
- The cost to the Australian economy of a two year delay to a national HSBB network (a comparison of the Carrier Grade and Delayed options) is \$3.2 billion over the period 2009-2020. This represents a 34 per cent decline in the positive economic contribution of a national HSBB network.
- The cost to the Australian economy of *both* a two year delay and an outside-in deployment pattern (a comparison of the Carrier Grade and Outside-in With Delay options) is \$4.9 billion over the period 2009-2020. This represents a 52 per cent decline in the positive economic contribution of a national HSBB network.

- The cost to the Australian economy of also adopting a lower quality network build design along with a two year delay and an outside-in deployment pattern (a comparison of the Carrier Grade and Best Endeavours options) is \$5.7 billion over the period 2009-2020. This represents a 60 per cent decline in the positive economic contribution of a national HSBB network.

## 5.2 Scenario 1 – Carrier Grade option

Table 5.1 shows the results of the Carrier Grade option, which considers the construction of a carrier grade network to 90 per cent of the population, constructed on an ‘inside-out’ basis and with no delay in the commencement of construction. Other economic indicators quantified in addition to NPV of GDP are also identified.

**Table 5.1: Results of Carrier Grade option**

	<b>Result (\$m)</b>
GNP	6,790
GDP	9,493
NNI	6,098
Investment	10,403
Household consumption	5,390
Government consumption	904
Exports	-1,564
Imports	4,045
Tax	3,134

GNP = Gross National Product

GDP = Gross Domestic Product

NNI = Net National Income

Under this scenario, the increased investment in Australia will total \$10.4 billion over the period 2009-2020. In the first few years, much of the investment stimulated by a carrier grade national HSBB network is in the construction of the network itself. Such front-loaded and large-scale investment would aid the currently slowing Australian economy, stimulating demand for construction goods and workers. This is what economists consider the construction effect; that is, the positive economic stimulus provided by the investment expenditure itself.

However, this construction effect alone would not outweigh the cost of the network itself, a cost reflecting funds that would have a productive use elsewhere in the economy. For the project to have ongoing positive impacts, especially as measured by the indicators of GDP, GNP and NNI, and particularly beyond the construction period itself, the infrastructure must have a productive use. Indeed, flow-on impacts on investment due to the enhanced productivity are realised more consistently throughout the projection period, and are more likely to be sustained longer into the future.

The only economic indicator to be lower under the Carrier Grade option is exports. This is largely a function of industry impacts, whereby the industries that gain the least from a national HSBB network tend to also be our major export industries, most notably mining and agriculture. Conversely the industries that benefit most (and hence grow) are the more import intensive ones, particularly those from the services sector.

## 5.3 Comparison between Carrier Grade option and others

### 5.3.1 Scenario 2 – Outside-in option

The Outside-in option (Scenario 2), involving an outside-in deployment pattern with all other variables the same as the Carrier Grade option, yields a slightly lower positive impact than the Carrier Grade option. The net cost to the Australian economy of an outside-in deployment pattern (a comparison of the Carrier Grade and Outside-in options) is \$1.4 billion over the period 2009-2020. This represents a 16 per cent decline in the positive economic contribution of a national HSBB network achieved through the Carrier Grade option.

The major reason for this is that, compared to the Carrier Grade option, more of the cost burden of this national HSBB network is realised early in the projection period, but the beneficial impacts due to coverage for the population are delayed. By 2016, the coverage (and hence direct impacts) will be the same as with the Carrier Grade option, but by then the economy will be on a slightly smaller path. The effect of discounting future gains amplifies the cost in NPV terms. Countering some of this is the upside to this scenario; for some of the population receiving coverage, a national HSBB network will have a greater direct impact on bandwidth in the early days, because high-speed service will be first concentrated into areas that currently have slower or, in some cases, no metropolitan equivalent broadband service. In other words, fewer of the population may benefit early on, but the magnitude of their direct benefit will be greater. However, this positive effect does not outweigh the negatives of this scenario; hence the net impact compared to the Carrier Grade option is negative.

