Superfast Broadband Business Exploitation Project
Economic Impact Report 2016

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WELSH ECONOMY RESEARCH UNIT
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Summary

This report sets out the results of Cardiff Business School's research into the economic impacts that derive from business use and exploitation of superfast broadband. The research builds on the findings of the *Digital Maturity Survey 2016* (WERU, 2017) and provides analysis of economic impacts at firm- and regional-levels. The research supports the Welsh Government's Superfast Broadband Business Exploitation (SFBBE) programme, and addresses the current lack of evidence on the economic impacts of superfast broadband.

As the first in a series of economic impact reports, the primary focus of the analysis is testing models for calculating economic impact. To this end, the analysis comprises the following exploratory analysis:

- A synthesis of findings from case study businesses
- Business efficiency, using Frontier analysis
- Input-output modelling for the Welsh economy

The *case study* findings examined the diverse ways in which the businesses are using superfast broadband to secure performance improvements and impacts. This found evidence of:

- Cost savings achieved through the adoption of new processes made possible by access to the superfast broadband
- Removal of IT investment entry barriers for businesses
- New opportunities to work remotely, and with this resulting in savings in travel time and associated cost
- Speeding up of business processes
- New opportunities to enhance customer value, increasing levels of innovative activity, particularly in terms of an ability to provide new services
- Increased sales return and customer reach

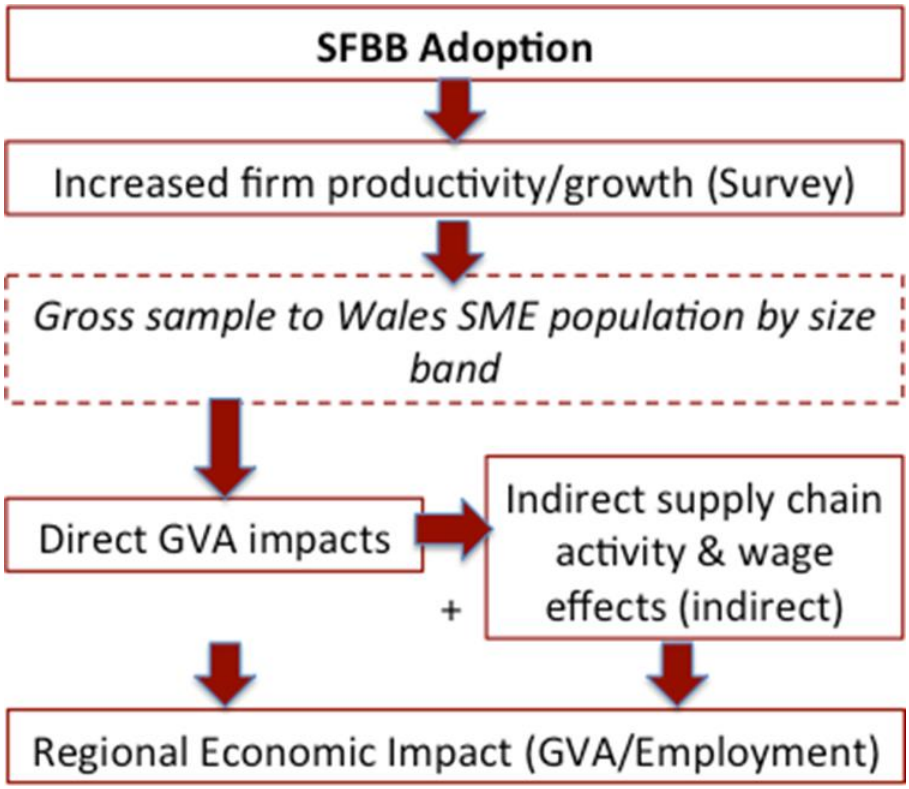
Most of the case study businesses, however, are in the early stages of adopting superfast broadband, and were unable to quantify fully the benefits gained. This is likely to change as further case studies are undertaken, and this will be monitored by the project over the next four years.

The *Frontier analysis* findings tested the feasibility of using this approach to model the impacts on the Welsh economy from businesses using superfast broadband. The analysis found substantial variations in technical efficiency across the firms. In relation to different digital maturity it found great diversity, in businesses responding to the first *Digital Maturity Survey*, in terms of their business efficiency.

The frontier analysis also revealed that whether or not firms have access to the superfast resource is a poor predictor of their business efficiency scores. Rather the presence of superfast needs to be understood as working with other variables such as strong IT infrastructure, the presence of digital technologies etc. in more of a cumulative fashion. Moreover, the frontier analysis revealed a number of cases of relatively high technical efficiency in firms with no access to superfast at all, but where firms were still able to benefit from relatively high levels of IT infrastructure and digital technologies use. Inevitably a research question arising here is what would happen to these relatively high performing firms were they to gain access to the superfast resource.

The research then used the framework of Input-Output (I-O) tables for Wales to estimate regional economic effects in terms of gross value added (GVA) and employment. The analysis adopts a simple conceptual model to identify economy-wide effects:

Figure 0-1 The conceptual framework



Based on the data available from the *Digital Maturity Survey 2016* one model scenario suggests that for every 1,000 businesses adopting superfast broadband, there may be a sales/turnover growth uplift of around £13.2m following adoption. Additionally, each superfast broadband-adopting businesses may have added around £11,500 in GVA to the Welsh economy (directly and via its increased purchases across Wales).

The findings suggest that the IO model is suitable for calculating GVA and employment changes associated with superfast broadband exploitation, but that further research will be needed to link impacts, entirely, to superfast broadband adoption. In this respect the 2016 survey information is assumed to be illustrative of the wider impacts of superfast broadband. Further observations are also needed to accurately gross up to economy wide effects.

Although elements of the case study work are continuing, the completion of the economic impact report brings to an end the first yearly cycle of research activity connected to the SFBBE project. The first phase has involved a great deal of learning among the team, and this points to the following challenges during the second cycle, with the emphasis on refining the survey tool and ensuring a greater response, while making use of secondary sources (e.g. Companies House and ONS statistics).

1 Introduction

This report outlines the results from Cardiff Business School's analysis of economic impacts associated with business adoption and use of superfast broadband and enabled digital technologies. The research builds on findings from the *Digital Maturity Survey 2016* (WERU, 2017). It draws on a survey of Small and Medium Enterprises (SMEs) in Wales to identify their adoption and use of digital technologies enabled by superfast broadband. The research is working to inform activity within the Welsh Government Superfast Broadband Business Exploitation (SFBBE) project.

1.1 The research

The *Economic Impact Report 2016* is the first of a series of annual reports that present impact data on business use and exploitation of superfast broadband. It provides evidence on firm-level, sector-level and regional-level impacts deriving from business adoption and use of digital technologies. The report's aim is to:

- Develop methodologies and models for calculating economic impacts from SFBBE business adoption and use in Wales.
- Provide case study evidence of impacts resulting from business exploitation of superfast broadband in Wales.
- Develop an evidence-base for policy-makers, to inform superfast broadband business support.

The report forms part of a wider programme of Superfast Broadband research, undertaken by Cardiff Business School, including the annual digital maturity survey and horizon scanning reports. Results of this research can be found at http://www.cardiff.ac.uk/superfast-broadband-project

The context for the research is the Welsh Government's support for superfast broadband. This support has focused on the roll out of high quality broadband infrastructure, particularly in more peripheral and rural parts of Wales. Superfast Cymru is scheduled to deliver high speed fibre broadband to 690,000 premises by June 2017 at speeds of at least 30Mbps. There is, however, recognition derived from UK and overseas case evidence, that the provision of the hard infrastructure may not in and of itself drive business adoption of superfast broadband technologies. Therefore the Welsh Government is seeking to further support the infrastructure programme through assisting SMEs to efficiently use superfast broadband technologies for business gain – The SFBBE programme.

Cardiff Business School's research has thus far only been able to reveal limited evidence on the impacts of businesses exploiting superfast broadband. While the *Digital Maturity Survey 2016* has gone some way to producing a picture of adoption and use of broadband, the economic impact report seeks to take this further by establishing the scope and scale of economic and wider impacts at the level of Wales and its sub-regions.

