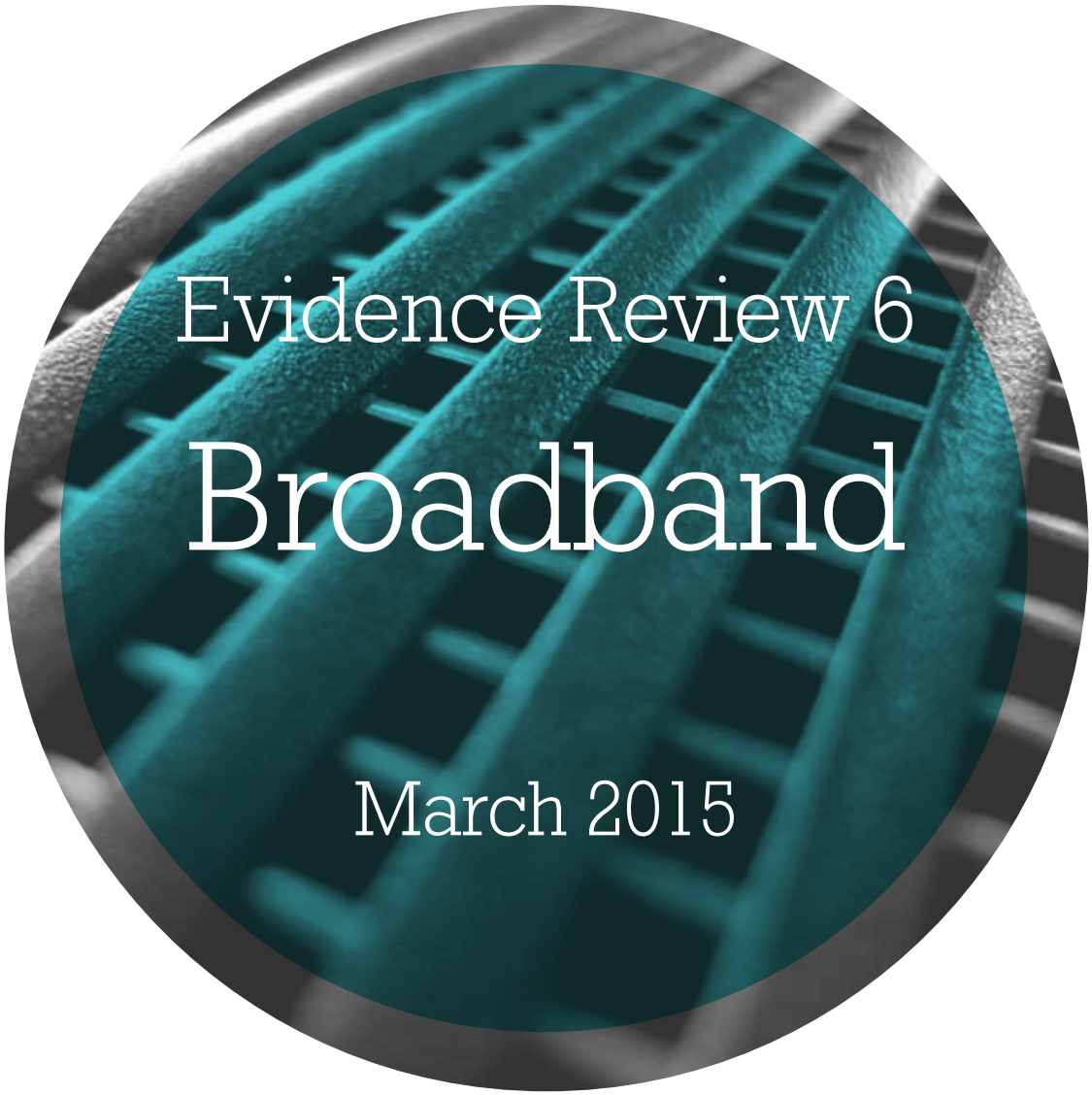

Evidence Review 6

Broadband

March 2015

what works centre for
local economic growth

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Contents

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Preface

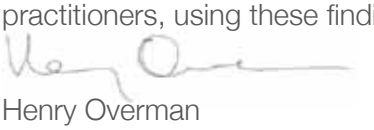
This report presents findings from a systematic review of evaluations of the local economic impact of broadband. It is the sixth of a series of reviews that will be produced by the What Works Centre for Local Economic Growth. The What Works Centre is a collaboration between the London School of Economics and Political Science, Centre for Cities and Arup and is funded by the Economic & Social Research Council, The Department for Communities and Local Government and The Department for Business Innovation & Skills.

The Centre's reviews consider a specific type of evidence – impact evaluation – that seeks to understand the causal effect of policy interventions and to establish their cost-effectiveness. To put it another way they ask 'did the policy work' and 'did it represent good value for money'? With this review we are particularly interested in demonstrating that the local economic impacts of broadband can be rigorously evaluated and in drawing out the wider lessons for policy.

Evidence on impact and effectiveness is clearly a crucial input to good policy making. In the case of broadband, of course, the main aims are not necessarily to improve the local economy. But policymakers often claim economic benefits for these interventions, and so economic impact evaluation is important to do to understand if these claims are justified. Other ways of considering the impact of broadband (e.g. case studies) provide a valuable complement to impact evaluation, but we deliberately do not focus on these.

We see these impact-focused reviews as an essential part of more effective policy making. We often simply do not know the answers to many of the questions that might reasonably be asked when implementing a new policy – not least, does it work? Figuring out what we do know allows us to make better decisions and to start filling the gaps in our knowledge. This also helps us to have more informed discussions and to improve policy making.

These reviews therefore represent a first step in improving our understanding of what works for local economic growth. In the months ahead, we will be working with local decision makers and practitioners, using these findings to help them generate better policy.



Henry Overman
Director, What Works Centre for Local Economic Growth

02

Executive Summary

This report presents findings from a systematic review of evaluations of the **local economic** impact of broadband. It is the sixth of a series of reviews that will be produced by the What Works Centre for Local Economic Growth.

The review considered more than **1,000** policy evaluations and evidence reviews from the UK and other OECD countries. It found **16** impact evaluations that met the Centre's minimum standards.

This is the smallest evidence base we have encountered to date, although the quality of some of these studies was high.

Overall, of the 16 evaluations reviewed, 14 found that broadband has positive impacts on the local economy. However, effects are likely to vary across types of firms, workers and areas, and may not be large in the aggregate.

Broadband is a 'general purpose technology' that is likely to have social and environmental impacts as well as economic effects. Policymakers may want to take all of these outcomes in to account when developing broadband strategies. However, this report focuses only on local economic impacts.

We considered four types of broadband projects:

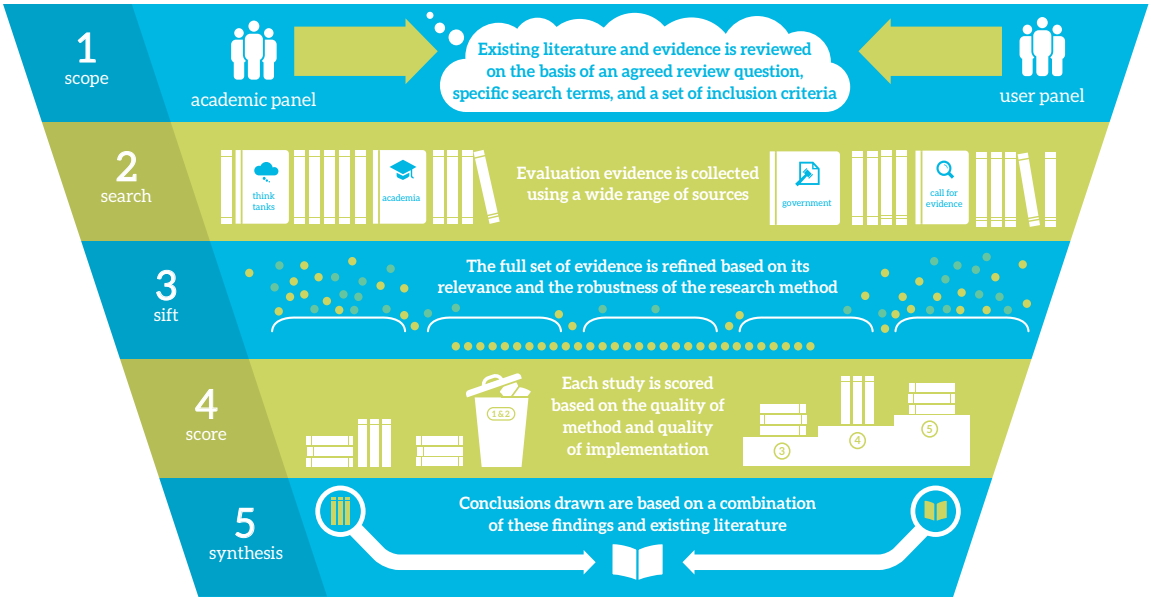
1. Private provision
2. Direct public provision to improve broadband infrastructure
3. Indirect public provision, such as grants, loans or vouchers to connect users to existing networks
4. Demonstration projects, where a private company provides fast internet infrastructure and/or service

Approach

The Centre seeks to establish causal impact – an estimate of the difference that can be expected between the outcome for areas that have broadband provision and the average outcome they would have experienced without provision (see Figure 1). Our methodology for producing our reviews is outlined in Figure 2. We would like to thank Gabriel Ahlfeldt, Oliver Falck and Ralf Martin for their help in completing this review.

Figure 1: Evaluating impact

Figure 2: Methodology



Findings

This section summarises the detailed findings. We emphasise that many of these findings depend on a small number of studies. They are, however, consistent with other research on the broader impact of ICT.

What the evidence shows

- Extending broadband to an area can affect firm productivity, number of businesses, and local labour market outcomes (such as employment, income and wages).
- These effects are not always positive, are not necessarily large, and may depend on complementary investments by firms (for example, training workers, or reorganizing sales strategy or supply chains to take advantage of faster internet connections).
- Effects can vary across different types of industries and workers with service industries and skilled workers possibly benefiting more than manufacturing industries and unskilled workers.
- The economic effects of broadband tend to be larger in urban areas (or close to urban areas) than in rural areas.