This option yields a very different path to the other options in terms of the impacts on individual industries of the economy. It tends to bring forward the beneficial impacts on industries located more in regional areas (the smaller towns or urban fringe areas), and delay them to those located in the out reaches of the major cities or in the smaller regional cities and towns (who currently do not have high-speed services, but would be the first to get them under the Carrier Grade option).

**Table 5.2: Results of Outside-in option and comparison with Carrier Grade option**

	Result (\$m)	Difference (\$m)
GNP	6,441	-348
GDP	8,050	-1,443
NNI	5,441	-658
Investment	9,014	-1,388
Household consumption	4,739	-650
Government consumption	823	-81
Exports	-1,638	-74
Imports	3,498	-547
Tax	2,606	-529

### 5.3.2 Scenario 3 – Delayed option

The Delayed option (Scenario 3), involving a two year delay to a national HSBB network with all other variables the same as the Carrier Grade option, yields lower positive impacts. The cost to the Australian economy of a two year delay to the national HSBB network (a comparison of the Carrier Grade and Delayed options) is \$3.2 billion over the period 2009-2020. This

represents a 34 per cent decline in the positive economic contribution of a national HSBB network.

The major reason for this is the delay to any of the positive contributions. They are eventually realised in a direct coverage and productivity sense, but as with the Outside-in option, by then the economy will be on a smaller path. The effect of discounting future gains amplifies the cost in NPV terms. In the first few years, while the national HSBB network is delayed and even early in its construction, the impact of this scenario is less than the reference case. In other words, its impacts are negative against the 'no national HSBB network' option.

**Table 5.3: Results of Delayed option and comparison with Carrier Grade option**

	<b>Result (\$m)</b>	<b>Difference (\$m)</b>
GNP	5,526	-1,264
GDP	6,302	-3,191
NNI	4,050	-2,048
Investment	7,798	-2,605
Household consumption	3,676	-1,714
Government consumption	566	-338
Exports	-1,472	92
Imports	3,038	-1,006
Tax	2,144	-990

### 5.3.3 Scenario 4 – Outside-in With Delay option

The cost to the Australian economy of both a two year delay and an outside-in deployment pattern (a comparison of the Carrier Grade and Outside-in With Delay options) is \$4.9 billion over the period 2009-2020. This represents a 52 per cent decline in the positive economic contribution of a national HSBB network.

**Table 5.4: Results of Outside-in With Delay option and comparison with Carrier Grade option**

	<b>Result (\$m)</b>	<b>Difference (\$m)</b>
GNP	4,858	-1,931
GDP	4,548	-4,945
NNI	3,007	-3,091
Investment	4,943	-5,460
Household consumption	2,672	-2,717
Government consumption	404	-500
Exports	-756	808
Imports	1,924	-2,120
Tax	1,448	-1,686

### 5.3.4 Scenario 5 – Best Endeavours option

The cost to the Australian economy of also adopting a lower quality network build design along with a two year delay and an outside in deployment pattern (a comparison of the Carrier Grade and Best Endeavours options) is \$5.7 billion over the period 2009-2020. This represents a 60 per cent decline in the positive economic contribution of a national HSBB network. The upside of this scenario is that it includes coverage to 98 per cent of the population, meaning

coverage for all regional cities, most regional towns and some rural and even remote areas. However, the effect of this additional (and costly) wireless component is more than outweighed by the lower overall quality, the delay to the project and the outside-in deployment pattern.