Much of the evidence on take-up of superfast broadband is incomplete, with business take-up of superfast broadband strongest in urban areas. In contrast, take-up in more rural parts of Wales has been largely by households rather than businesses. As a consequence, parts of Wales are falling behind the UK average for broadband take-up among businesses (Ofcom, 2016). There is also a need for a higher level of take-up by businesses, but also a challenge for these same businesses to use broadband in more innovative ways.

More generally business broadband exploitation support is set in a context of sub regions of Wales facing persistent socio-economic disadvantage. This is typically defined in terms of relatively low levels of gross value-added per capita. A contributory factor is poor productivity among SMEs and here the innovative take-up of superfast broadband could work to lever productivity gains, and act as a component of economic convergence processes.

The *Economic Impact Report 2016* begins to address the need for further data on the economic impacts of business exploitation of superfast broadband and associated technologies. The purpose of the research is therefore one of addressing this weakness to both inform Welsh Government policy, and to contribute towards the emerging evidence base on broadband, ICT and economic development/impact.

1.2 Research methodology

The *Economic Impact Report 2016* reports findings from case studies of business adoption and use of superfast broadband, and results from our economic analysis of impacts at the firm and regional levels.

The case studies draw on interviews with 11 businesses across Wales. They were selected, in part, from respondents to the *Digital Maturity Survey 2016*, and recommendations from our research partners (Welsh Government, FSB Wales). Each case study comprised an interview with the business owner or manager, plus analysis of supporting evidence (for example, a survey return). They were selected to ensure a mixed sample, with respect to different sectors, geographical areas and size bands of businesses (see Table 1-1 for more details). The synthesis of the case studies presented in this report draws on analysis using qualitative data analysis software (Nvivo), and coding by two members of the research team.

The findings from the case studies are not intended to be generalizable to all businesses in Wales. Instead they provide in-depth evidence of the experiences of businesses that have adopted superfast broadband, and illustrate the nature of impacts that are being achieved from using associated digital technologies.

The economic analysis is based on two techniques:

- Frontier analysis
- Input-Output modelling

Both techniques build on business data taken from the *Digital Maturity Survey 2016*. The focus of the Frontier analysis is to estimate business efficiency against an optimal (frontier) level of efficiency. In contrast, input-output modelling provides a method for estimating the Wales-wide economic impact. In both cases the use of the methods here is largely exploratory, and with this due to the relatively smaller samples achieved in the *Digital Maturity Survey 2016*. However, the methods hint at what analysis we expect to replicate in future economic impact reports.

1.3 Structure of report

The report is structured as follows. Section 2 sets out performance evidence from the case studies. This is followed by the economic impact results, including the findings from our frontier analysis and input-output modelling (Section 3 and 4). The report concludes with implications/lessons for subsequent economic impact research (Section 5).

Table 1-1 Case study businesses

Company name	Business activity	Location	Sector	Employees (FTEs)
CloudGenius Ltd	CRM services	SW Wales	Information & communication	3
Menter Berllan Community Enterprise Hub	Business services	Mid Wales	Business & professional services	1.5
Recycle Scooters and Bikes	Online motorbike and scooter marketplace	SE Wales	Retail, wholesale & transport	3.5
Method4 Ltd	Software and consultancy	SE Wales	Information & communication	21
Bursali Towels	Wholesale of towels	SE Wales	Retail, wholesale & transport	4
D&G Office Interiors Ltd.	Office furniture & office fit-out	SE Wales	Retail, wholesale & transport	17.5
The Royal Victoria Hotel, Llanberis	Hotel	N Wales	Accommodation & food services	55
Rhiannon Cyf	Manufacture of jewellery	Mid Wales	Production and construction	14
NLS Solicitors	Solicitors	SE Wales	Business & professional services	5.5
DevOpsGuys	IT Consultancy & managed services.	SE Wales	Information & communication	22
Sean Carr Lining Technology	Installation of geosynthetic lining	N Wales	Production and construction	22.5

Section 2 of this report provides a synthesis of the case study results, with individual case studies reports to be made available on the SFBBE project website: http://www.cardiff.ac.uk/superfast-broadband-project

2 Performance benefits

This section illustrates the broadband-related performance benefits achieved by a selected group of 11 case study businesses across Wales. The analysis provides a synthesis of the findings, highlighting the range of performance benefits achieved and the underpinning factors. While the primary focus is on describing the nature of performance benefits achieved, the analysis also, where possible, includes businesses' assessment of the quantitative benefits achieved. It does, however, highlight the difficulties businesses face in assigning *precise* performance benefits to adoption.

2.1 Business efficiency

The case studies illustrate how businesses are improving their efficiency by adopting digital technologies. Such efficiencies can derive from both the cost reduction, but also in relation to business process improvements that are enabled by such technologies.

Cost savings can be made in a range of business processes such as customer relationships, document management, storage, and so on. In such instances, digital technologies no longer require expensive up-front IT investment in server equipment (WERU, 2017). The Royal Victoria Hotel, for example, reported that they had been able to replace traditional switchboard technology with a Voice over Internet protocol (VoIP) system, resulting in significant cost savings. Similarly, Menter Berllan Community Enterprise Hub noted:

> *"…Since we've been using Skype for our outbound phone calls –we save around £15 per month on our bill for calls. This is a reduction of 50%, amounting to £180 per annum. For our tiny business this is a significant saving…"*

The comparative low cost of cloud technologies had lowered barriers to entry for new start-up companies. NLS Solicitors, for example, noted that this had been an important contributing factor in their ability to launch the business, enabling them to implement cloud-based business software, storage and a telephone system in multiple offices, without having to invest in costly infrastructure.

In addition to cost savings, efficiencies are also evident in the time taken to complete tasks. Here, broadband enables data to be downloaded more quickly, and new software / infrastructure services accessed (WERU, 2017). This can result in business processes being freed up and time spent on additional business activity. The Bursali Towels case study illustrates the potential impact of such efficiencies on travel time:

"…Before, we could not use the Customer Relationship Management (CRM) system at all, everything was too slow, it was just tortuous to use… I used to do fifty thousand miles a year going to see customers around the UK…apart from my flights to Europe to see them…that was just miles on the road in the UK. I have seen two customers in five years now; we have totally changed the way we do business. We don't have people on the road, it's all emails, and fantastic customer service – answer the phones within two rings…"

CRM systems were cited as an important efficiency tool by a number of case study businesses. Bursali Towels described how the introduction of a CRM had enabled the automation of many aspects of customer interaction, through provision of timely pricing information, reminders and order monitoring. Similar benefits were reported by other case study businesses, in relation to online sales ordering technologies. Here the process of taking an order via the internet was said to require minimal time input from the business, relative to traditional methods. Other process efficiency benefits include Recycle Scooter's improved stock picking process. This helped it to make use of wireless / tablet technologies to identify parts more easily.

The availability of digital technologies has enabled several businesses to make more effective use of remote working. By accessing cloud-based data and software, staff are able to work from home and other locations outside business premises. This has the potential to reduce the frequency of travel and provide environmental benefits. For Menter Berllan, superfast broadband speed has enabled the organisation to communicate with clients using Skype and TeamViewer (a software package that allows the facilitator to log on remotely to a customer's computer to observe and coach the client in computer use), simultaneously. This has helped to drive down expenses:

"…Training and supporting our clients via TeamViewer saves on fuel costs, and both team and client travel time. We are also able to run sessions in the evening, which works better for clients in a rural area who do not want to travel on winding and remote roads at night. Typically, our clients live anywhere between 4 to 20 miles away from the hub. Assuming a mileage rate of £0.45 per mile, that can represent savings, on each round trip, in the range of £3.60 to £18.00…"

Access to software and data when at customer premises can also help to improve efficiencies by speeding up processes such as quotation provision, delivering of improved 'on site' services etc. (D&G Office Interiors case study). Other cases indicate that, while digital technologies can enable remote working, face-to-face interaction in person continues to be important for building relationships (Cloud Genius case study).