Where there is a lack of evidence

- Most studies look at the effect of broadband provision. Only two studies **compare broadband adoption with provision**. It is hard to generalize conclusions from these two studies but they do suggest that the effects of adoption and provision may differ.
- Only two studies look at the **effects on profits and sales** – one shows a positive effect (for US farms), but the other shows zero effect (for firms in East Yorkshire).
- Only one study looks at the effects on **property prices** - showing a positive effect on domestic property prices.
- We have surprisingly little evaluation evidence of broadband's impact on **working patterns** – one study finds that broadband positively affects female labour force participation; another study, however, finds no net effects on working at home, telecommuting or operating a home-based business.
- We only found three high quality evaluations of specific **broadband policies** (voucher schemes, direct public provision or public/private partnerships).
- **Costs** are rarely addressed in the studies reviewed. Only one paper attempts a cost-benefit analysis.
- We have no studies that evaluate the kind of **SME-targetted voucher scheme** currently running in the UK.
- It would be very useful to know more about the relative effects of **indirect v direct provision** (ie, voucher schemes for services v direct investment infrastructure). The UK is funding both approaches at the moment.
- There is a lack of evidence in **other areas of internet technology** such as the effect of wi-fi networks, and fast mobile internet. Future evaluations in this area would greatly improve the evidence base.

How to use these reviews

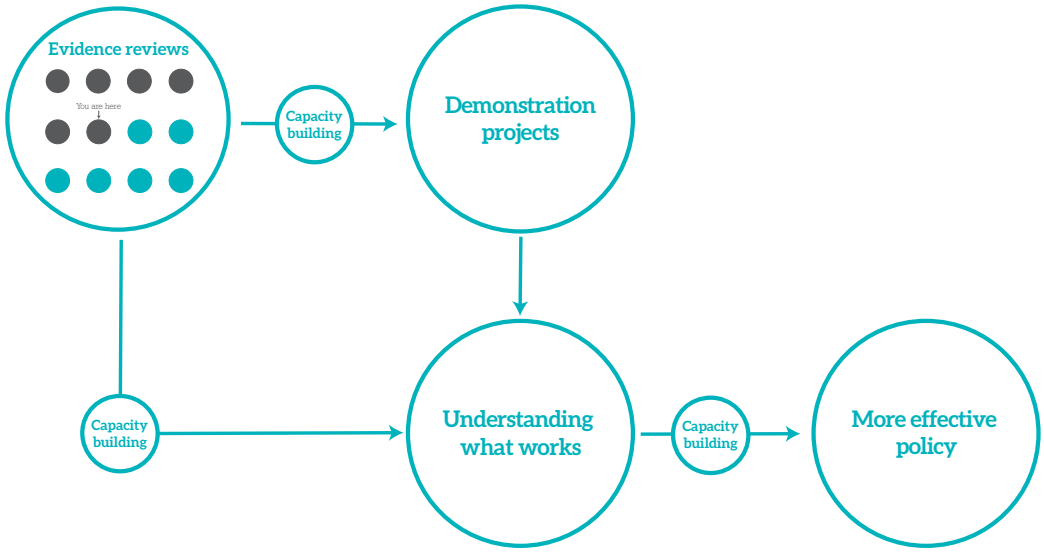
The evidence review highlights a number of factors for policy makers to be aware of when considering broadband policy:

- Broadband, like many ICTs, is a 'disruptive' technology that creates winners and losers, and has spillover effects across local boundaries. It is not a silver bullet for local economic development;
- There is evidence that broadband has positive local economic impacts, but some of these may be due to in-migration. Existing households may not be the biggest beneficiaries;
- Broadband seems to benefit skilled workers more than low- or un-skilled workers;
- The effects of adoption and provision may differ. More work needs to be done to understand whether and how to encourage adoption and productive business use.
- Rural areas may need to subsidise broadband provision but the economic benefits of doing so will not be as large as for urban areas.

To determine policy priorities

The Centre's reviews consider a specific type of evidence – impact evaluation – that seeks to understand the causal effect of policy interventions and to establish their cost-effectiveness. In the longer term, the Centre will produce a range of evidence reviews that will help local decision makers decide the broad policy areas on which to spend limited resources. Figure 3 illustrates how the reviews relate to the other work streams of the Centre.

Figure 3: What Works Centre work programme



Helping to fill the evidence gaps

As should be clear from this review, there are many things that we do not know about the local economic impact of broadband.

If achieving local economic impact is an important part of the case for broadband provision, then there need to be more evaluations that explicitly explore these impacts. Central and local policymakers – and private sector partners – should:

- Look to make greater use of treatment and comparison groups; and to use the rollout of new, fast broadband infrastructure to help generate these groups. Existing local experiments such as YorkCORE and Google Fiber in the US are useful examples to draw on;
- Focus on evaluating take-up and use of broadband, rather than simply availability and access; in particular linking together broadband take-up with wider business advice and support;
- Consider evaluating programmes that target firms, e.g. SMEs, that might need additional assistance to use broadband to the full;
- Attempt to clearly separate out impacts on firms and the business community from impacts on local labour markets and households.

The Centre's longer term objectives are to ensure that robust evidence is embedded in the development of policy, that these polices are effectively evaluated and that feedback is used to improve them. To achieve these objectives we want to:

- work with local decision makers to improve evaluation standards so that we can learn more about what policies work, where.
- set up a series of 'demonstration projects' to show how effective evaluation can work in practice.

Interested policymakers please get in touch.

03

Introduction

This review looks at the local economic impacts of broadband. Broadband infrastructure and services are fundamental components of today's internet. 'Broadband' is a generic term to describe always-on access to an internet service, and there are many varieties of broadband technology in use around the world today. Table 1 provides an overview of these.

Table 1. Internet technologies

Type	Network	Status	Typical speed
Dial-up	Copper	Obsolete	56 Kbps
ADSL 2+	Copper	Live	Up to 20 Mbps
FTTC	Fibre + Copper	Live	Up to 80 Mbps
HFC	Fibre + Cable	Live	150 Mbps
G.fast	Fibre + Copper	Field trials	700 Mbps
XG.fast	Fibre + Copper	Lab trials	1 Gbps
FTTH	Fibre	Live	1 Gbps

Source: Kenny 2015 / NESTA

In the UK, the government would like universal coverage of ADSL by 2015, and – while it remains technology-neutral – is focusing its 'superfast broadband' efforts on 'fibre to the node' technologies.[1] Even though 'superfast' in the UK is rather slower than is standard in countries like Korea, the government hopes that the economic impacts of faster broadband speeds will be substantial. Research commissioned by DCMS projects that fast broadband could add £17bn to the UK's ***annual*** GVA by 2024.[2]

To get a sense of where these economic benefits might come from, we need to look at the wider role of the internet, and information and communication technologies (ICTs) in general. Broadband

1 https://www.gov.uk/broadband-delivery-uk, accessed 5 February.
2 SQW 2013.

internet, like many other ICTs, is generally considered to be a 'general purpose technology' in that it functions across many areas of economic and social life, and is an enabler of further innovation in those fields.[3] Economic analysis of these ICTs looks at both direct effects (such as the growth of the digital economy and online industries) and indirect effects (on GDP, employment and wages, industry structure and the organization of work).[4] This review focuses on these wider, indirect economic effects, which are of most interest to local policy makers concerned with whether or not to intervene to improve broadband provision in their areas. We also focus on studies of past impact rather than projections of possible future impact.

There are differing views of how ICTs and the internet shape economic progress. Enthusiasts argue that ICT adoption helps explain growth in productivity (particularly of labour) in developed countries. They point to US experience with computerisation in the 1980s as an illustration of what ICT can deliver.[5] By contrast, sceptics suggest that these economic effects are overstated, and that the internet – in particular – is far less significant than is often assumed. These critics also emphasise the potential for ICTs to increase inequality and the economic cost of technological disruption.[6]

There is a middle camp between these groups, which assumes that the internet and ICTs contribute to economic change, but that the extent of this change depends on how people and firms adapt to and innovate around technology. For example, a number of studies suggest that ICT investment only delivers productivity gains for firms who also introduce training for staff, and new ways of working.[7]

In turn, this perspective suggests that takeup and use of broadband may be more important than simply availability of the technology. It also suggests that the firms most likely to gain from broadband might be the most likely to adopt the technology, which creates a challenge for evaluators (see discussion below).

What economic impacts of broadband availability might we expect to see? For firms and their workers, broadband should allow for efficiencies in production, both by lowering costs (for data storage, advertising or working with suppliers) and by enabling innovation (reaching new customers online, for instance, or employing big data analytics).[8] Those productivity gains could translate into higher wages, and possibly higher levels of employment (although firms might well shed staff in response to technological change). At the same time, broadband may allow for more flexible patterns of work, including working at home or on the move. For some groups of people, such as those with caring responsibilities, more flexibility may increase labour force participation, which could in turn raise employment. More broadly, broadband may lower the barriers to starting a business, particularly in sectors like retail.[9]

It is also important to recognise that there may be winners and losers from these changes. If broadband makes industries more competitive, some firms will lose staff or go out of business altogether.[10] ICTs like broadband are complementary to human capital, so we might also expect skilled workers to gain more (in terms of wages). Broadband might also help accelerate automation, which penalises less skilled workers and those doing routine tasks.[11] Increased labour force participation might raise overall employment levels, but that increase in labour supply might depress

3 Bresnahan and Tratjenberg 1995.
4 OECD 2013.
5 Jorgenson et al 2008, Oliner et al 2007.
6 Gordon 2012 and 2014, Keen 2015.
7 Brynjoloffson and Hitt 2000 and 2003, Bloom et al 2012.
8 Bakhshi and Mateos-Garcia 2012.
9 http://www.retailresearch.org/onlineretailing.php, accessed 26 January 2015.
10 Aghion et al 2009 RESTA, Moretti 2012
11 Bresnahan et al 2002, Autor et al 2003, Brynjolffson and McAfee 2014.

wages – or leave employment rates unchanged (if changes in participation outweigh numbers of people moving into work).[12]

We should also expect to see broadband having different economic impacts in different types of places. Specifically, the academic literature suggests that the economic effects of broadband (and ICTs) in general may be bigger in urban areas. This is because, as discussed above, broadband and ICTs enable 'production complementarities', especially for skilled workers and knowledge-intensive firms. Both of these groups are – by and large – urban-orientated.[13] However, for sparser, rural areas, broadband might still have some economic impact, and could deliver social gains. It is also important to note that while these predictions on likely relative benefits are evidence based it would be very helpful to know whether they hold in practice for broadband.