**Table 5.5: Results of Best Endeavours option and comparison with Carrier Grade option**

	Result (\$m)	Difference (\$m)
GNP	4,613	-2,177
GDP	3,756	-5,737
NNI	2,654	-3,445
Investment	5,667	-4,736
Household consumption	2,500	-2,890
Government consumption	312	-592
Exports	-1,485	79
Imports	2,265	-1,780
Tax	1,377	-1,757

### 5.3.5 Adjusted Scenario 1 – Carrier Grade in a time of higher unemployment

The above results identified thus far are from a modelling baseline with a tight labour market, without significant levels of otherwise idle labour ready to be deployed due to economic stimulus of the construction of a HSBB network. In the modelling scenarios presented thus far, both wage rates and employment levels are flexible although, given the tight labour market until recently, the labour market adjustments due to the HSBB network had been realised more in rising real wages rather than an increase in employment. This is because, under the tight labour market conditions prevailing until recently, any additional employment effects generated by the construction of a HSBB network had generally come at the expense of employment elsewhere in the economy. As such, the aggregate employment figures for the whole economy do not rise as much in proportional terms as much as the rise in real wages. In other words, instead of the HSBB network increasing the aggregate employment levels in the economy, the effects tended to be absorbed more in the form of rising real wages.

However, under certain circumstances, the ability of wages to rise is limited. A labour market with spare capacity, characterised by high levels of unemployment, is one such circumstance in which this might occur. Indeed, currently there is rising unemployment leaving us with slack in the market. With more people looking for work it is unlikely that wages will rise in the short term<sup>5</sup>.

<sup>5</sup>If one person is not willing to work for a given wage then an employer will simply offer the position to someone else. One might surmise that the same logic would see wages fall as employers constantly search for workers willing to work for a lower wage. However, under the modelling assumption of a fixed wage rate, this logic is not applied. There are two main conceptual reasons for this. Firstly, firms will be willing to pay an amount up to the marginal value of output for a worker. Paying anything less than this will mean the worker will have an incentive to search elsewhere for work and the firm runs the risk of losing the worker and his output. Employing a new worker is possible given the slack labour market however this will incur costs to the firm in the form of lost production, search costs, administration, retraining and so forth so it is not an attractive proposition. Secondly, institutional factors – employment contracts, unions, etc. – make wages sticky. This means that wages can resist downward pressure even if external influences such as a deteriorating economy dictate otherwise. Normally if the nominal wage remains constant over time the real wage will fall as inflation erodes the value of a dollar (real wage is defined as the nominal wage (w)

In light of the recent slowing of the economy and the increase in unemployment, we have run a further scenario by not allowing wages to respond in the short term and letting the adjustment process take place entirely in terms of the number of people employed. This is an illustrative scenario for the purposes of testing the sensitivity of the model to the labour market assumptions. In the longer term, by 2013 and beyond, we assume that the circumstances that led to this form of adjustment being appropriate begin to dissipate and the market begins to adjust in a more 'normal' sense by allowing both the real wage and the number of people employed to adjust. As outlined, this contrasts with the original scenarios discussed so far, where both real wages and employment are flexible from the outset.

When this change to the modelling assumptions is made to reflect the recent economic slowdown, the impacts of the overall impacts on GDP are significantly higher, and the economic benefits are realised in different ways. Applied to Scenario 1, the NPV of benefits more than double, from approximately \$9.5 billion to \$21.0 billion. The reasons for this are complex, but can be summarised by the conclusion that a greater value of a given infrastructure investment is realised in times of a weaker economy characterised by higher unemployment.