Access to cloud-based data and software can also deliver efficiencies through improved flexibility of operations. Here, several businesses reported how staffing / resource planning had improved through online access to staff calendars (The Royal Victoria Hotel case study). While time / cost savings were evident in the majority of the case study businesses, these do not necessarily occur immediately. As jewellery maker, Rhiannon Cyf, noted:

"…Obviously it takes a while for a business to make the most of digital technologies, you can't expect to just suddenly go onto superfast and, overnight, reap all the benefits. However, if you are taking a twelve-month view or twenty-four month or over five years, it gives you a vast new range of possibilities. It allows you to implement things that you just could not have implemented before, which are performance enhancing for the business. I cannot stress how important it is for pretty much any business…"

These findings illustrate the diverse ways in which the case study businesses are using superfast broadband to gain efficiencies. Most case study businesses, however, are in the early stages of adopting superfast broadband, and found it difficult to quantify efficiency benefits gained. This is likely to change, as further case studies are undertaken longitudinally over the next four years.

2.2 Customer value

The customer interface represents an important area where superfast broadband is enabling improved business performance in the case studies. While interaction with customers has long been enhanced by other forms of technologies and communications (postal, telephone, catalogues etc.) the emergence of digital technologies and superfast broadband provides the basis for offering customers new ways to place orders, access information about products and services and make contact with businesses.

The value of superfast broadband was particularly important for the hotel and business premises case studies. Here, the growth of the internet, generally, and the prevalence of cloud computing across multiple devices means that customers are increasingly demanding access to the internet. In this respect, superfast broadband is valued highly as a feature of hotels and premise services, and often of equal importance to other basic services. The case study of The Royal Victoria Hotel illustrates how superfast broadband can add customer value by providing access to high bandwidth for activities such as video streaming:

"…Apart from the expectation that if a customer comes to stay in the hotel these days they may want to stream a TV programme or whatever, we've got to live up to that expectation somehow in order to give us a competitive edge over other operators in the area…"

The cloud and CRM systems discussed in the earlier section (2.1) can also provide benefits to customers. This includes the provision of detailed information on products services and the wider sales process (see D&G Office Interiors and the Recycle Scooters case studies). In this respect cloud access and CRMs can help to improve the customer experience by offering access to online information and help such as monitoring purchases, shipping and so on (see Bursali Towels case study). It can also help, generally, by offering improved speed in reacting to customer needs.

2.3 Innovation

Innovation can take a range of different forms including the introduction of new products, processes or services, new forms of organisation and marketing (OECD/Eurostat, 2005). This can include innovation that is 'new to the world' in the sense that it represents a novel form of innovation, or it can be 'new to the company'. Results from the *Digital Maturity Survey 2016* suggest that there is a positive link between adoption of superfast broadband and the frequency by which businesses innovate (WERU, 2017).

The principal form of innovation evident in the case studies is 'new to the company' and based on the application of existing technologies. Almost all case study businesses reported using digital software (enabled by superfast broadband) to automate existing business processes, with a number using it to offer completely new services.

NLS Solicitors, for example, was established by a team of solicitors that had previously worked together in another company. As a new start-up, the business made extensive use of cloud-enabled software (Case Management Systems) to automate previously manual processes, such as the preparation of legal documents. A similar process was evident in established businesses, such as D&G Office Interiors – a company that design and supply office equipment. By accessing superfast broadband, this business was able to replace a largely manual process of producing printed design layouts and materials and transporting these to the customer sites, with the greater flexibility of electronic transfer.

The case studies reveal businesses that have used superfast broadband to offer new services. For example, Recycle Scooters has been able to harness the selling tools of software platforms such as eBay, alongside a YouTube channel, to provide videos of engines and scooter parts to customers. This, again, would not have been possible without access to broadband:

> *"…When we were on normal broadband it took so long to try and upload videos to YouTube, and when we were on dial-up it was pointless. It took so long to upload content that we frequently did not put videos up. Now we are here and we are on superfast we can do it on the tablet and 15 seconds later, it is on YouTube. We do get positive customer feedback, a lot of customer feedback, about the fact that people can now go on the YouTube channel and watch the videos…"*

While many of the case studies had been able to innovate by adopting and implementing existing technologies, the case studies highlight a number of businesses that provide support and consultancy services to businesses. Such companies can be characterised as 'enablers' or 'carriers' of innovation, providing knowledge and expertise to businesses in the area of digital technologies and innovation (Miles et al., 1995). The services offered by both Dev Ops Guys and Method4 are indicative of this role, helping businesses to digitise their business processes and activities. Dev Ops Guys described its role as follows:

"…We essentially help customers transform and accelerate the way they deliver software. We do that because most companies these days, in every industry and every market, are being disrupted by one form of technology or another. Therefore, every company, in our view, is becoming a software company. These organisations are having to wake up to understand how they build the right digital culture, the right digital 'backbones' to deal with modern age disruption and it's coming through cloud, it's coming through mobile, it's coming through social, it's coming through big data, all of these four pillars of technology…"

Organisational innovation is evident in the use of digital technologies to operate new business models. Such business model innovation has an increasingly important role in business adaptability and competitive advantage (Teece, 2010). The case studies are dominated by examples where traditional businesses have digitised their activities (see the Recycle Scooters and NLS Solicitors case studies). In such cases, the businesses have not replaced core aspects of their activities, but have made use of digital technologies to improve and expand their offer to customers. Such hybrid business models are most prevalent in the case studies, indeed there are no 'fully-digital' businesses in the sample to date.

2.4 Sales

Sales represent an important indicator of businesses success, and their ability to monetise the benefits of superfast broadband. While the *Digital Maturity Survey 2016* findings indicate that just under half of businesses (49%) sell online (WERU, 2017), the case studies suggest a number of reasons why more companies do not do so. Some service businesses, for example, do not always sell 'off the shelf', 'products'. Instead, their offer is less tangible, and tailored to individual customer needs (for example, Dev Ops Guys, Cloud Genius). In other cases, some businesses require face-to-face interaction for validation purposes (for example, NLS Solicitors). These issues further highlight the difficulty businesses face in quantifying the extent to which sales can be linked directly to superfast broadband. As the Method 4 case study illustrates, the pervasiveness of broadband enabled digital technologies across all parts of some businesses means that accurate added-value figures are difficult to obtain.

Despite these challenges, all of the case study businesses report that superfast broadband is contributing positively towards their sales return. A key sales route enabled by superfast broadband is access to ecommerce platforms. Bursali Towels, for example, report that selling products via Amazon produced greater margins than wholesale retailing. Furthermore, its CRM system had helped it to convert 30% more sales leads into orders.

Elsewhere, Recycle Scooters indicated that their sales had increased due to the additional information and video content they were able to offer via eBay / Youtube. Such platforms increase the reach of businesses and open up the potential to sell products and services beyond Wales (see, for example, NLS Solicitors and Cloud Genius case studies). While it is possible to access some eCommerce sites using standard broadband, the sales power of such platforms is increased through the addition of superfast broadband - video and images, and the use of technologies such as VoIP.

2.5 Summary

These findings point to the diverse ways in which the case study businesses are using superfast broadband to secure performance improvements and impacts, including evidence of:

- Cost savings achieved through the adoption of new processes made possible by access to the superfast broadband
- Removal of IT investment entry barriers for businesses
- New opportunities to work remotely, and with this resulting in savings in travel time and associated cost
- Speeding up of businesses processes
- New opportunities to enhance customer value, increasing levels of innovative activity, particularly in terms of an ability to provide new services

Most of the case study businesses, however, are in the early stages of adopting superfast broadband, and were unable to quantify fully the benefits gained. This is particularly difficult for those businesses that have adopted cloud technologies across multiple business processes, and is likely to change, as further case studies are undertaken. The following sections will, however, seek to capture these impacts at the business and economy levels.

Future economic impact reports will include case study evidence from a wider range of businesses (circa 25). Our intention will be to re-interview some of these businesses over the subsequent years of the project, in order to provide a longitudinal perspective on the evolution of business performance benefits.

3 Business efficiency analysis

The economic impacts from businesses adopting and exploiting superfast broadband can be analysed at a range of different levels, including the firm, supply chain, sector and overall economy. The following section examines these impacts in relation to the firm using efficiency analysis.