Given broadband's general purpose nature, policymakers need to set these economic factors alongside social and environmental issues when deciding what their broadband strategy should be. In most countries, broadband infrastructure and service provision is market-led: the state's role is to ensure a competitive market, and to regulate service levels and coverage. Critically, this means we have relatively few examples of explicit broadband delivery programmes, and thus, relatively few policy evaluations to draw on. In the EU, state aid rules may further limit national government's freedom of manoeuvre. As we explain in Section 6, this also makes evaluation of broadband's economic impacts more challenging than evaluation in some other areas of economic development policy.

Where governments do take a more active role, this takes two broad forms. The first is indirect provision that subsidises connections to existing networks, either through voucher schemes or loans. Related to this, governments may part-fund infrastructure in locations where there is market failure (such as some rural areas), or provide basic funding to incentivise research and development.

The second form of active policy is direct provision of broadband infrastructure or services. Some city governments have partnered with the private sector on projects such as Google Fiber[14], the YorkCORE project[15] or public wifi systems. In other cases, such as Norway's Public Broadband programme, a state-owned utility has rolled out a network across the country; in a few examples, such as Munich, city governments own telecoms companies that provide the network and services. In the UK, Hull had a wholly publicly owned telecoms company until 1997, when the council sold the majority of its shares; the rest were sold in 2007.[16]

In this review we cover the literature on the economic effects of broadband, and look at policy evaluations where these exist. Because ICTs like broadband have a very wide set of impacts, we cluster these together, and focus on:

- productivity;
- firm entry and business numbers;
- employment and other labour market outcomes;
- income and wages; and
- other outcomes (e.g. sales and property prices).

12 Kolko 2012.
13 Beaudry et al 2010.
14 Originally launched in Kansas City, the scheme is now also live in Provo, Utah and Austin, Texas.
15 http://www.cityfibre.com/yorkcore/, accessed 27 January 2015.
16 Study 948 compares firms in Hull served by Kingston Communications, the local ISP, with nearby firms served by BT during the period 2000-2004.

We also discuss studies that compare impacts in different places, typically urban and rural locations. These are the effects that we think are most likely to be of interest to local policy makers when thinking about the potential impact of broadband on local economic performance.

Unfortunately we are not able to say as much as we would like about policy design issues such as the relative effects of indirect versus direct provision; 'superfast' versus 'ultrafast' technologies; policies that target SMEs or other types of firms; or scheme costs.[17] This is because not many explicit policy evaluations exist, and not all those that do exist are robust enough to pass our quality filters. As recent NESTA research argues, further broadband demonstrator / local evaluation projects are essential to understand the economic and social impacts both of the technologies and how they are made available.[18]

17 The Broadband Stakeholder Group has also highlighted the dearth of UK evidence on how SMEs use broadband. See BSG (2014).
18 Kenny (2015).

04

Impact evaluation

Governments around the world increasingly have strong systems to monitor policy inputs (such as spending on subsidized broadband provision) and outputs (such as the total number of houses or business connected to broadband). However, they are less good at identifying policy outcomes (such as the wider effect of broadband on local employment). In particular, many government-sponsored evaluations that look at outcomes do not use credible strategies to assess the **causal impact** of broadband policies (henceforth, we refer to these as 'projects').

By causal impact, the evaluation literature means an estimate of the difference that can be expected between the outcome for areas undertaking a project (e.g. improving broadband provision) and the average outcome they would have experienced without the project. Pinning down causality is a crucially important part of impact evaluation. **Estimates of the benefits of a project are of limited use to policy makers unless those benefits can be attributed, with a reasonable degree of certainty, to that project.**

The credibility with which evaluations establish causality is the criterion on which this review assesses the literature.

Using Counterfactuals

Establishing causality requires the construction of a valid counterfactual – i.e. what would have happened to an area (or part of an area) if the project hadn't happened. That outcome is fundamentally unobservable, so researchers spend a great deal of time trying to rebuild it. The way in which this counterfactual is (re)constructed is the key element of impact evaluation design.

A standard approach is to create a counterfactual group of similar places not undertaking the kind of project being evaluated. Changes in outcomes can then be compared between the 'treatment group' (locations affected by improved broadband provision) and the 'control group' (locations not affected). As we discuss below, in the case of broadband, such treatment and control groups are not always easy to identify.

A key issue in creating the counterfactual group is dealing with the 'selection into treatment' problem. Selection into treatment occurs when locations that undergo broadband

improvements differ from those who do not do so.

An example of this problem for broadband projects would be when a government focuses broadband provision on its best performing cities. If this happens, estimates of policy impact may be biased upwards because we incorrectly attribute better economic outcomes to the project, rather than to the fact that the city is already performing better.

Selection problems may also lead to downward bias. For example, if a local authority programme explicitly targets slow growing areas for broadband provision then we may mistakenly attribute poor economic performance to the programme rather than the underlying conditions.

These factors are often unobservable to researchers. **So the challenge for good programme evaluation is to deal with these issues, and to demonstrate that the control group is plausible.** If the construction of plausible counterfactuals is central to good policy evaluation, then the crucial question becomes: **how do we design counterfactuals?** Box 1 provides some examples.

Box 1: Impact evaluation techniques

One way to identify causal impacts of a project is to randomly assign participants to treatment and control groups. For researchers, such **Randomised Control Trials** (RCTs) are often considered the 'gold standard' of evaluation. Properly implemented, randomisation ensures that treatment and control groups are comparable both in terms of observed and unobserved attributes, thus identifying the causal impact of the project. However, **implementation of these 'real world' experiments is challenging and can be problematic**. RCTs may not always be feasible for local economic growth policies – for example, policy makers may understandably be unwilling to randomise the location of projects.[19]

Where randomised control trials are not an option, **'quasi-experimental'** approaches of randomisation can help. These strategies can deal with selection on unobservables, by (say) exploiting institutional rules and processes that result in some locations quasi-randomly undertaking projects.

Even using these strategies, though, the treatment and control groups may not be fully comparable in terms of observables. Statistical techniques such as **Ordinary Least Squares** (OLS) and **matching** can be used to address this problem.

Note that higher quality impact evaluation first uses identification strategies to construct a control group and deal with selection on unobservables. Then it tries to control for remaining differences in observable characteristics. It is the combination that is particularly powerful: OLS or matching alone raise concerns about the extent to which unobservable characteristics determine both treatment and outcomes and thus bias the evaluation.

Evidence included in the review

We include any evaluation that compares outcomes for areas improving broadband provision (the treated group) after the project with outcomes in the treated group before the project; relative to a comparison group used to provide a counterfactual of what would have happened to these outcomes in the absence of the project.

This means we look at evaluations that do a reasonable job of estimating the impact of the project using either randomised control trials, quasi-random variation or statistical techniques (such as OLS

19 Gibbons, Nathan and Overman (2014)

and matching) that help make treatment and control groups comparable. We view these evaluations as providing credible impact evaluation in the sense that they identify effects that can be attributed, with a reasonable degree of certainty, to the project in question. A full list of shortlisted studies is given in Appendix B.

Evidence excluded from the review

We exclude evaluations that provide a simple before and after comparison only for those places undertaking broadband projects because we cannot be reasonably sure that changes for the treated group can be attributed to the effect of the project.

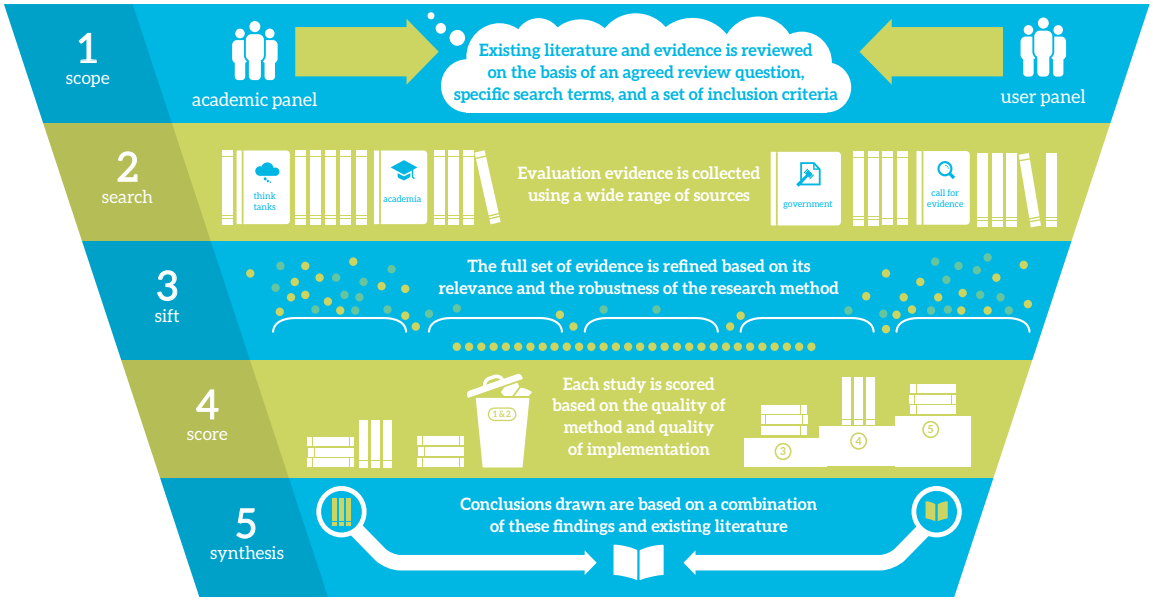
We also exclude case studies or evaluations that focus on process (how the project is implemented) rather than impact (what was the effect of the project). Such studies have a role to play in helping formulate better policy but they are not the focus of our evidence reviews.