**Table 5.6: Results of Adjusted Carrier Grade option and comparison with Carrier Grade option**

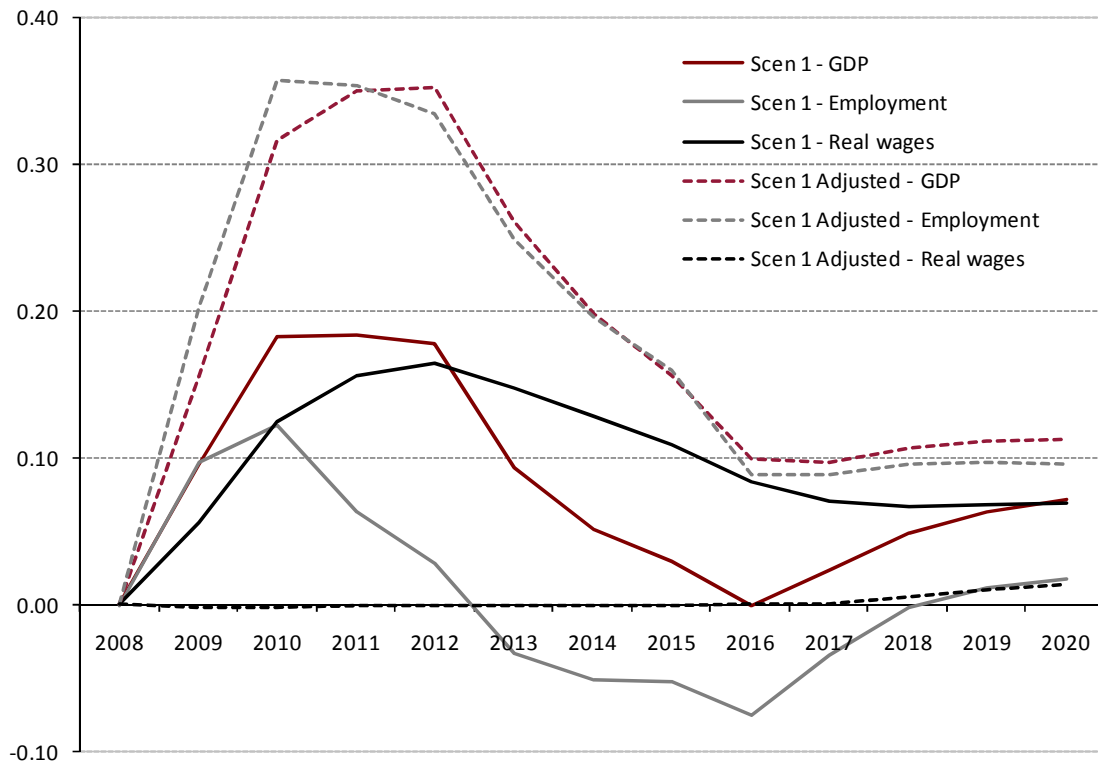
	<b>Result (\$m)</b>	<b>Difference (\$m)</b>
GNP	17,101	10,312
GDP	21,002	11,509
NNI	15,870	9,772
Investment	9,686	-717
Household consumption	10,845	5,456
Government consumption	3,797	2,893
Exports	1,846	3,410
Imports	4,250	206
Tax	5,839	2,704

Not only are the aggregate impacts greater, they are realised in different ways. With real wages held fixed in the short term, the labour market adjustment is realised in the form of rising employment. Chart 5.3 illustrates how, in the initial construction phase, employment increases by 0.36 per cent in 2010, compared to only 0.12 per cent in the original Scenario 1.

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divided by price (p) – w/p). In an economy where inflation is slowing this is no longer the case meaning that wages and prices rise at the same pace and real wages remain constant as a result.

**Chart 5.3: Macroeconomic impacts relative to the reference case\***



\*Per cent change

The 0.36 per cent in 2010 corresponds to approximately 31,000 FTE jobs. Not only are the employment effects greater during the construction phase, they are also longer lasting, persisting well beyond the end of the construction period when the additional employment is driven more by the productivity impacts rather than the direct employment required to construct the HSBB network. The same employment effect is not possible in a scenario of a tighter labour market, where employment may be reallocated and move around between industries, but does not increase in total to the same extent.

It is important to note that holding real wages fixed until 2013 is a sensitivity test to explore the importance of the labour market conditions in influencing the economic impacts of the HSBB network, an important consideration in light of the recent economic slowdown. Holding real wages fixed in the short term is an artificial economic constraint performed within the model that may not hold. In reality, the actual labour market conditions over the coming years as the HSBB network is deployed will be somewhere between the tight labour market of our original scenarios and the fixed wage rates market of our subsequent model run. As such, the different results should be seen as defining a range of possible impacts, with the actual real world impact defined by the highly uncertain future labour market conditions.

This assumes that not only do we have readily available resources that are otherwise under-employed, but they can be deployed efficiently on the construction of the HSBB network.