3.1 Introduction

One of the objectives of the programme of superfast broadband research was to seek to identify connections between digital maturity factors, superfast broadband access and then business efficiency. The earlier *Digital Maturity Survey* (WERU, 2017) presented descriptive material showing the performance of the different respondent firms according to their digital characteristics. The number of respondents to the first survey was limited but still provided an early opportunity to test approaches to examine the relationships between SME productivity growth, and a set of variables which would include metrics that would describe firm functional and process use of broadband leveraged services, and the presence of skills in SMEs to use broadband resources.

The earlier project scoping report (WERU, 2015) provided that a number of problems beset economic analysis that seeks to link broadband services ('adoption' and 'exploitation') to business and economy-wide gains. A particular problem here is defining effective exploitation with the academic literature revealing a diversity of process changes linked with successful exploitation (as opposed to usage), and associated productivity gains.

In what follows we have tested one means, using established econometric analysis techniques, of examining whether SME performance in terms of digital maturity and superfast broadband access can be linked to SME productivity.

3.2 Background

Econometric analysis is a useful method to measure the performance of businesses. In what follows we employ Stochastic Frontier Analysis (SFA) method to estimate the efficiency with which businesses convert a set of resources (i.e. inputs) into productive outputs. Fundamentally this method compares the efficiency of a set of businesses against a theoretically possible maximum output level – the efficiency frontier. These types of methods are commonly used to track changes in industrial and national productivity and to assess over time how closely businesses might move towards the efficiency frontier.

The research uses data on inputs consumed and outputs produced in businesses that participated in our Digital Maturity Survey and then employ a statistical software to estimate the frontier. This then allows each business' technical efficiency to be measured according to their distance from the optimal efficiency frontier. The analysis then turns to explaining the variations in business' efficiency. This includes analysis of whether successful exploitation of broadband enabled services and different digital maturity factors might be important in explaining the variations in business' efficiencies.

The analysis was limited in respect to the first *Digital Maturity Survey 2016* because of the smaller number of survey respondents with whom we could collate all of the financial information needed for the analysis, and with one element of the analysis requiring us to match the survey respondents with publicly available accounting information (from Companies House – FAME dataset). Then the results below might be taken as illustrative, and with care needed in the interpretation. However these, and similar techniques employed consistently over the programme of research, will help show:

- What types of SMEs are most efficient and what is the role of successful exploitation of broadband services in making firms closer to the efficiency frontier?
- What types of SME broadband exploitation practices are most effective in moving closer to the frontier through time?

In what follows the focus is on a summary of results, and with further technical information in the appendix to this report.

3.3 The production efficiency of Digital Maturity Survey 2016 respondents

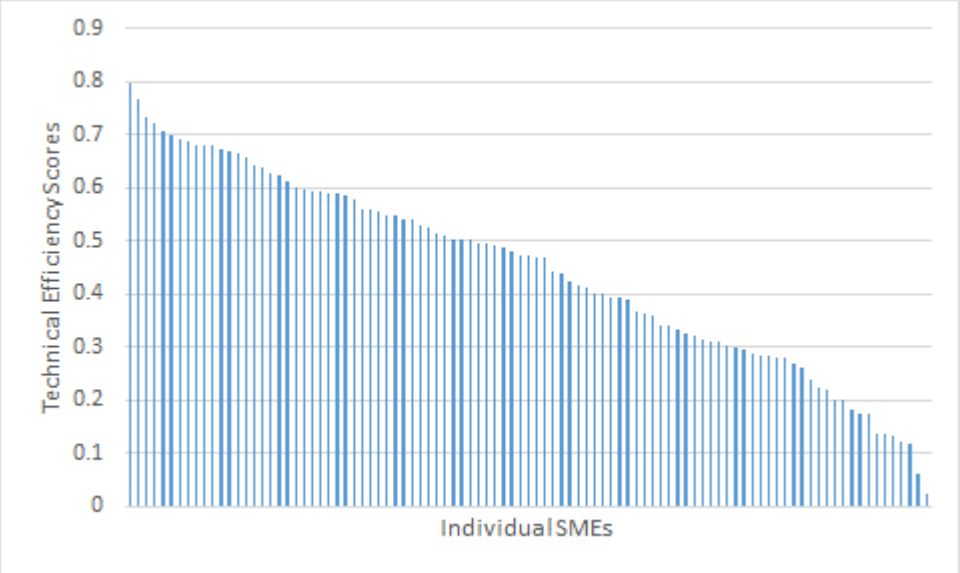
The first step in the analysis was to estimate the production efficiency of SMEs in our sample. This is assumed to be in terms of their ability to transform a given set of inputs into outputs. To do this a SFA technique was employed to estimate the following production function where:

Output (Sales) = Input 1 (Employees) + Input 2 (Debt) + Input 3 (Equity),

Here the sales output is assumed to be a function of labour and capital inputs into the process. Debt refers to long-term liabilities and equity refers to shareholders' funds. The data were collected from the Jordan FAME database and supplemented by self-reported data from the *Digital Maturity Survey 2016*. The figures reflect year 2015. It was necessary to remove some SME cases from the analysis when sales figures were missing as an output. The analysis was based on 97 SMEs where the necessary data were available, and the results confirmed that elements of capital and labour were a statistically significant determinant of sales performance.

The technique employed allows us to first examine variations in technical efficiency across our sample of 97 businesses. The results are summarised in Figure 3-1. Figure 3-1 reveals (as expected) that there is strong variation in technical efficiency across the firms (i.e. the SMEs vary considerably in their proximity to the optimal theoretical frontier).

Figure 3-1 Variation in technical efficiency (n=97)



Further analysis of the findings in Figure 3-1 revealed that:

- Businesses were on average 44% of the way to the efficiency frontier.
- The median (i.e. midpoint) technical efficiency was around 48%.
- The best performing businesses were around 80% of the way to the frontier.

The analysis also revealed that the top 25 SMEs in terms of technical efficiency:

- Were on average 67% of the way to the frontier.
- Had technical efficiency scores in the range from 59% to 80%.

Similarly the worst 25 performers in terms of technical efficiency:

- Were on average 21% of the way to the frontier.
- Had technical efficiency scores in the range from 2% to 31%.

3.4 Best and worst performers and their digital maturity and other characteristics

One of the questions of interest to the research team is whether the distance that SMEs were from the efficiency frontier was related to their digital maturity characteristics.

The *Digital Maturity Survey 2016* revealed that our digital maturity indicators included:

IT infrastructure. The extent of SMEs' investment on information technologies. The measure captured SMEs' physical IT-related resources and included annual spending on broadband subscription, hardware, software and network. To account for SMEs' sizes in the respondent sample, the total annual IT spend was divided by the number of employees. The values below £500 were coded as Low; in the range £500-£1,499 as Medium and above £1,500 as High.

Human IT. The level of SMEs' human IT-related resources. This was a composite measure based on SME respondents' answers to four questions: 1) IT skills of staff; 2) access to IT support; 3) presence of staff development budget; 4) use of cloud services by workforce.

Use of e-commerce. The degree to which SMEs exploit the opportunity to engage in online transactions with customers and suppliers. This was a composite measure based on SME respondents' answers to three questions: 1) the proportion of sales made online; 2) the proportion of purchases made online; 3) SME use of website, website analytics, and website live support.

Use of digital technologies. The degree to which SMEs exploit broadband enabled services across various business functions. Broadband enabled services capture four types of packages: 1) software packages, 2) cloud storage packages, 3) infrastructure packages and 4) generic business service applications. Business functions include Business Management, Production, Purchasing, Distribution and Logistics, Human Resource Management, Accounting and Finance, Marketing, Sales, Research and Development, Information Systems and Technology. For each package the number of business functions it is used for is summed. Then the sum of all these is calculated to gain an estimate of the SME use of digital technologies.

There was also interest in how technical efficiency was related to a series of other variables including:

- *Business age*. The number of years since firm's founding until 2015.
- *Innovation*. The number of new-to-the-firm and new-to-the-market products and services introduced by the firm in the last two financial years.
- *Sales per employee growth*. Year-on-year labour productivity growth in percentage terms.