05

Methodology

To identify robust evaluation evidence on the causal impact of broadband we conducted a systematic review of the evidence from the UK and across the world. Our review followed a five-stage process: scope, search, sift, score and synthesise.

Figure 1: Methodology



Stage 1: Scope of Review

Working with our User Panel and members of our Academic Panel, we agreed the review question, key terms and inclusion criteria. We also used existing literature reviews and meta-analyses to inform our thinking.

Stage 2: Searching for Evaluations

We searched for evaluation evidence across a wide range of sources, from peer-reviewed academic research to government evaluations and think tank reports. Specifically, we looked at academic databases (such as EconLit, Web of Science and Google Scholar), specialist research institutes (such as CEPR and IZA), UK central and local government departments, and work done by think tanks (such as the OECD, ILO, ippr and Policy Exchange.) We also issued a call for evidence via our mailing list and social media. This search found just over 1000 books, articles and reports. Appendix C provides a full list of sources and search terms.

Stage 3: Sifting Evaluations

We screened our long-list on relevance, geography, language and methods, keeping impact evaluations from the UK and other OECD countries, with no time restrictions on when the evaluation was done. We focused on English-language studies, but would consider key evidence if it was in other languages. We then screened the remaining evaluations on the robustness of their research methods, keeping only the more robust impact evaluations. We used an adjusted version of the Maryland Scientific Methods Scale (SMS) to do this.[20] The SMS is a five-point scale ranging from 1, for evaluations based on simple cross sectional correlations, to 5 for randomised control trials (see Box 2). We shortlisted all those impact evaluations that could potentially score three or above on the SMS[21]. In this case we found no evaluations scoring five: for examples of impact evaluations that score three or four on the SMS scale see the case studies and our scoring guide available at www.whatworksgrowth.org.

Stage 4: Scoring Evaluations

We conducted a full appraisal of each evaluation on the shortlist, collecting key results and using the SMS to give a final score for evaluations that reflected both the quality of methods chosen and quality of implementation (which can be lower than claimed by some authors). Scoring and shortlisting decisions were cross-checked with the academic panel members and the core team at LSE. The final list of included studies and their reference numbers (used in the rest of this report) can be found in Appendix B.

Stage 5: Synthesising Evaluations

We drew together our findings, combining material from our evaluations and the existing literature.

20 Sherman, Gottfredson, MacKenzie, Eck, Reuter, and Bushway (1998).
21 Sherman et al. (1998) also suggest that level 3 is the minimum level required for a reasonable accuracy of results.

Box 2: Our robustness scores (based on adjusted Maryland Scientific Methods Scale)

Level 1: Either (a) a cross-sectional comparison of treated groups with untreated groups, or (b) a before-and-after comparison of treated group, without an untreated comparison group. No use of control variables in statistical analysis to adjust for differences between treated and untreated groups or periods.

Level 2: Use of adequate control variables and either (a) a cross-sectional comparison of treated groups with untreated groups, or (b) a before-and-after comparison of treated group, without an untreated comparison group. In (a), **c**ontrol variables or matching techniques used to account for cross-sectional differences between treated and controls groups. In (b), control variables are used to account for before-and-after changes in macro level factors.

Level 3: Comparison of outcomes in treated group after an intervention, with outcomes in the treated group before the intervention, and a comparison group used to provide a counterfactual (e.g. difference in difference). Justification given to choice of comparator group that is argued to be similar to the treatment group. Evidence presented on comparability of treatment and control groups. Techniques such as regression and (propensity score) matching may be used to adjust for difference between treated and untreated groups, but there are likely to be important unobserved differences remaining.

Level 4: Quasi-randomness in treatment is exploited, so that it can be credibly held that treatment and control groups differ only in their exposure to the random allocation of treatment. This often entails the use of an instrument or discontinuity in treatment, the suitability of which should be adequately demonstrated and defended.

Level 5: Reserved for research designs that involve explicit randomisation into treatment and control groups, with Randomised Control Trials (RCTs) providing the definitive example. Extensive evidence provided on comparability of treatment and control groups, showing no significant differences in terms of levels or trends. Control variables may be used to adjust for treatment and control group differences, but this adjustment should not have a large impact on the main results. Attention paid to problems of selective attrition from randomly assigned groups, which is shown to be of negligible importance. There should be limited or, ideally, no occurrence of 'contamination' of the control group with the treatment.

Note: These levels are based on but not identical to the original Maryland SMS. The levels here are generally a little stricter than the original scale to help to clearly separate levels 3, 4 and 5 which form the basis for our evidence reviews.

06

Definition

Broadband and "High-speed internet" are generic terms used to describe the nature and the speed of access to an internet service. As we set out in the Introduction, broadband is always on and faster than dial-up; in practice, there are multiple broadband technologies (such as DSL, fibre and wireless) offering a range of speeds and modes of access.

We used this definition to search for articles on the topic. We searched for articles on 'broadband' in order to capture studies evaluating fast internet services, in addition to searches for 'wi-fi' and 'mobile internet', in order to capture newer high-speed internet technologies which rely less upon extensive cabling and physical infrastructure.

Ultimately, we consider studies covering four types of broadband projects:

- Private provision: Our searches turned up a lot of studies looking at private sector broadband provision, for reasons we discuss in the Introduction.
- Direct public provision: for example, where government provides local councils with funding so that they can hire private companies to extend infrastructure, or where broadband infrastructure is state owned.
- Indirect public provision: typically, grants, loans or vouchers to connect users to existing networks.
- Demonstration projects: where a private company provides fast internet infrastructure and/or service, such as Netville or Google Fiber; or public-private partnerships, such as the free wi-fi scheme on the London Underground.

Impact evaluation

As discussed in the introduction, assessing the economic effects of broadband is challenging: as a general purpose technology, broadband will affect multiple economic outcomes in ways that are hard for researchers to disentangle.

There are also specific challenges in deploying impact evaluation tools. It is fairly easy to understand how we might construct control groups and undertake evaluation for policies targeted at individuals,

households or firms. It is harder to think about how we might do this for policies – such as broadband – that target areas in order to reach homes or businesses. In addition to our substantive interest in the impacts of policy, one of our motivations in considering broadband is to help convince decision makers that better evaluation is possible. This section provides a brief explanation of how the reports we considered have tried to do this. Further details on specific examples can be found in our scoring guide available from www.whatworksgrowth.org.

Evaluation of the local economic growth effects of broadband is particularly challenging. Private sector broadband providers invest only where they expect there to be strong and growing demand. These locations are likely to be already experiencing economic growth and increases in jobs/wages. These selection effects mean that underlying trends must be disentangled from any potential effects of broadband access.

Selection is likely to be a much bigger problem in the policy area of broadband than for some of our previous policy areas (such as sports events and facilities). For those who decide where a sports event will take place, economic factors may be one consideration among many. However, for broadband suppliers, economic factors (and hence demand) are the core consideration for broadband deployment. For this reason, treated areas are almost always likely to be different to untreated areas. Some of these differences will be hard to observe in available data, making it very difficult to construct an appropriate control group. Furthermore, these unobservable differences are not fixed over time since suppliers have large incentives to respond very quickly to changes in demand, and to be informed and sophisticated in predicting future economic success of locations.

Many studies in this review attempt to address these 'selection problems' using variations on the difference-in-difference or panel fixed effects methods. In these methods, the change in outcome in the 'treatment' areas (which got broadband) is compared with the change in outcome in a group of similar control areas (which did not get broadband). The control group is constructed to be similar to the treatment group either by matching on observed characteristics or by using control variables. By taking a before-and-after difference, this method eliminates all fixed unobservable differences between the treatment and control groups. However, as discussed, there are also likely to be time-varying unobservable differences that drive private broadband roll-out.

In order to more reliably assess the impact of broadband it is important to exploit some source of randomness – either in the way ISPs deliver broadband, or through a public policy where some element of randomisation is built in. One third of the studies in this review have attempted to do this. This is a larger share than for our other reviews reflecting the importance of such methods for evaluating this policy.

For example, study 755 looks at the effect of broadband on property prices by using a housing unit's distance to the nearest telephone exchange as an instrumental variable. The original locations of the telephone exchanges were based on different requirements than today's broadband network, therefore are not subject to the same selection problem. But the distance does determine today's broadband availability since houses beyond a certain distance cannot receive broadband. The method essentially compares houses that 'randomly' got broadband because they are within the threshold distance to houses that 'randomly' didn't get it because they are outside the threshold.

By contrast, Study 947 is a policy evaluation that uses features of the policy to get at the causal effects of broadband. Policymakers designed a scheme to roll out broadband nationally; however, cost constraints meant that firms in some areas got the technology sooner than others. Because the

cost factors were related to the policy and not market forces, this allowed the researchers to ‘back out’ the impact of broadband on recipient versus non-recipient firms.

Future evaluations in the area of broadband should pay close attention to techniques used in studies such as these. These methods are potentially the only way to achieve reliable estimates of the impact of broadband on local economic growth outcomes.

We think there is great opportunity to use these kind of approaches for the evaluation of specific broadband policies in the UK, both voucher schemes (such as the current SME voucher scheme) or targeted direct provision. These hold potential since the selection problem may not be as strong as with private provision. This means a diff-in-diff/panel method that controls for observable characteristics would be an appropriate method. Furthermore, it may be feasible to randomise or quasi-randomise part of the programme roll out or the voucher allocation.

07

Findings

This section sets out the review's findings. We begin with a discussion of the evidence base, and then explore the overall pattern of results. After this we consider specific outcomes in more detail.

Quantity and quality of the evidence base

The review initially considered over 1,000 articles and evaluations from the UK and other OECD countries, which were identified during the initial keyword search.