## 6 Conclusions

There are several key conclusions arising from this analysis:

- The newness of the development of HSBB combined with the diffuse nature of its benefits means that any assessment of the net economic benefits to be garnered from the expansion will be subject to a large degree of uncertainty. The timing of the impacts is particularly difficult to assess. Greater confidence attaches to the relative size of the net benefits across the various scenarios.
- All of the scenarios modelled have a positive NPV over the reference case, meaning that the benefits outweigh the costs in all cases. In other words, the expansion of coverage of HSBB in any of its forms is an economically beneficial project to be pursuing when compared to the option of doing nothing.
- The Carrier Grade option has the greatest NPV, despite its higher construction cost. The additional cost of this network is more than compensated for by its greater aggregate benefits.
- Importantly, the positive economic benefits increase the faster the continued rollout of HSBB occurs, and the more it is first directed to the most densely populated areas of the economy not yet serviced by HSBB. Furthermore, these benefits also increase with a higher grade of service, for example a carrier grade service with full CAN rehabilitation, despite the higher costs of providing these quality services.
- The positive economic benefits will be greater in times of a weak economy and higher unemployment, and they will be realised in different ways. In particular, less of the gains will be in the form of higher real wages, but there will be a greater boost to employment.
- The benefits captured in this modelling are likely to understate the overall long-term gains. In particular, some of the beneficial impacts on households cannot be reliably quantified, especially as they relate to household convenience, entertainment value and time savings, nor can the network benefits that flow from faster bandwidth in creating a more interactive society be measured.



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## Appendix A: AE-RGEM Technical Note

AE-RGEM is a large scale, dynamic, multi-state/region, multi-commodity computable general equilibrium model of the world economy. The model allows policy analysis in a single, robust, integrated economic framework. This model projects changes in macroeconomic aggregates such as GDP (or GSP at the State level), employment, export volumes, investment and private consumption. At the sectoral level, detailed results such as output, exports, imports and employment are also produced.

The model is based upon a set of key underlying relationships between the various *components* of the model, each which represent a different group of agents in the economy. These relationships are solved simultaneously, and so there is no logical start or end point for describing how the model actually works. Figure A.1 shows the key components of the model for an individual region (say, Queensland). The components include a representative household, producers, investors and international (or linkages with the other regions in the model, including other Australian States and foreign regions). Below is a description of each component of the model and key linkages between components. Some additional, somewhat technical, detail is also provided.

AE-RGEM is based on a substantial body of accepted microeconomic theory. Key assumptions underpinning the model are:

- The model contains a 'regional consumer' that receives all income from factor payments (labour, capital, land and natural resources), taxes and net foreign income from borrowing (lending).
- Income is allocated across household consumption, government consumption and savings so as to maximise a Cobb-Douglas (C-D) utility function.
- Household consumption for composite goods is determined by minimising expenditure via a CDE (Constant Differences of Elasticities) expenditure function. For most regions, households can source consumption goods only from domestic and imported sources. In the Australian regions, households can also source goods from interstate. In all cases, the choice of commodities by source is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.
- Government consumption for composite goods, and goods from different sources (domestic, imported and interstate), is determined by maximising utility via a C-D utility function.
- All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of creating capital.
- Producers supply goods by combining aggregate intermediate inputs and primary factors in fixed proportions (the Leontief assumption). Composite intermediate inputs are also combined in fixed proportions, whereas individual primary factors are combined using a CES production function.
- Producers are cost minimisers, and in doing so choose between domestic, imported and interstate intermediate inputs via a CRESH production function.

