



Welsh Economy
Research Unit

Yr Uned Ymchwil
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Superfast Broadband Business Exploitation Project Digital Maturity Economic Impact Report for Wales 2017

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Summary

Capitalising on the opportunities presented by broadband-enabled digital technologies is vital to strengthening both business performance and regional economic performance in Wales. The *Digital Maturity Economic Impact Report for Wales 2017* provides a comprehensive analysis of the business level and regional level impacts that result from Welsh SMEs adopting and using digital technologies. It shows how the use of broadband resources can help SMEs to improve their performance, become more efficient and contribute towards stronger regional productivity. This is important for Wales in order to bridge the regional prosperity gap with the UK.

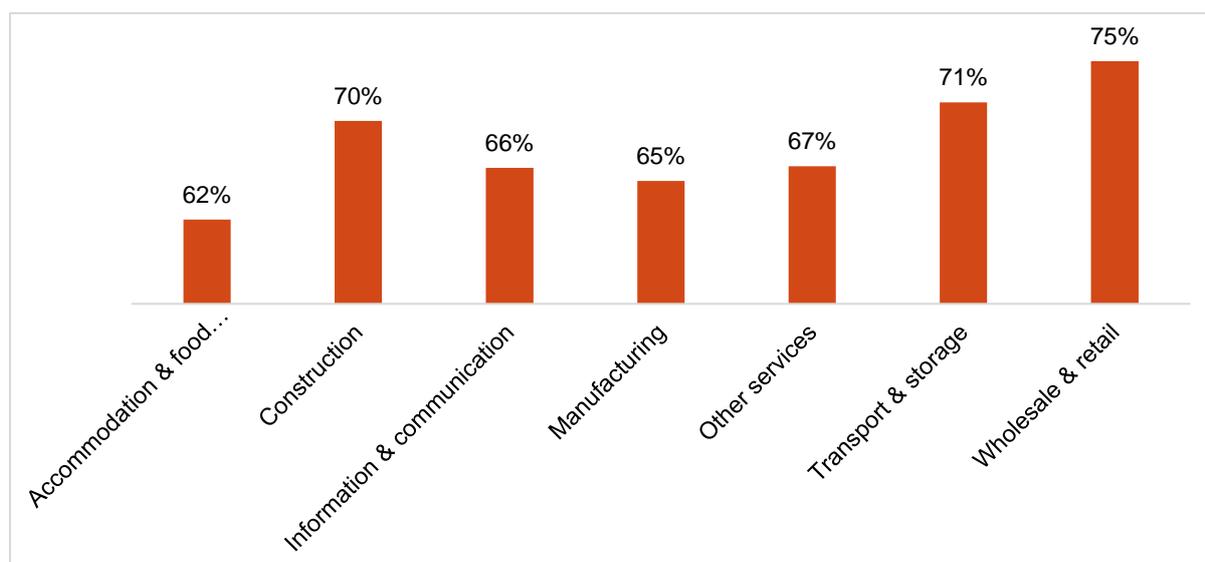
The *Report* builds on the findings from the *Digital Maturity Survey for Wales 2017* and presents:

- Case study evidence outlining business advantages gained from engagement and adoption of the broadband resource;
- Business efficiency analysis revealing differences between the least and the most digitally mature businesses in the respondent sample;
- Analysis of how many SMEs in Wales have been positively effected in terms of sales and employment growth, alongside the scale of expected increases.

Case study evidence outlines advantages to businesses that engage with the superfast resource. Benefits are exemplified in terms of cost reductions, more efficient use of time, enhancing customer value, and more innovation in both products and processes. The case studies reveal that adoption and use of broadband improves communication channels of SMEs, enhancing interactions with employees, customers and suppliers at a local, national and international scale.

An analysis of SMEs that responded to the *Digital Maturity Survey 2017* revealed large variations in technical efficiency. Based on the results from a sample of 229 businesses, Welsh SMEs on average produced 68% of the maximum output available from their combination of human and capital outputs. Variation in technical efficiency is also evident by industry sector (see Figure 0-1 on next page).

Figure 0-1 Technical efficiency by industry sector



The findings indicate that the most digitally mature SMEs (Digitally Embedded) outperform the least digitally mature (Digitally Disengaged) SMEs in terms of technical efficiency. However, the overall results suggest that digital maturity and adoption of superfast broadband alone are insufficient to explain variation in productivity. As a result, the explanatory factors underpinning variations in efficiency merit further investigation via more advanced modelling techniques.