Following a further high level review, 800 were sifted out as not ultimately relevant (e.g. because they were theoretical rather than data-based; were comparative or descriptive rather than analytical; or because they reviewed non-OECD countries, were written in a foreign language or because of subject relevance). From the remaining evaluations, we discarded 63 purely qualitative evaluations. A further 32 clearly did not meet the centre's minimum standard of quantitative evidence (i.e. scored 2 or below on the SMS scale). Finally 111 articles were shortlisted for detailed review.

Of those 111 shortlisted studies reviewed in detail, a further 2 were ultimately discounted on grounds of relevance and 93 on grounds of not meeting the Centre's minimum standard of evidence (i.e. scored 2 or below on the SMS scale). The absence of a control group and the use of cross-sectional rather than time series data (i.e. changes in outcomes) were the two most common reasons for rejection.

The remaining 16 studies have been included in this review.

This is a smaller evidence base than all our reviews to date (on employment training, business advice, sports and culture projects, access to finance and estate renewal). As discussed above, this partly reflects the difficulties in evaluating broadband policies but is also indicative of a failure to carefully evaluate existing policy interventions. Table 1 shows the distribution of the studies ranked by SMS score.

Table 1: Implementation Quality Scores

SMS Score	No. of studies	Evaluation reference numbers
4	6	755, 798, 802, 947, 948, 1006
3	10	760, 761, 769, 770, 771, 780, 794, 795, 799, 801
Total	16	

We found no studies that used randomised control trials, but six studies that used credible random sources of variation.[22] As discussed in the previous section, this is not that surprising given the nature of these projects. The remaining ten studies used variations in OLS, difference-in-difference or matching techniques (scoring 3 on the SMS). The techniques applied in these studies mean that we can be reasonably confident that they have done a good job of controlling for observable characteristics of areas and individuals. However, it is likely that unobservable characteristics may still be affecting the results.

Type and Focus of Support

In previous evidence reviews we have focused on specific policy interventions aimed at delivering particular objectives (e.g. government funded employment training in our first review). In contrast, the vast majority of broadband studies in this review do not evaluate a specific policy with explicit objectives and rationales; rather they simply look at the effects of having fast broadband access, speed of service, or both.

As outlined in the introduction, this partly reflects the fact that in most countries, broadband infrastructure and service provision is market-led, and so the role of policy is largely around competition and regulation, rather than supply. It also reflects the fact that broadband (and fast internet generally) is a general-purpose technology, with multiple uses and impact channels.

Restricting evaluations to specific programmes with precise objectives is difficult in cases like this. We did find four evaluations of specific programmes – studies 769, 770, 947 and 1006, each of which involves the public and private sector. Studies 769 and 770 cover the USDA Broadband Loan scheme, aimed at increasing broadband provision for 'underserved' rural communities. Loans were extended to small ISPs based in these communities to encourage the rollout of broadband services. Study 947 evaluates the Norwegian National Broadband Programme, in which the state-owned national telecoms company rolled out the technology across the country. Local governments in rural areas could bid for additional public funding to cover the costs of installation. The other study (Study 1006) analyses a specific policy where the public authority in Trento, Italy provided a subsidy to the telecoms provider to finance the installation of broadband in areas which were not privately supplied.

The remaining studies do not cover specific interventions. Due to the small number of short-listed evaluations, the diverse group of programmes they cover and the rationale for those programmes, it makes little sense to come to a conclusive judgment on whether broadband 'works'. The move away

22 Seven papers were given a preliminary score of 4: six of these used Instrumental Variable approaches and one a Regression Discontinuity Design. Two of these studies (799 and 801) were eventually scored 3 due to concerns over the validity of the instruments used.

from specific policies also means that it does not make sense to compare outcomes to programme objectives (as we have done in previous reviews). Instead, this review focuses only on understanding the effects on specific outcomes of interest and the extent to which these differ between urban and rural areas, between industries and across different types of workers.

Our shortlisted studies do not attempt to distinguish between different aspects of broadband provision (e.g. speed versus availability). Only two studies directly compare broadband adoption with provision (794 and 795). It is hard to generalize conclusions from these two studies but they do suggest that the effects of adoption and provision may differ (we indicate the differences below when appropriate). Clearly, while provision is a necessary condition for adoption, the difference between policies aimed at increasing provision and those aimed at encouraging effective adoption may be important. It is interesting to note that assessing the impact of specific adoption programmes is more amenable to high quality evaluation because, for example, it is easier to construct a control group for policies that support adoption by some firms but not others. Evaluating the role of complementary investments is likely to be trickier, given that firms that use broadband more effectively may differ from firms that do not.

Of the 16 studies on the final shortlist, 8 are from the USA;[23] two each from the UK and Italy[24] and one each from Norway, Germany and Ireland.[25] The remaining study uses data from across the OECD.[26]

Findings by outcome

A breakdown of the studies by outcome and overall finding is provided in Appendix A.

GDP per capita

We start by considering the one study that looks at the link between GDP per capita and broadband. Study 798 examines the wider effects of broadband on GDP per capita across OECD countries, finding that a 10-percentage point increase in broadband penetration raises national annual per capita growth by 0.9-1.5 percentage points. This is only one study, but it is high quality (SMS level 4) and provides some evidence to back the focus of national governments on broadband provision.

Productivity

Broadband can positively impact firm productivity. But effects are not always positive, are not necessarily large and may depend on complementary investment. Productivity effects can vary across different types of workers with skilled workers possibly benefiting more than unskilled.

Likely of more interest to local decision makers are the five studies that look directly at firm level productivity. Of these one finds a consistently positive effect on productivity, two find mixed results and two find no effect.

Paper 947 (an SMS level 4 study) uses firm-level data from a Norwegian public broadband programme. It finds positive effects of broadband on overall productivity, although the effects are fairly

23 Studies 769, 770, 771, 780, 794, 795, 799, 802.
24 UK Studies 755 and 948; Italy Studies 760 and 1006.
25 ; Norway Study 947; Germany Study 761; Ireland Study 801.
26 Study 798.

small accounting for only a few percent of the overall variation in total factor productivity across firms; rather less than is explained by the effects of taking on skilled workers.

Further, the study finds that while broadband may help overall firm productivity, this is driven by gains to skilled workers and losses to unskilled workers. Specifically, broadband access raises the productivity of skilled workers by $0.27 whereas the marginal productivity of unskilled labour was found to decrease by $0.06. The authors suggest this is because broadband is a substitute for unskilled labour and workers doing routine tasks; analysis using task-level data gives similar results. Consistent with this, firms with a lot of skilled workers were the quickest adopters of broadband when it became available.

Along similar lines, paper 760 finds that broadband has a significant positive impact on firm productivity in manufacturing SMEs; however this effect is found to be dependent upon the firm making structural/strategic changes and adopting advanced complementary applications, such as video communications, virtual private networks and supply chain management applications. Without these accompanying changes, the effect of broadband is zero or even negative. This is consistent with earlier studies on computerisation and the ICT literature in general.

In contrast to these studies, two studies find no productivity effects at firm level. Paper 801 examines the productivity of manufacturing firms in Ireland. It finds no significant effects of broadband on productivity both when considered generally and when separated by broadband type (into DSL, cable, leased line, fibre optic cable etc.). The paper also finds that broadband is ineffective regardless of firm characteristics (size, ownership, internet usage, region or industry sector etc.) Paper 948 looks at firms in East Yorkshire, and compares those in Hull (served by Kingston Communications) with those just outside (served by BTm who received broadband five years later). It finds zero effect of broadband availability on treated firms' output and labour productivity.

Firm entry and number of businesses

Broadband can increase the number of businesses – either because it increases firm entry or because it helps with firm survival.

Firm entry may also be associated with employment growth (which we consider more directly below). Either way, effects on firm entry, exit and the overall number of business may be of interest to local decision makers. Four studies consider these effects (one of them, 948, is SMS level 4). Two of the four articles report positive results – one for firm entry (771), the other for number of establishments (794). One study (948) reports no effect on firm exit while the final study (769) reports mixed results for the number of establishments.

Article 771 reports a positive impact of broadband availability on firm entry in US rural counties, especially those with larger population settlements (above 2,500) and/or adjacent to urban counties. In these areas, a 10% increase in broadband availability in these counties raises firm entry by 1.6%. By contrast, in rural areas with similar settlements but not adjacent to a metropolitan area, the implied increase in probability of firm entry is only 0.2%. In the sparsest rural counties, there is no effect on firm entry.

Paper 794, another US study on rural areas, also reports positive effects on numbers of firms (which could be explained by positive effects either on entry or on firm survival). The results demonstrate that "low adoption" nonmetropolitan counties saw lower growth in the number of firms. In this study, the

effects of broadband adoption are stronger than for broadband access and speed.

In contrast, paper 769 finds mixed results for the USDA Broadband Loan Program. Loans made in 2002 and 2003 under the pilot phase of the programme had a positive impact on the number of business establishments. But by 2007, the full programme had had no significant effects on the number of firms (although this may be due to the short time period over which the study is able to observe potential impacts).

Paper 948, a UK study, finds zero effect of broadband availability on firm exits.

Employment

Broadband can positively impact local employment. But effects are not always positive, are not necessarily large and may be offset by population increases (leaving unemployment unchanged). Employment effects can vary across different types of areas, industries and workers with urban areas, service industries and skilled workers possibly benefiting more than rural areas, manufacturing industries and unskilled workers.

We now turn to the set of studies that directly consider the labour market effects of broadband provision. This is by far the most studied outcome with 8 studies assessing the impacts – although these consider a wide range of employment and related labour market outcomes. (and some studies consider more than one outcome). The three studies that look at employment rates split equally in terms of finding positive, zero or mixed effects. Of the six studies that look at employment, three find positive effects, two zero effects and one reports mixed results. Results for unemployment and labour force participation are positive in the studies (one each) that looks at those outcomes. Finally, one study finds no effect on home working.