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- The model contains a more detailed treatment of the electricity sector that is based on the ‘technology bundle’ approach for general equilibrium modelling developed by ABARE (1996).<sup>6</sup>
  - The supply of labour is positively influenced by movements in the real wage rate governed by an elasticity of supply (assumed to be 0.2).
  - Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. A global investor ranks countries as investment destinations based on two factors: global investment and rates of return in a given region compared with global rates of return. Once the aggregate investment has been determined for Australia, aggregate investment in each Australian sub-region is determined by an Australian investor based on: Australian investment and rates of return in a given sub-region compared with the national rate of return.
  - Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.
  - Prices are determined via market-clearing conditions that require sectoral output (supply) to equal the amount sold (demand) to final users (households and government), intermediate users (firms and investors), foreigners (international exports), and other Australian regions (interstate exports).
  - For internationally-traded goods (imports and exports), the Armington assumption is applied whereby the same goods produced in different countries are treated as imperfect substitutes. But in relative terms imported goods from different regions are treated as closer substitutes than domestically-produced goods and imported composites. Goods traded interstate within the Australian regions are assumed to be closer substitutes again.
  - The model accounts for greenhouse gas emissions from fossil fuel combustion. Taxes can be applied to emissions, which are converted to good-specific sales taxes that impact on demand. Emission quotas can be set by region and these can be traded, at a value equal to the carbon tax avoided, where a region’s emissions fall below or exceed their quota.

## The representative household

Each region in the model has a so-called *representative household* that receives and spends all income. The *representative household* allocates income across three different *expenditure* areas: private household consumption; government consumption; and savings.

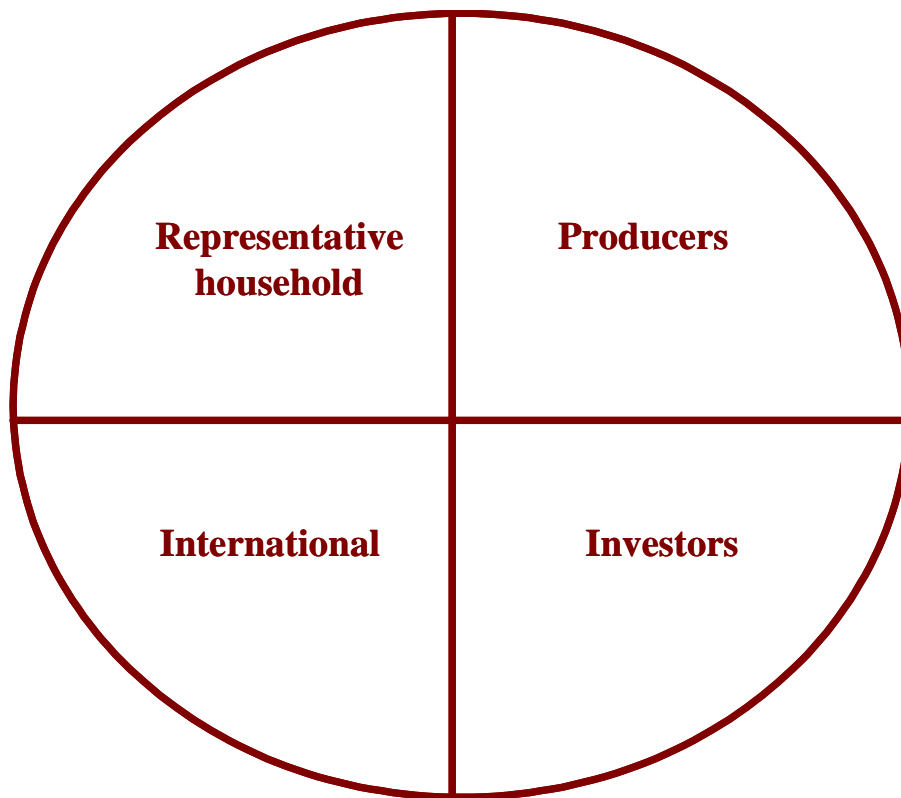
Going clockwise around Figure A.1, the representative household interacts with producers in two ways. First, in allocating expenditure across household and government consumption, this sustains demand for production. Second, the representative household owns and receives all income from factor payments (labour, capital, land and natural resources) as well as net taxes. Factors of production are used by producers as *inputs into production* along with intermediate

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<sup>6</sup> Australian Bureau of Agricultural and Resource Economics (ABARE), 1996, *MEGABARE: Interim Documentation*, Canberra.

inputs. The level of production, as well as supply of factors, determines the amount of income generated in each region.