- *Superfast broadband*. Whether or not the SME has a superfast internet connection at their main premises in Wales with speed exceeding 24mbps.

In what follows we employed these various characteristics and indicators to graphically depict the differences between the top 25 performing SMEs (here shown as Cluster 1) and bottom 25 performing SMEs (as Cluster 2). The results are shown in the following panels in Figure 3-2.

It is important to note here that this is based on a small sample of firms, but Figure 3-2 reveals that:

- In terms of *IT infrastructure* - the extent of SMEs' investment in information technologies, the best performing firms tended to spend more i.e. average close to £1,500 per employee compared to the poorer performing firms where spend was a little over £1,000 per employee. Median values were also examined here in the expectation of some outliers in terms of high and low spending, but with these figures also evidencing differences in spend between the best and worst performers in terms of technical efficiency.

- In terms of *human IT resources* there was little identified difference between the best and worst performers.

- In terms of the *use of e-commerce* it seemed to be the poorer performing SMEs that made more use of e-commerce.

- The better performing SMEs in terms of technical efficiency had marginally higher *use of digital technologies*.

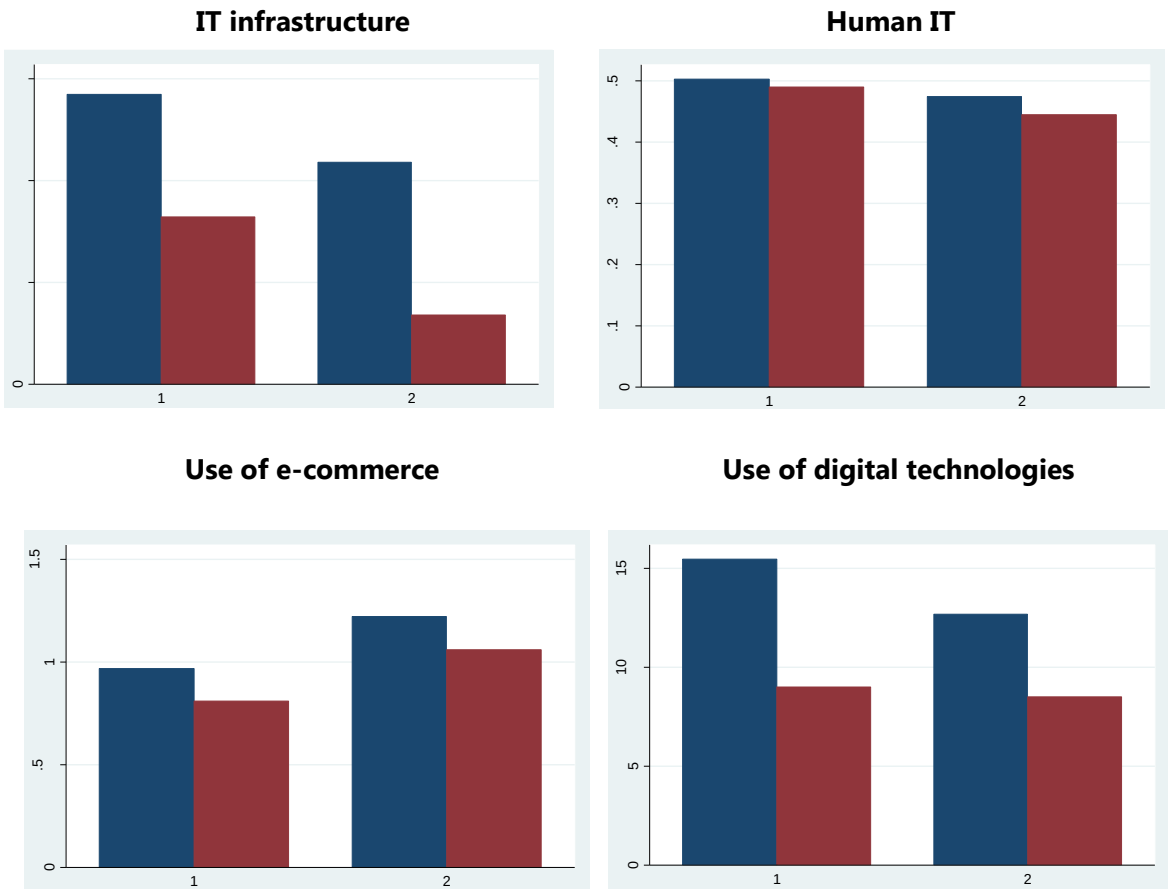
- The better performing SMEs tended to be older and more innovative firms, and were characterised by higher labour productivity (sales per employee).

- There was little variation in whether there was access to superfast broadband between higher and lower performers in terms of technical efficiency. This latter is not entirely surprising given that one of the central tenets of the intervention programme being operated by Welsh Government is that mere access to the resource is not enough to improve business performance, rather how the opportunity is levered.

3.5 Conclusions

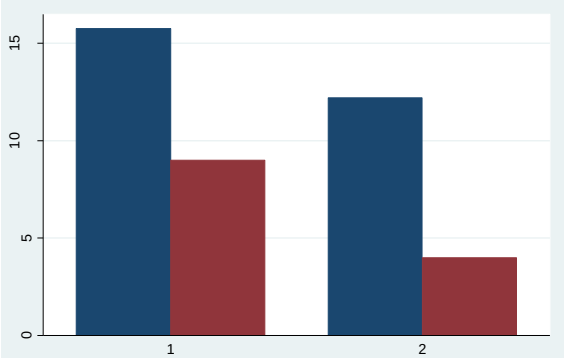
At one level the research team were encouraged that it was possible to combine information from the *Digital Maturity Survey 2016* with that from other company records to attempt a technical efficiency analysis. The quality of the analysis here should be improved in future years as the number of observations increases, and then with the possibility to refine elements of the economic analysis to pick up on how digital maturity affects survival characteristics of SMEs, and to look more deeply into how industry and location combines with digital characteristics to lever different technical efficiency scores.

Figure 3-2 Characteristics of best/worst performers in terms of technical efficiency scores[1]

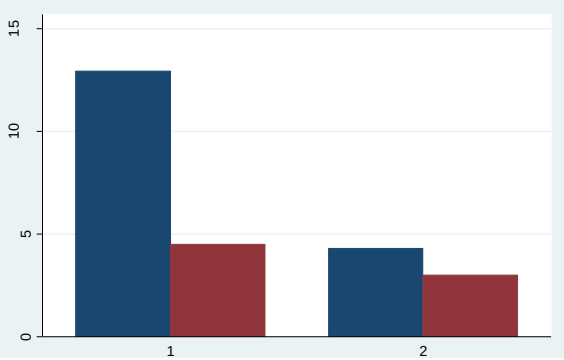


[1] Blue bars depict mean values, red bars depict median values.

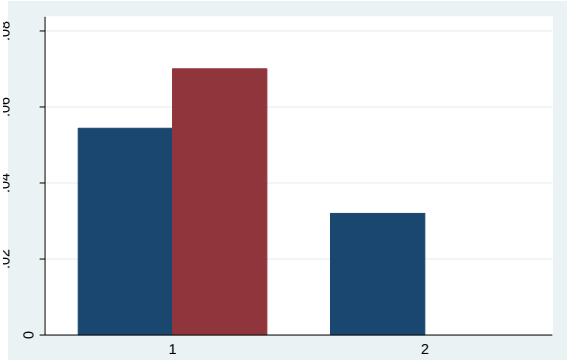
Firm age



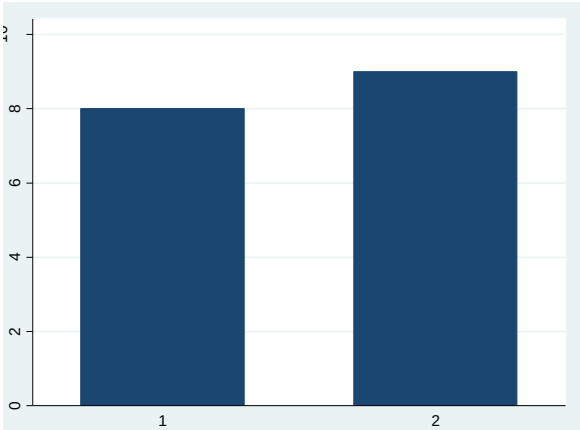
Innovation



Sales per employee growth[2]



Superfast broadband[3]



[2] The median value for cluster 2 is equal to zero.
[3] SFBB is a categorical variable, so the bars show the sum of superfast broadband users in a respective cluster.