Looking first at employment, study 802 finds positive effects on area-level employment: the magnitude of the effect of an area moving from no broadband providers to 1-3 providers is a 6.4 percentage point increase in local employment. In contrast, Study 948 finds little evidence of a causal relationship between broadband and plant-level employment levels or growth – once other factors, such as managerial ability, are controlled for. Study 769 finds that employment and annual payroll are positively affected by broadband in metropolitan ZIP codes, but there are zero or negative effects upon these outcomes in semi-rural and rural ZIP codes. Consistent with this, study 795 also finds that there is no effect of broadband availability on employment in rural US counties. Interestingly study 794 (which is one of two studies that look at adoption) does find positive employment effects for high adoption rural counties.[27] Finally, study 761 suggests that employment effects may vary by industry – with services seeing positive effects and manufacturing seeing no effects.

Where positive employment effects do occur, they do not necessarily translate in to positive employment rate effects if population also responds positively to broadband provision. Consistent with this, study 802 finds no effect on employment rates despite a positive effect on employment.

In contrast, study 794 reports reduced unemployment rates for high adoption counties, while 761 reports positive (albeit small) effects on area-level employment rates. Study 794 only considers rural areas, but study 761 provides a comparison suggesting that the effects on employment rates are larger in rural areas. These see a 0.15 percentage point increase in employment rate with a 10

27 High adoption counties have adoption rates greater than 60%.

percentage point increase in DSL, compared to an average of 0.039 percentage points across the sample (including urban areas). This result is puzzling given the absence of employment effects in rural areas for other studies as discussed above.

Study 947 (for Norway) suggests that effects may differ between skilled and unskilled workers. Against a background of falling employment (at least for part of the study period) the paper calculates that in 2005 the employment rate for skilled workers was 1.3 percentage points higher than it would have been, whereas for unskilled workers the employment rate was 0.9 percentage points lower.

Finally, two papers also look at specific aspects of labour market change. Paper 802 tests for links between broadband rollout and home working in the US, finding no impact at the household level on telecommuting, working at home or operating a home-based business. In contrast, study 799 finds that high speed internet usage in the US does increase area-level labour market participation rates for women (by 6.7 percentage points).

Income and wages

Broadband can positively impact local incomes and wages. But effects are not always positive and can vary across different types of workers with high skilled possibly benefiting more than low skilled.

There are a number of channels through which broadband can affect wages and income. Wage effects will depend on the overall effects on labour demand and supply (which may in turn depend on productivity and other effects). Income effects will depend on what happens to wages and employment, as well as what happens to non-labour market component of incomes. In contrast to employment, we have more limited evidence on these effects. Of the five studies that consider either wages or income, two find positive effects, one no effect, one negative effects and one reports mixed results.

Studies 794 and 795 find positive effects of broadband at area level. Study 794 suggests that “high adoption” non-metro counties had faster growth in median household income. Results for article 795 are similar showing that increases in broadband adoption levels are associated with increases in median household income. Interestingly, there are no significant impacts of broadband availability as opposed to adoption.

Results for the two higher quality studies (802 and 947; which both score level 4 on the SMS) are more mixed. Study 802 evaluates the effect on both income and wages; it finds zero effects on wages but a significant negative effect on household income.

Finally, study 947 (for Norway) again find that results depend on skill levels. Broadband was found to result in an increase in the wages of high-skilled labour of 1.4% and a fall of 2.8% for low-skilled workers, compared to a scenario with no broadband expansion.

Other outcomes

Two studies look at sales (studies 770 and 948). Study 948 looks at firm-level sales growth for companies which had access to broadband five years before others nearby. It finds no effect on firm sales growth. The authors also assess whether enterprises outside the treatment area relocated to take advantage of broadband provision – but found no evidence of any such relationship.

Paper 1006 (an SMS level 4 study) used firm-level data from an Italian rural broadband initiative. It finds mixed effects of broadband on turnover with positive effects for micro-businesses run by highly educated owners and no significant effect for lowly educated owners. The authors suggest that results are consistent with a skills bias to the impacts of broadband, with greater impacts experienced by more skilled organisations.

Study 770 examines sales, expenditure and profits – for *farms* (not firms) that benefit from the USDA Broadband Loan Programme. Farm commodity sales were found to increase by around 6.5%, with increases in expenditure (around 3.5%) partly offsetting this to leave farm profits increased by a little under 3%. This effect on farm profits is identical across urban and rural counties. It is not clear whether these results would generalize to other firms (or other settings).

Study 755 shows that broadband has a positive effect on domestic property prices. No study looked at the impact on commercial property and, again, it is not clear whether these results would generalize (although one might expect them to).

Urban versus rural

The economic effects of broadband tend to be larger in urban areas, or close to urban areas.

Given debates over rural broadband, it is interesting to look at the findings from the small number of papers that compare the economic impact of broadband across rural and urban areas. As discussed in the introduction, the existing evidence base suggests that we should expect larger benefits for urban areas. The balance of findings is in line with this prediction.

Paper 795 finds find that there is no effect of broadband availability on employment or income in rural US counties. Study 769 finds that employment and annual payroll are positively affected by broadband in metropolitan ZIP codes, but there are zero or negative effects upon these outcomes in semi-rural and rural ZIP codes. Although the study does find positive effects of the pilot USDA Loan Program on the number of firms in both rural and urban areas (which implies that average size of firms decreases in rural areas given the effects on employment).

Similarly, paper 771 finds that broadband has positive impacts on firm entry in rural ZIP codes adjacent to urban areas with the effects decreasing in size as an area becomes more rural. A 10% increase in broadband availability raises firm entry by 1.6% in metropolitan areas with populations greater than 2,500; but only 0.2% in areas that are not adjacent to metropolitan areas. In the most rural areas, there is no effect of broadband availability on firm entry.

Paper 802 finds positive effects from broadband on employment growth in more densely populated neighbourhoods, once larger metropolitan area characteristics are taken into account.

Only one study (761) contradicts this general urban/rural pattern finding proportionately greater effects of DSL on employment rates in more rural areas, with areas more than 32km from the nearest regional centre seeing a 0.15 percentage point increase in employment rate with a 10 percentage point increase in DSL, compared to an average of 0.039 percentage points across the sample. The paper also finds that areas with lower population density see an increase in employment rate with increased broadband availability, whilst the returns to broadband in areas with higher population densities is zero.

Even without these differences in impact, cost differences may lead to different cost-effectiveness across areas. Unfortunately, the studies provide very little information on costs and provide no detailed cost benefit analysis (this is true even for the three studies that look at specific programmes).[28] Study 755 uses the effect on house prices to calculate benefits of broadband (using the assumption that benefits are capitalized in to land, and hence house, prices).[29] Comparing these to costs it calculates that increasing broadband provision and speed is cost effective in urban and some suburban areas, but not in rural areas. Specifically, the benefits of broadband provision in rural areas only equate to 15% of the cost of roll out, whereas in urban areas, the benefits of broadband deployment and speed upgrades are large enough to cover costs. Allowing for higher effects in urban areas (consistent with most other studies) would reinforce these results. Again, this is only one study, although it does highlight questions about the relative cost effectiveness of broadband provision in rural compared to urban areas.

28 Studies 769 and 770, which evaluate the USDA Rural Loans programme do provide information on costs. According to both papers, since 2000 a total of $1.8 billion has gone to private telecommunications providers to improve availability of highspeed data transmission capacity across the US. For the USDA loan specifically, between 2002 and 2003, loans worth $180 million were made to broadband providers serving 98 communities located in 13 states.

29 See our public realm briefing for more discussion of capitalisation of amenities in to property values.

08

Summary of findings

This review considers the economic impacts of broadband. Broadband is a general purpose technology that will have economic, social and environmental impacts. Policymakers may want to take all of these into account when developing broadband strategies.

This section summarises the detailed findings. We emphasise that many of these findings depend on a small number of studies. They are, however, consistent with other research on the broader impact of ICT).

What the evidence shows

- Extending broadband to an area can affect firm productivity, number of businesses, and local labour market outcomes (such as employment, income and wages).
- These effects are not always positive, are not necessarily large, and may depend on complementary investments by firms (for example, training workers, or reorganizing sales strategy or supply chains to take advantage of faster internet connections).
- Effects can vary across different types of industries and workers with service industries and skilled workers possibly benefiting more than manufacturing industries and unskilled workers.
- The economic effects of broadband tend to be larger in urban areas (or close to urban areas) than in rural areas.

Where there is a lack of evidence

- Most studies look at the effect of broadband provision. Only two studies **compare broadband adoption with provision**. It is hard to generalize conclusions from these two studies but they do suggest that the effects of adoption and provision may differ.
- Only two studies look at the **effects on profits and sales** – one shows a positive effect (for US farms), but the other shows zero effect (for firms in East Yorkshire).
- Only one study looks at the effects on **property prices** - showing a positive effect on domestic property prices.
- We have surprisingly little evaluation evidence of broadband's impact on **working patterns**

– one study finds that broadband positively affects female labour force participation; another study, however, finds no net effects on working at home, telecommuting or operating a home-based business.

- We only found three high quality evaluations of specific **broadband policies** (voucher schemes, direct public provision or public/private partnerships).
- **Costs** are rarely addressed in the studies reviewed. Only one paper attempts a cost-benefit analysis.
- We have no studies that evaluate the kind of **SME-targetted voucher scheme** currently running in the UK.
- It would be very useful to know more about the relative effects of **indirect v direct provision** (ie, voucher schemes for services v direct investment infrastructure). The UK is funding both approaches at the moment.
- There is a lack of evidence in **other areas of internet technology** such as the effect of wi-fi networks, and fast mobile internet. Future evaluations in this area would greatly improve the evidence base.

How to use these reviews

The evidence review highlights a number of factors for policy makers to be aware of when considering broadband policy:

- Broadband, like many ICTs, is a 'disruptive' technology that creates winners and losers, and has spillover effects across local boundaries. It is not a silver bullet for local economic development;
- There is evidence that broadband has positive local economic impacts, but some of these may be due to in-migration. Existing households may not be the biggest beneficiaries;
- Broadband seems to benefit skilled workers more than low- or un-skilled workers;
- The effects of adoption and provision may differ. More work needs to be done to understand whether and how to encourage adoption and productive business use.
- Rural areas may need to subsidise broadband provision but the economic benefits of doing so will not be as large as for urban areas.