**Figure A.1: Key components of AE-RGEM**



The *representative household's* relationship with investors is through the supply of investable funds – savings. The relationship between the *representative household* and the international sector is twofold. First, importers compete with domestic producers in consumption markets. Second, other regions in the model can lend (borrow) money from each other.

#### **Some detail**

- The representative household allocates income across three different expenditure areas – private household consumption; government consumption; and savings – to maximise a Cobb-Douglas utility function.
- Private household consumption on composite goods is determined by minimising a CDE (Constant Differences of Elasticities) expenditure function. Private household consumption on composite goods from different sources is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.
- Government consumption on composite goods, and composite goods from different sources, is determined by maximising a Cobb-Douglas utility function.
- All savings generated in each region is used to purchase bonds whose price movements reflect movements in the price of generating capital.

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## Producers

Apart from selling goods and services to households and government, producers sell products to each other (intermediate usage) and to investors. Intermediate usage is where one producer supplies inputs to another's production. For example, coal producers supply inputs to the electricity sector.

Capital is an input into production. Investors react to the conditions facing producers in a region to determine the amount of investment. Generally, increases in production are accompanied by increased investment. In addition, the production of machinery, construction of buildings and the like that forms the basis of a region's capital stock, is undertaken by producers. In other words, investment demand adds to household and government expenditure from the representative household, to determine the demand for goods and services in a region.

Producers interact with international markets in two main ways. First they compete with producers in overseas regions for export markets, as well as in their own region. Second, they use inputs from overseas in their production.

### Some detail

- Sectoral output equals the amount demanded by consumers (households and government) and intermediate users (firms and investors) as well as exports.
- Intermediate inputs are assumed to be combined in fixed proportions at the composite level. As mentioned above, the exception to this is the electricity sector that is able to substitute different technologies (brown coal, black coal, oil, gas, hydropower and other renewables) using the 'technology bundle' approach developed by ABARE (1996).
- To minimise costs, producers substitute between domestic and imported intermediate inputs is governed by the Armington assumption as well as between primary factors of production (through a CES aggregator). Substitution between skilled and unskilled labour is also allowed (again via a CES function).
- The supply of labour is positively influenced by movements in the wage rate governed by an elasticity of supply is (assumed to be 0.2). This implies that changes influencing the demand for labour, positively or negatively, will impact both the level of employment and the wage rate. This is a typical labour market specification for a dynamic model such as AE-RGEM. There are other labour market 'settings' that can be used. First, the labour market could take on long-run characteristics with aggregate employment being fixed and any changes to labour demand changes being absorbed through movements in the wage rate. Second, the labour market could take on short-run characteristics with fixed wages and flexible employment levels.

## Investors

Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. The global investor ranks countries as investment destination based on two factors: current economic growth and rates of return in a given region compared with global rates of return.

### Some detail

- Once aggregate investment is determined in each region, the regional investor is constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.

### International

Each of the components outlined above operate, simultaneously, in each region of the model. That is, for any simulation the model forecasts changes to trade and investment flows within, and between, regions subject to optimising behaviour by producers, consumers and investors. Of course, this implies some global conditions must be met such as global exports and global imports are the same and that global debt repayments equals global debt receipts each year.

### Dynamics

AE-RGEM is a recursive dynamic model that solves year-on-year over a specified timeframe. The model is then used to project the relationship between variables under different scenarios, or states, over a predefined period.

Set against the reference case scenario (i.e., the model's path under a no policy change assumption) is a 'scenario projection'. This scenario represents the impacts of imposing a policy change, which results in a new projection of the path of the model's variable over the simulation time period. The impacts of the policy change are reflected in the differences in the reference case and policy simulations for each model variable at each point in time.

As shown in Chart A.1, the index (=1.0 in shock reference year of 2009, for instance) on the vertical axis can represent all sorts of macroeconomic indicators (i.e. real GSP/GDP, GNP, household consumption etc.) and microeconomic ones (i.e. industry output and exports etc.). And it can be projected to increase over time.

Chart A.1: Dynamic simulation using AE-RGEM