4 Input-output analysis

Section 4 builds on the results of the *Digital Maturity Survey 2016* to provide an overall, illustrative, estimate of economic impacts. Like Section 3 the intention is to test the feasibility of using this approach to model the impacts on the Welsh economy from businesses using superfast broadband.

4.1 Introduction

The adoption and exploitation of superfast broadband and related processes, technologies and services will have impacts on the productivity and hence competitiveness of superfast broadband-adopting businesses. This activity will also have related, but complex impacts on employment, with these potentially both positive and negative, and arising in the short and longer term.

The surveys and case studies provide insight into the changes in business approaches that superfast broadband exploitation enables, but information cannot be gathered directly from all adopting businesses to assess the actual or potential importance of superfast broadband for the entire SME sector, and hence the Welsh Economy overall. Understanding the importance of superfast broadband exploitation for Wales therefore requires the development of methodologies to 'gross up' survey data, and that from superfast broadband interventions and from secondary sources, to represent Wales-wide economic impacts.

Additional to this grossing-up process, superfast broadband exploitation is also expected to have implications for supply chains in Wales, again both positive (for example if superfast broadband-exploiting firms grow more quickly and buy more products and services from their suppliers) and negative (e.g. if the switch to cloud accounting package means an SME no longer has to employ a local accountant). There will be additional impacts on the Welsh economy as employees are (perhaps) paid more by more competitive firms, and spend their additional income, in part, across Wales.

There are a number of ways of assessing this overall impact of superfast broadband exploitation by Welsh SMEs. Here the focus is on the potential of regional economic modelling frameworks, specifically using the Input-Output (IO) method. This method provides an industry-level breakdown of an economy's purchases (locally and outside the region), sales and exports, consumer behaviours and government spending, and allows for an overall, quantitative estimate of superfast broadband related impacts in terms of gross value added (GVA) and employment. The IO Tables for Wales, have been developed at Cardiff Business School over many years, and have been used as part of a bespoke economic modelling framework in a range of different sector and activity impact studies.

In the following sections we briefly show the history, scope and uses of the IO Tables for Wales, and consider the potential benefits and limitations of the framework in assessing the overall impact of superfast broadband. The section then provides a purely indicative example of how the framework can be used to provide Wales-wide estimates of the economic impacts of superfast broadband business exploitation using data from the initial survey of businesses. We then discuss these results.

4.2 Background

Since the late 1990s, the Welsh Economy Research Unit at Cardiff Business School has constructed and published the IO Tables for Wales. These Tables are the only bespoke and industry-level picture of how the Welsh economy works, in terms of its purchases (locally and outside the region), sales and exports, consumer behaviours and government spending[4]. The Tables also detail, for each of the more than 80 defined industries, the wages and profits that are important to consider in the superfast broadband case.

The IO Tables have been used extensively in Wales to assess the economic impact of a variety of sectors, events and facilities for clients ranging from Welsh Government and other public bodies, to the third sector and private corporations. Some key studies include the economic analysis of the steel industry, new infrastructure such as the A55, and A465, tourism and major sports events, and on a number of energy developments[5].

In each case the studies have provided estimates of consequent (or related) employment, GVA and economic output that are cross-comparable, transparent and replicable. The results include direct and indirect effects, with the latter related to the supply chain impacts and to wage spending in the Welsh economy that arises from employees' income. In all cases the estimation of the indirect (or 'multiplier') effects rely upon the generic financial map of the Welsh economy and its detailed transactions, as set out in the IO Tables, and on a number of key assumptions around firms' behaviours. The quality of this map, and the nature of the assumptions, has implications for the quality and reliability of any estimate of economic impact.

4.3 Estimating the economic impact of superfast broadband

There are caveats and limitations that must be considered in any estimate of the economic impact of superfast broadband. Some of these issues are specific to IO Tables, whilst others are relevant for any regional economic modelling approach. Some of these issues are outlined below.

[4] Scotland has its own IO Tables, published annually by the Scottish Government: http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output

[5] For examples see: Jones (2001), Pinto and Jones (2012), Bryan et al. (2015).

4.3.1 Sampling and representativeness

Any analytical approach that assumes the behaviours or characteristics of a population based on a sample is always open to inaccuracy due to biases in the chosen sample. In normal circumstances, such issues can be addressed by increasing the sample size, and using selected known characteristics of the population to assess sample representativeness. In the case of superfast broadband, and as the project develops, the research team will undertake a number of processes to check sample reliability including;

- Assessing the sector, size and other characteristics of respondents in comparison to known SME population characteristics (including by geography);
- Rolling annual respondents into an project-aggregate respondent database (whilst remaining aware of the analytical issues this raises);
- Triangulating sample characteristics with other survey and secondary data (broadband and otherwise);
- Weighting of survey data to reflect known population characteristics.

The superfast broadband project does, however bring particular issues with respect to sampling, and which impact upon regional modelling approaches;

- Overall sample size and structure, and hence accuracy is constrained by response rates, especially in the early years of the project;
- The SME population (and especially micro businesses) have a variety of unknown characteristics, including overall population size, that makes weighting difficult;
- There will be many unobservable characteristics of businesses, both the sample and the population as a whole, that might impact upon superfast broadband related competitiveness but which cannot be uncovered via survey;
- The number of businesses in Wales that have adopted superfast broadband or are using high value enabled services is not known, hence it is not possible to judge the overall opportunity for future take-up and use, or how far the economy is from the saturation point.

As the project progresses methodologies will be developed and tested to address a number of these weaknesses. **However for this initial economic impact report the numbers presented in following Sections must only be considered as illustrative.**

4.3.2 The 'average' firm

Related to the above sampling issues (which apply to *any* regional impact analysis) are those specifically related to IO analysis. In such analyses it is assumed that each firm responds to an economic stimulus in a similar way as the 'average' firm in the sector, in terms of labour use and purchasing propensities for example. Moreover the modelling assumes that any changes in the scale of operations results in linear responses in terms of economic inputs, there are no efficiencies of scale, scope or knowledge currently in the Welsh IO model.

Some of these issues will be addressed in the future development of the economic impact approach: for example, the IO Tables will be restructured to better represent the sectors and firms of interest, so that that the 'average' firm better represents the actuality of firms in that sector (or of that size). Survey results and case study intelligence can also be used to build scenarios that better represent how businesses change their behaviours following superfast broadband adoption and exploitation, thus splitting the analysis more explicitly for non-adopters[6] and adopters. However, even in the longer-term the analysis (especially in terms of indirect impacts) will be subject to caveats related to these issues, especially as the pace of technology changes, as might heterogeneous responses across firms.

4.3.3 Timeliness and structure

The structure of the IO Tables is currently not well-suited for superfast broadband analysis. Some sectors of key interest are 'hidden' in wider industry aggregations (e.g. in business services), and there is no disaggregation by business size. In addition there are likely to be within industry/sector differences in the characteristics of those businesses using and exploiting superfast broadband and those who are not. To fully understand these characteristics, and the possible differential impacts of superfast broadband using businesses on the economy would require a separation of each relevant industry within the IO Tables into superfast broadband businesses and non-superfast broadband businesses. Some of these issues (such as separately identifying sectors of interest) will be explored as part of the update and restructuring of the IO Tables during 2017, with others (including the disaggregation by superfast broadband and non-superfast broadband businesses) needing longer-term development and considerably more information.

[6] This refers to businesses without superfast broadband. It can include businesses that have broadband connection that is below the 24mbts threshold for superfast broadband.