Helping to fill the evidence gaps

As should be clear from this review, there are many things that we do not know about the local economic impact of broadband provision.

If achieving local economic impact is an important part of the case for broadband provision, then there need to be more evaluations that explicitly explore these impacts. Central and local policymakers – and private sector partners – should:

- Look to make greater use of treatment and comparison groups; and to use the rollout of new, fast broadband infrastructure to help generate these groups. Existing local experiments such as YorkCORE and Google Fiber in the US are useful examples to draw on;
- Focus on evaluating take-up and use of broadband, rather than simply availability and access; in particular linking together broadband take-up with wider business advice and support;
- Consider evaluating programmes that target firms, e.g. SMEs, that might need additional

assistance to use broadband to the full;

- Attempt to clearly separate out impacts on firms and the business community from impacts on local labour markets and households.

The Centre's longer term objectives are to ensure that robust evidence is embedded in the development of policy, that these polices are effectively evaluated and that feedback is used to improve them. To achieve these objectives we want to:

- work with local decision makers to improve evaluation standards so that we can learn more about what policies work, where.
- set up a series of 'demonstration projects' to show how effective evaluation can work in practice.

Interested policymakers please get in touch.

09

References

Aghion, P., Blundell, R., Griffith, R., Howitt, P., Prantl, S., 2009. The Effects of Entry on Incumbent Innovation and Productivity. Review of Economics and Statistics 91, 20-32.

Ahlfeldt, G; Koutroumpis, P; Valletti, T. (2014). Speed 2.0: Evaluating Access to Universal Digital Highways. CEIS Research Paper. 12. (10) 328.

Akerman, A; Gaarder, I; Mogstad, M (2013). The Skill Complementarity of Broadband Internet. IZA Discussion Paper 7762.

Autor, D.H., Levy, F., Murnane, R.J., 2003. The skill content of recent technological change: An empirical exploration. Quarterly Journal of Economics 118, 1279-1333.

Bakhshi, H., Mateos-Garcia, J., 2012. The Rise of the Datavores. NESTA, London.

Beaudry, P., Doms, M., Lewis, E., 2010. Should the Personal Computer Be Considered a Technological Revolution? Evidence from U.S. Metropolitan Areas. Journal of Political Economy 118, 988-1036.

Bloom, N., Sadun, R., Van Reenen, J., 2012. Americans Do IT Better: US Multinationals and the Productivity Miracle. American Economic Review 102, 167-201.

Bresnahan, T.F., Brynjolfsson, E., Hitt, L.M., 2002. Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence. The Quarterly Journal of Economics 117, 339-376.

Bresnahan, T.F., Trajtenberg, M., 1995. General purpose technologies: Engines of growth? Journal of Econometrics 65, 83-108.

Broadband Stakeholder Group (2014). Capitalising on Connectivity: Realising the benefits of broadband for UK Small and Medium Sized Enterprises. London, BSG

Brynjolfsson, E., Hitt, L.M., 2000. Beyond Computation: Information Technology, Organizational Transformation and Business Performance. The Journal of Economic Perspectives 14, 23-48.

Brynjolfsson, E., Hitt, L.M., 2003. Computing Productivity: Firm-Level Evidence. The Review of Economics and Statistics 85, 793-808.

Brynjolfsson, E., McAfee, 2014. The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies. W. W. Norton & Company, New York.

Canzian, G; Poy, S; Schuller, S (2014). Broadband Diffusion and Micro-firm Productivity: Quasi-experimental Evidence from the Province of Trento.

Colombo, MG; Croce, A; Grilli, L (2013). ICT Services and Small Businesses' Productivity Gains: An Analysis of the Adoption of Broadband Internet Technology. Information Economics and Policy. 25. 171–189.

Czernich, N; Falck, O; Kretschmer, T; Woessmann, L (2011). Broadband Infrastructure and Economic Growth. The Economic Journal. 121. 505–532.

De Stefano; T; Kneller, R; Timmis, J (2014). The (Fuzzy) Digital Divide: The Effect of Broadband Internet Use on UK Firm Performance. University of Nottingham Discussion Papers in Economics. Discussion Paper 14/06.

Dettling, LJ (2013). Broadband in the Labor Market: The Impact of Residential High Speed Internet on Married Women's Labor Force Participation. Finance and Economics Discussion Series Divisions of Research & Statistics and Monetary Affairs Federal Reserve Board, Washington, D.C.

Fabritz, N (2013). The Impact of Broadband on Economic Activity in Rural Areas: Evidence from German Municipalities. IFO Working Paper. 166.

Farivar, C. 2012. "Google Fiber is live in Kansas City, real-world speeds at 700Mbps." Retrieved 26 January 2015, from http://arstechnica.com/business/2012/11/google-fiber-is-live-in-kansas-city-real-world-speeds-at-700-mbps/.

Gibbons, S., Nathan, M. and Overman, H. (2014). Evaluating Spatial Policies. SERC Policy Paper SERCPP0012, London, LSE.

Gordon, R.J., 2012. Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds, NBER Working Paper 18135. NBER, Cambridge, Mass.

Gordon, R.J., 2014. The Demise of U.S. Economic Growth: Restatement, Rebuttal, and Reflections, National Bureau of Economic Research Working Paper Series 19895. NBER, Cambridge, MA.

Haller, SA; Lyons, S (2012). Broadband Adoption and Firm Productivity: Evidence from Irish Manufacturing Firms. MPRA Paper 42626.

Hampton, K., Wellman, B., 2003. Neighboring in Netville: How the Internet Supports Community and Social Capital in a Wired Suburb. City & Community 2, 277-311.

Jorgenson, D.W., Ho, M.S., Stiroh, K.J., 2008. A Retrospective Look at the U.S. Productivity Growth Resurgence. The Journal of Economic Perspectives 22, 3-24.

Kandilov, AMG; Kandilov, IT; Liu, X; Renkow, M (2011). The Impact of Broadband on U.S. Agriculture: An Evaluation of the USDA Broadband Loan Program. Selected paper Prepared for Presentation at the Agricultural and Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting. Pittsburgh, Pennsylvania, July 24-26, 2011.

Kandilov, IT; Renkow, M (2010). Infrastructure Investment and Rural Economic Development: An Evaluation of USDA's Broadband Loan Program. Growth and Change. 41(2). 165–191.

Keen, A., 2015. The Internet is Not the Answer. Atlantic, New York.

Kenny, R., 2014. Exploring the costs and benefits of FTTH in the UK. NESTA, London.

Kim, Y; Orazem, P (2012). Broadband Internet and Firm Entry: Evidence from Rural Iowa. Iowa State university Working Paper No. 12026.

Kolko, J (2012). Broadband and Local Growth. Journal of Urban Economics. 71. 100–113.

Mahasuweerachai, P; Whitacre, BE; Shideler, DW (2010). Does Broadband Access Impact Migration in America? Examining Differences between Rural and Urban Areas. The Review of Regional Studies. 40(1). 5-26.

Moretti, E., 2012. The New Geography of Jobs. Haughton Mifflin Harcourt, Boston.

OECD, 2013. Measuring the Internet Economy: A contribution to the research agenda, OECD Digital Economy Papers 226. OECD Publishing.

Oliner, S., Sichel, D., Stiroh, K., 2007. Explaining a Productive Decade. Brookings Papers on Economic Activity 38, 81-152.

Sherman, L. W., Gottfredson, D. C., MacKenzie, D. L., Eck, J., Reuter, P., & Bushway, S. D. (1998). *Preventing Crime: What Works, What Doesn't, What's Promising*. Washington DC: US Department of Justice.

SQW, 2013. UK Broadband Impact Study: Impact Report, Report to DCMS, November 2013. SQW Consulting, London.

Whitacre, B; Gallardo, R; Strover, S (2014a). Broadband's Contribution to Economic Growth in Rural Areas: Moving Towards a Causal Relationship. Telecommunications Policy.

Whitacre, B; Gallardo, R; Strover, S (2014b). Does Rural Broadband Impact Jobs and Income? Evidence from Spatial and First-Differenced Regressions. The Annals of Regional Science. DOI 10.1007/s00168-014-0637-x.

Appendix A: Findings by Outcome

Outcome Evaluated		Total	Evaluation reference numbers	+ve	No effect	Mixed	-ve
GDP	**Total**	**1**	**798**	**1**	**0**	**0**	**0**
	GDP per capita	1	798	798			
Productivity	**Total**	**5**	**760, 801, 947, 948**	**1**	**2**	**2**	**0**
	Productivity (firm)	4	760, 801, 947, 948	947	801, 948	760	
	Productivity (labour)	1	947			947	
Number of firms	**Total**	**4**	**769, 771, 794, 948**	**2**	**1**	**1**	**0**
	Number of Establishments	2	769, 794	794		769	
	Firm Entry	1	771	771			
	Firm Exit	1	948		948		
Labour market	**Total**	**12**	**761, 769, 794, 795, 799, 802, 947, 948**	**6**	**4**	**2**	**0**
	Employment Rate	3	761, 802, 947	761	802	947	
	Employment	6	761, 769, 794, 795, 802, 948	761, 794, 802	795, 948	769	
	Unemployment	1	794	794			
	Labour force participation	1	799	799			
	Working from Home	1	802		802		
Income and wages	**Total**	**5**	**794, 795, 802, 947**	**2**	**1**	**1**	**1**
	Wages	2	802, 947		802	947	
	Household Income	3	794, 795, 802	794, 795			802
Property prices	**Total**	**1**	**755**	**1**	**0**	**0**	**0**
	House prices	1	755	755			
Sales/Profit/ Turnover	**Total**	**3**	**770, 948, 1006**	**1**	**2**	**0**	**0**
	Sales/Profit/ Turnover	3	770, 948, 1006	770	948, 1006		