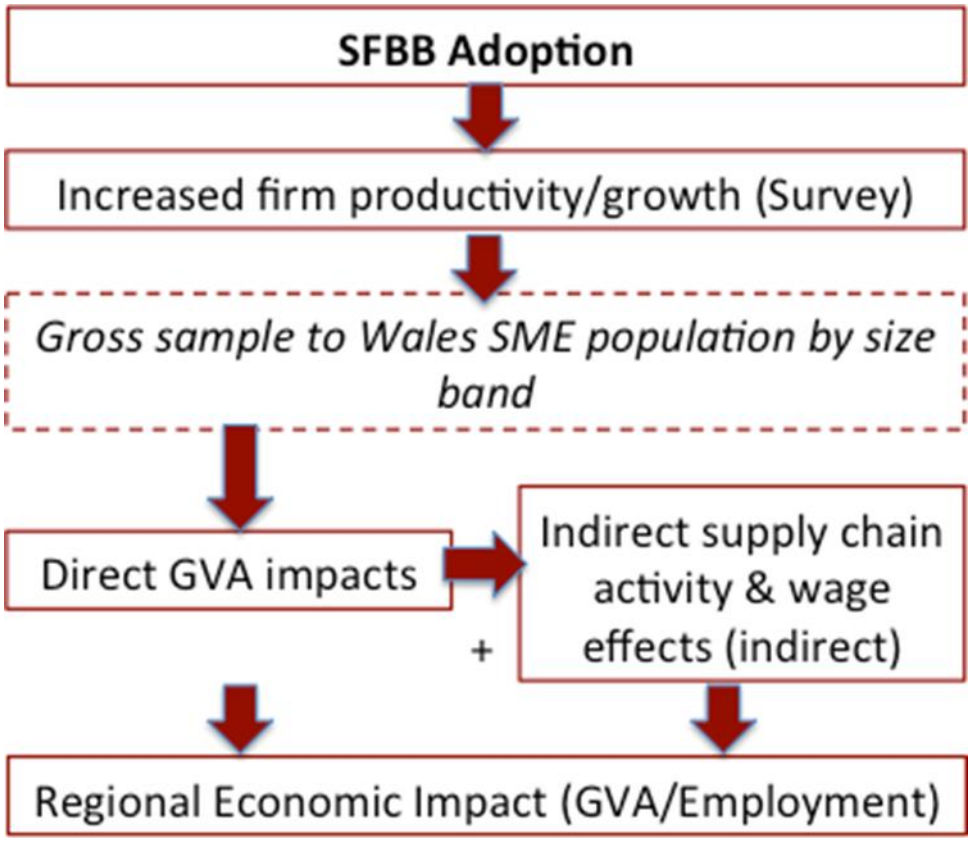
4.4 The conceptual framework

Despite the above limitations, IO analysis remains the most appropriate way to assess the regional economic impact of the superfast broadband intervention, at least in terms of a process which reveals the important sector- and firm- level productivity changes, and their importance within the wider Welsh economy. This will be especially true, as over the lifetime of the SFBBE project, sample size increases, Table structure and timeliness improves and analytical techniques become more refined.

IO analysis remains however only one of a number of mechanisms that will be used to assess the economic impact of superfast broadband adoption and exploitation. Complementary quantitative techniques are discussed elsewhere in this report, and these will combine with qualitative case study data, and the survey returns themselves, to provide as holistic a picture as is reasonably possible.

There are a number of ways in which superfast broadband adoption and exploitation may be assumed to lead to business changes and hence to changed regional economic conditions. This initial analysis seeks to establish the impact of superfast broadband on both employment and GVA. The conceptual framework is outlined in Figure 4-1Figure 4-1.

Figure 4-1 The conceptual framework



As the earlier sections emphasise, the 2016 survey information is assumed to be illustrative of the wider impacts of superfast broadband adoption, and moreover that the survey is assumed to be reasonably representative of the wider business cohort: these issues will be discussed later in this report.

4.5 The economic impact of superfast broadband adopting firms

As importantly, the superfast broadband survey of businesses is necessarily brief as it relates to economic outcomes, as more extensive or invasive questions risk reducing response rates even further. However, drawing from the survey, an indicative turnover can be derived and used to assess regional economic impact – albeit here for illustrative purposes due to sample size issues (Table 4-1Figure 4-1).

Table 4-1 Sample impact and regional population

Size	Valid Cell Survey Responses 2016 (superfast broadband & otherwise)	Estimated Population, number of firms (IDBR)	Average superfast broadband Turnover uplift (Y-o-Y)
Micro	53	237,210	£9,615
Small	15	9,090	£15,165
Medium	8	2,105	£384,060
Total	76	248,405	£13,200*

*Weighted average, adjusted to £2016[7]

Sales growth information is abstracted from the survey, and can be used as the economic stimulus within the regional impact assessment. Here 2016 survey returns are examined to identify the difference in year-on-year turnover growth differences between businesses that have adopted superfast broadband and those that have not. This turnover growth, once adjusted to represent the size structure of the Welsh SME cohort, as in Table 3.1, could be used to suggest that for every 1,000 businesses adopting superfast broadband, there may be a sales/turnover growth uplift of around **£13.2m** following adoption. Such a suggestion would however require an assumption that the turnover uplift was entirely linked to superfast broadband adoption. In reality a number of factors will combine to impact on business turnover growth in any business at any time. Over time, and with more information, the complex causality chain will be more clearly understood such that future economic impact can be estimated with more confidence and less assumptions. Once a turnover uplift has been identified, this could be assessed within the IO Table structure to provide information on regional GVA and employment impact.

[7] Medium firms reported a far greater turnover uplift, but are by far the smallest proportion of the Welsh SME economy.

The additional £13.2m is allocated as a turnover uplift to representative IO sectors based on the distribution of SMEs across industries as reported in the Office for National Statistics Inter-Departmental Business Register (IDBR). Based on the initial survey each superfast broadband-adopting businesses may have added around £11,500 in GVA to the Welsh economy (directly and via its increased purchases across Wales). All financial impacts are **illustrative only** and are for £2016.

The survey results also reveal the complexity of superfast broadband business and economic impacts. For example survey respondents of micro and small size who were superfast broadband adopters added fewer jobs than similarly sized firms that were *not* superfast broadband adopters, with Medium firms reporting no difference (Table 4-2).

Table 4-2 Sample reported average change in employment (jobs)

	No superfast broadband	Superfast broadband	Difference
Micro	0.29	-0.67	-0.96
Small	4.19	1.96	-2.23
Medium	5.17	5.17	0

It should be remembered that the sample as a whole shows increased turnover growth is associated with superfast broadband-adoption. Some potential implications and causal inferences can be drawn from these results.

Table 4-3 Superfast broadband, employment and productivity

Cause?	**Future Investigation**
The sample is currently too small to deliver reliable results.	True. Follow up with larger sample in 2017.
Superfast broadband and employment and/or turnover growth are unconnected.	Unlikely but possible in some firms. Investigate with more sophisticated econometric analysis and case study work.
Superfast broadband is associated with higher levels of labour productivity.	Almost certainly true. Investigate with case study work.
Superfast broadband is associated with higher levels of services outsourcing and resultant employment loss.	Possibly true. Investigate with case study work & refined survey.

This differential between productivity (or rather here turnover growth) and employment highlights a central development issue for Wales; of those who are in work, too many are adding low levels of value, meaning that even when unemployment is low, GVA per worker lags the UK. Whilst the superfast broadband intervention is aimed directly at addressing this issue, this initial analysis does suggest that employment creation is an inappropriate metric with which to judge success.

4.6 Understanding the modelling process

In summary the modelling process is as follows;

- Establish the turnover growth differential between superfast broadband-adopting and non-superfast broadband adopting firms from the survey;
- Posit this additional economic activity as a 'shock' to the Welsh economy within the IO framework;
- Establish the indirect economic impact of this additional economic activity on the rest of the Welsh economy through supply chain and wage effects.

At this stage of the project the intention is to establish the conceptual framework for future analysis and in particular to uncover any critical limitations; reveal conceptual 'fuzziness; and comment on the suitability of the survey data for this estimation. Key issues include:

The Time-Profile of Superfast Broadband Economic Impact – The analysis is predicated on turnover growth that is higher for superfast broadband-adopting firms than for others. There is currently insufficient information to judge whether this turnover impact is a 'one-off' increase following superfast broadband (and relevant services) adoption, or whether superfast broadband firms are more growth oriented over the medium/long term. This is an important, indeed central, distinction in terms of regional economic impact, and one which will be examined in case study and other strands of work; for example job losses might be a 'one off' impact, but growth gains might persist over multiple years.

Understanding Existing Superfast Broadband Penetration – The economic impact results are presented here in terms of impacts per-1000 firms. This is because the proportion of Wales' businesses (in each size band) that are currently superfast broadband-adopting is unknown. The overall market opportunity is therefore also not known. Arriving at an estimate of pre-intervention adoption rates will be an important part of assessing overall Programme impact.

The Structure of the Input-Output Tables – The current analysis is limited by a 'picture' of the Welsh economy that is not fit for this specific purpose. The restructuring and updating of the IO Tables is currently under discussion.

Changes in Business Processes, Products and Behaviours – The analysis is necessarily based upon the 'average' behaviour of existing Welsh firms. Even if the modelling allowed the distinction of SMEs from other firms, it will still not capture the changes in firm behaviours that arise from superfast broadband adoption. As Section 3.2 shows, these have potentially complex and different regional economic impacts. Adopting firms may be more productive, competitive and fast growing than non-adopters, but they may also outsource more functions (likely outside Wales), and employ fewer staff, at least in the short term. Understanding how to best understand and address these complexities is key to the development of future economic impact methodologies.

5 Conclusions

This was the first of a five year series of economic impact assessments around the Superfast Broadband Business Exploitation project. The case study elements of this first report are rich in identifying outcomes resulting from more efficient use of the superfast resource. However, the quantitative analysis elements were somewhat hindered by the paucity of returns to the first *Digital Maturity Survey*. One of the priorities of the research team over the summer will be to improve the numbers of surveys returns that we receive.

However, our initial analysis in this first economic impact report, also points towards a requirement to gain more specific financial information on responding SMEs, and with elements of the quantitative analysis here requiring the team to seek financial information from secondary sources. It is also accepted that at this stage some elements of the quantitative analysis were more exploratory in nature. For example, the material in Section 4 of this report was based on the framework of input-output tables for Wales which are gradually becoming out of date. These tables are currently being revised and updated and will provide a far better platform for analysis in future years. Indeed, we expect the material gained from the *Digital Maturity Survey* and the case studies to assist in this revision process.

The case studies programme revealed selected performance benefits for SMEs resulting from access to resources levered by the superfast broadband resource. For example the case studies revealed:

- Cost savings achieved through the adoption of new processes made possible by access to the superfast resource.
- Removal of IT investment entry barriers for businesses.
- New opportunities to work remotely, and with this resulting in savings in travel time and associated cost.
- Speeding up of businesses processes.
- New opportunities to enhance customer value, increasing levels of innovative activity, particularly in terms of an ability to provide new services.

While the case studies described gains it was often more difficult for firms to actually quantify the value of this gain, and with this in part linked to the problems of developing a sound counterfactual. However, what was clear was that some of the gains reported through the cases would not always lead to employment gains within higher performing SMEs. The relationship between SME efficiency improvement and employment growth is not a straightforward one, and we expect that in understanding these linkages it will be necessary to follow selected case study firms over the much longer term.

The difficulty of ascribing more quantitative returns to improved use of the superfast resource provided the context for the use of more complex methods. Two methods were used in the first report - frontier analysis and input-output modelling – but we expect that a suite of approaches will develop through the project, particularly as the amounts of data available increase.

The frontier analysis served to show the great diversity of businesses responding to the first Digital Maturity Survey in terms of their business efficiency. The frontier analysis also revealed that whether or not firms have access to the superfast resource or not is a poor predictor of their business efficiency scores. Rather the presence of superfast needs to be understood as working with other variables such as strong IT infrastructure, the presence of digital technologies etc. in more of a cumulative fashion. Moreover, the frontier analysis revealed a number of cases of relatively high technical efficiency in firms with no access to superfast at all, but where firms were still able to benefit from relatively high levels of IT infrastructure and digital technologies use. Inevitably a research question arising here is what would happen to these relatively high performing firms were they to gain access to the superfast resource.

While the frontier analysis focused on individual firms, there was also a challenge to think about economy-wide effects. At the heart of ERDF funding as it applies to Wales is to improve regional productivity and regional gross value added. A simple conceptual model was presented to pick up on economy-wide effects, but we caution care in interpretation here due to the limited number of firm observations on which we gross up to economy wide effects. Moreover, our conceptual model while considering something of the multiplier effects in Wales associated with better performing firms, tells us little about displacement effects in the region as perhaps, firms better able to gain advantage from employment the superfast resource outcompete those less able to capitalise on the new opportunities.

Although elements of the case study work are continuing, the completion of the economic impact report brings to an end the first yearly cycle of research activity connected to the Superfast Broadband Business Exploitation project. The first phase has involved a great deal of learning among the team, and this would point to the following challenges during the second cycle:

- Uppermost is refining the survey tool. Both elements of the quantitative analysis were affected by the low number of returns. While there will be improvements in the administration of the survey based on our experience through the first cycle, the most important learning outcome was the need to develop a more concise survey tool.
- Shortening the survey tool is not costless. The elements of the survey tool that deal with financial and general business performance were particularly useful for the quantitative analysis, however, these same areas represented parts of the survey where we faced more missing information from those who responded. One corollary of this will be to investigate how far we can use secondary information from published sources to reduce the business burden of the survey. For example, in the frontier analysis developed in this report we were able to supplement survey material from that derived from Companies House records. In this respect it will be useful to examine other data sources including those from ONS Statistics with which we can match our Digital Maturity Survey returns.
- There remains a challenge to develop other quantitative methods through which to investigate the linkages between access to the superfast resource and business productivity. We expect that having a time series of survey returns will permit the usage of a series of econometric techniques, and we will be investigating these over the coming months.

- Sub regional analysis. The total number of returns has made it difficult to investigate sub-regional trends in business performance, and how far economic effects linked to access to superfast vary through space. This will be an important issue during the next cycle of activity, with real interest in establishing whether the pattern of effects linked to broadband access varies between West Wales and the Valleys and East Wales, and then between more rural and urban areas.

References

Bryan, J., Evans, N., Jones, C. and Munday, M., 2015. Regional electricity generation and employment in UK regions. Regional Studies 51:3, 414-425. http://dx.doi.org/10.1080/00343404.2015.1101516.

Jones, C., 2001. Mega-events and host region impacts: Determining the true worth of the 1999 Rugby World Cup. International Journal of Tourism Research 3, 241-251. http://dx.doi.org/10.1002/jtr.326

Miles, I., Kastrinos, N., Bilderbeek, R., Den Hertog, P., Flanagan, K., Huntink, W., Bouman, M., 1995. Knowledge-intensive business services: users, carriers and sources of innovation, European Innovation Monitoring System (EIMS) Reports.

OECD/Eurostat, 2005. Oslo Manual, 3rd ed. OECD Publishing, Paris. http://dx.dio.org/10.1787/9789264013100-en

Ofcom, 2016. Connected nations report 2016. Ofcom, London. Available at: https://www.ofcom.org.uk/__data/assets/pdf_file/0035/95876/CN-Report-2016.pdf

Pinto, V. and Jones, C. (2012). The Economic Impact of Tata Steel in Wales. Welsh Economic Review, 23, pp. 20-32. Available at: https://publications.cardiffuniversitypress.org/index.php/WER/article/view/14/14

Teece, D.J., 2010. Business models, business strategy and innovation. Long Range Planning 43, 172-194. http://dx.doi.org/http://doi.org/10.1016/j.lrp.2009.07.003

WERU, 2015. Evaluating Business Usage and Exploitation of Superfast Broadband in Wales: A Review and Recommendations for Metrics and a Digital Dashboard. Cardiff University, Cardiff.

WERU, 2017. Superfast Broadband Business Exploitation Project: Digital Maturity Survey Report 2016. Cardiff University, Cardiff. Available at: http://www.cardiff.ac.uk/superfast-broadband-project/digital-maturity-survey/digital-maturity-survey-2016