Appendix B: Evidence Reviewed

Ref No.	Reference
755	Ahlfeldt, G; Koutroumpis, P; Valletti, T. (2014). Speed 2.0: Evaluating Access to Universal Digital Highways. CEIS Research Paper. 12. (10) 328
760	Colombo, MG; Croce, A; Grilli, L (2013). ICT Services and Small Businesses' Productivity Gains: An Analysis of the Adoption of Broadband Internet Technology. Information Economics and Policy. 25. 171–189
761	Fabritz, N (2013). The Impact of Broadband on Economic Activity in Rural Areas: Evidence from German Municipalities. IFO Working Paper. 166.
769	Kandilov, IT; Renkow, M (2010). Infrastructure Investment and Rural Economic Development: An Evaluation of USDA's Broadband Loan Program. Growth and Change. 41(2). 165–191.
770	Kandilov, AMG; Kandilov, IT; Liu, X; Renkow, M (2011). The Impact of Broadband on U.S. Agriculture: An Evaluation of the USDA Broadband Loan Program. Selected paper Prepared for Presentation at the Agricultural and Applied Economics Association's 2011 AAEA &NAREA Joint Annual Meeting. Pittsburgh, Pennsylvania, July 24-26, 2011.
771	Kim, Y; Orazem, P (2012). Broadband Internet and Firm Entry: Evidence from Rural Iowa. Iowa State university Working Paper No. 12026.
780	Mahasuweerachai, P; Whitacre, BE; Shideler, DW (2010). Does Broadband Access Impact Migration in America? Examining Differences between Rural and Urban Areas. The Review of Regional Studies. 40(1). 5-26.
794	Whitacre, B; Gallardo, R; Strover, S (2014a). Broadband's Contribution to Economic Growth in Rural Areas: Moving Towards a Causal Relationship. Telecommunications Policy.
795	Whitacre, B; Gallardo, R; Strover, S (2014b). Does Rural Broadband Impact Jobs and Income? Evidence from Spatial and First-Differenced Regressions. The Annals of Regional Science. DOI 10.1007/s00168-014-0637-x.
798	Czernich, N; Falck, O; Kretschmer, T; Woessmann, L (2011). Broadband Infrastructure and Economic Growth. The Economic Journal. 121. 505–532.
799	Dettling, LJ (2013). Broadband in the Labor Market: The Impact of Residential High Speed Internet on Married Women's Labor Force Participation. Finance and Economics Discussion Series Divisions of Research & Statistics and Monetary Affairs Federal Reserve Board, Washington, D.C.
801	Haller, SA; Lyons, S (2012). Broadband Adoption and Firm Productivity: Evidence from Irish Manufacturing Firms. MPRA Paper 42626.
802	Kolko, J (2012). Broadband and Local Growth. Journal of Urban Economics. 71. 100–113.
947	Akerman, A; Gaarder, I; Mogstad, M (2013). The Skill Complementarity of Broadband Internet. IZA Discussion Paper 7762.
948	De Stefano; T; Kneller, R; Timmis, J (2014). The (Fuzzy) Digital Divide: The Effect of Broadband Internet Use on UK Firm Performance. University of Nottingham Discussion Papers in Economics. Discussion Paper 14/06.
1006	Canzian, G; Poy, S; Schuller, S (2014). Broadband Diffusion and Micro-firm Productivity: Quasi-experimental Evidence from the Province of Trento.

Appendix C: Search Terms and Sources

Source	Search Terms
Web of Science	broadband AND impact
Web of Science	broadband AND eval*
Web of Science	broadband AND experiment
Web of Science	broadband AND effect*
Web of Science	broadband AND caus*
Web of Science	“mobile internet” AND impact
Web of Science	“mobile internet” AND eval*
Web of Science	“mobile internet” AND experiment
Web of Science	“mobile internet” AND effect*
Web of Science	“mobile internet” AND caus*
Web of Science	“fast internet” AND impact
Web of Science	“fast internet” AND eval*
Web of Science	“fast internet” AND experiment
Web of Science	“fast internet” AND effect*
Web of Science	“fast internet” AND caus*
Web of Science	“high speed internet” AND impact
Web of Science	“high speed internet” AND eval*
Web of Science	“high speed internet” AND experiment
Web of Science	“high speed internet” AND effect*
Web of Science	“high speed internet” AND caus*
Web of Science	DSL AND impact
Web of Science	DSL AND eval*
Web of Science	DSL AND experiment
Web of Science	DSL AND effect*
Web of Science	DSL AND caus*
Web of Science	“cable broadband” AND impact
Web of Science	“cable broadband” AND eval*
Web of Science	“cable broadband” AND experiment
Web of Science	“cable broadband” AND effect*
Web of Science	“cable broadband” AND caus*
Web of Science	“fib* optic” AND impact
Web of Science	“fib* optic” AND eval*
Web of Science	“fib* optic” AND experiment
Web of Science	“fib* optic” AND effect*
Web of Science	“fib* optic” AND caus*
Web of Science	3G AND impact

Source	Search Terms
Web of Science	3G AND eval*
Web of Science	3G AND experiment
Web of Science	3G AND effect*
Web of Science	3G AND caus*
Web of Science	4G AND impact
Web of Science	4G AND eval*
Web of Science	4G AND experiment
Web of Science	4G AND effect*
Web of Science	4G AND caus*
Web of Science	LTE AND impact
Web of Science	LTE AND eval*
Web of Science	LTE AND experiment
Web of Science	LTE AND effect*
Web of Science	LTE AND caus*
Web of Science	wifi OR wi-fi AND impact
Web of Science	wifi OR wi-fi AND eval*
Web of Science	wifi OR wi-fi AND experiment
Web of Science	wifi OR wi-fi AND effect*
Web of Science	wifi OR wi-fi AND caus*
EconLit	broadband AND impact
EconLit	broadband AND eval*
EconLit	broadband AND experiment
EconLit	broadband AND effect*
EconLit	broadband AND caus*
EconLit	internet AND impact AND (econo* OR growth OR jobs)
EconLit	internet AND eval*
EconLit	internet AND experiment
EconLit	internet AND effect* AND (econo* OR growth OR jobs)
EconLit	internet AND caus*
EconLit	“fast internet” AND impact
EconLit	“fast internet” AND eval*
EconLit	“fast internet” AND experiment
EconLit	“fast internet” AND effect*
EconLit	“fast internet” AND caus*
EconLit	“mobile internet” AND impact
EconLit	“mobile internet” AND eval*

Source	Search Terms
EconLit	“mobile internet” AND experiment
EconLit	“mobile internet” AND effect*
EconLit	“mobile internet” AND caus*
EconLit	wifi OR wi-fi AND impact
EconLit	wifi OR wi-fi AND eval*
EconLit	wifi OR wi-fi AND experiment
EconLit	wifi OR wi-fi AND effect*
EconLit	wifi OR wi-fi AND caus*
REPEC	broadband AND impact
REPEC	broadband AND eval*
REPEC	broadband AND experiment
REPEC	broadband AND effect*
REPEC	broadband AND caus*
REPEC	“fast internet” AND impact
REPEC	“fast internet” AND eval*
REPEC	“fast internet” AND experiment
REPEC	“fast internet” AND effect*
REPEC	“fast internet” AND caus*
REPEC	“mobile internet” AND impact
REPEC	“mobile internet” AND eval*
REPEC	“mobile internet” AND experiment
REPEC	“mobile internet” AND effect*
REPEC	“mobile internet” AND caus*
REPEC	wifi OR wi-fi AND impact
REPEC	wifi OR wi-fi AND eval*
REPEC	wifi OR wi-fi AND experiment
REPEC	wifi OR wi-fi AND effect*
REPEC	wifi OR wi-fi AND caus*
Google Scholar	broadband AND impact AND (econo* + growth + jobs)
Google Scholar	broadband AND eval* AND (econo* + growth + jobs)
Google Scholar	broadband AND experiment AND (econo* + growth + jobs)
Google Scholar	broadband AND effect* AND (econo* + growth + jobs)
Google Scholar	broadband AND caus* AND (econo* + growth + jobs)
Google Scholar	“fast internet” AND impact AND (econo* + growth + jobs)

Source	Search Terms
Google Scholar	“fast internet” AND eval* AND (econo* OR growth OR jobs)
Google Scholar	“fast internet” AND experiment AND (econo* OR growth OR jobs)
Google Scholar	“fast internet” AND effect* AND (econo* OR growth OR jobs)
Google Scholar	“fast internet” AND caus* AND (econo* OR growth OR jobs)
Google Scholar	“mobile internet” AND impact AND (econo* OR growth OR jobs)
Google Scholar	“mobile internet” AND eval* AND (econo* OR growth OR jobs)
Google Scholar	“mobile internet” AND experiment AND (econo* OR growth OR jobs)
Google Scholar	“mobile internet” AND effect* AND (econo* OR growth OR jobs)
Google Scholar	“mobile internet” AND caus* AND (econo* OR growth OR jobs)
Google Scholar	wifi OR wi-fi AND impact AND (econo* OR growth OR jobs)
Google Scholar	wifi OR wi-fi AND eval* AND (econo* OR growth OR jobs)
Google Scholar	wifi OR wi-fi AND experiment AND (econo* OR growth OR jobs)
Google Scholar	wifi OR wi-fi AND effect* AND (econo* OR growth OR jobs)
Google Scholar	wifi OR wi-fi AND caus* AND (econo* OR growth OR jobs)
IZA Discussion Papers	broadband
IZA Discussion Papers	internet
IZA Discussion Papers	“mobile internet”
CEPR Discussion Papers	broadband
CEPR Discussion Papers	internet
CEPR Discussion Papers	“mobile internet”
NBER	broadband
NBER	internet
NBER	“mobile internet”
SERC	No search terms - visual scan
Gov.uk	broadband
Gov.uk	internet
Gov.uk	“mobile internet”
CESifo	broadband AND impact
CESifo	broadband AND eval*

Source	Search Terms
CESifo	broadband AND experiment
CESifo	broadband AND effect*
CESifo	broadband AND caus*
North East LEP	visual search
Tees Valley LEP	visual search
London Enterprise Panel	visual search
National Audit Office Publications	broadband
National Audit Office Publications	internet
National Audit Office Publications	“mobile internet”

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