The *Report* goes on to show the estimated number of enterprises in Wales that have been positively impacted by adoption and use of standard or superfast broadband. Here, 47% of responding businesses reported turnover increases as a result of adoption of standard or superfast broadband (compared with 1% reporting a decrease), and 25% reported that employment had increased as a result of broadband adoption (against just 2% revealing that their employment had decreased).

Analysis reveals that broadband-enabled digital technologies could have improved turnover prospects for around 111,000 SMEs in Wales. Based on a conservative 1% increase in turnover in affected SMEs for illustrative purposes, it is estimated that total sales for SMEs in Wales attributable to broadband adoption could be almost £229m, of which £124m (54%) is derived from superfast broadband-enabled technologies alone. With superfast broadband take up of around 42% among businesses, this is a notable contribution to increased turnover. Employment increases are also found to be similarly positive, with around 32,100 SMEs, of which 16,600 (52%) SMEs were superfast broadband users, potentially seeing a sustained employment increase. Also based on an illustrative assumption of 1% employment increase in affected companies, around 1,752 new employment opportunities are expected to emerge. Indeed, the *Digital Maturity Survey* findings hint at higher levels of sales and job creation as a result of superfast broadband adoption.

Based on the conclusions from the 2017 analysis, the research team at Cardiff University will continue to analyse the results, and refine the performance and productivity analysis of individual sectors for subsequent reports.

This report was written by Dylan Henderson, Calvin Jones, Max Munday, Laura Reynolds, Annette Roberts, Neil Roche, and Anna Scedrova. Results of the survey and other research activities can be found at <http://www.cardiff.ac.uk/superfast-broadband-project>

1. Introduction

This report provides findings from Cardiff Business School's analysis of the economic impacts associated with business use of superfast broadband. It draws on evidence from Cardiff Business School's annual *Digital Maturity Survey* of Small and Medium Enterprises (SMEs), and case studies of business adoption and use of digital technologies enabled by superfast broadband. The research forms part of the Superfast Broadband Business Exploitation (SFBE) project, part-funded by the European Regional Development Fund (ERDF) through Welsh Government.

One context for the research is persistent socio-economic disadvantages faced by Wales' sub-regions, and the SMEs within them. This is reflected in relatively low levels of gross value-added per capita. A further contributory factor is poor productivity among SMEs. The innovative take-up of superfast broadband could therefore work to lever productivity gains, and act as a component of economic convergence processes.

The *Report* provides a comprehensive analysis of economic impacts of superfast broadband use by businesses in Wales. No comparable dataset is available for Wales, and the purpose of this report is to contribute towards understanding the impacts as they evolve over time. The economic impact research forms part of a wider programme of research undertaken by Cardiff Business School.

This report's aim is to:

- Present frameworks for understanding economic impacts from business adoption and use of superfast broadband 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.

Results of all research activities, including Digital Maturity Surveys, case studies and horizon scanning research can be found at <http://www.cardiff.ac.uk/superfast-broadband-project>

The *Report* is structured as follows. Section 2 sets out evidence on the performance benefits associated with standard and superfast broadband use of a selection of case studies. This is followed by analysis of how broadband adoption and use links through to business productivity (Section 3). The report then discusses the wider Welsh economic implications of broadband adoption (Section 4). The report concludes with implications/lessons for subsequent economic impact research (Section 5).

2. Case-study performance analysis

In 2017 a total of 11 new case studies were undertaken to assess the performance benefits achieved by a sample of SMEs using standard or superfast broadband. These case studies followed a similar methodology to those undertaken in 2016, seeking to understand how businesses were using digital technologies enabled by superfast broadband and the resulting benefits.

2.1 Methodology

The case studies draw on interviews with 11 businesses. These were selected to reflect different sectors and geographical locations across Wales. They were identified from respondents to the *Digital Maturity Survey 2017*, as well as from recommendations from our research partners (Welsh Government, Superfast Broadband Business and the Superfast Broadband Business Exploitation Advisory Group). Each case study comprised an interview with the business owner or manager, plus analysis of supporting evidence (for example, a survey return). Full details of the 2017 case studies can be found in Table 2-1.

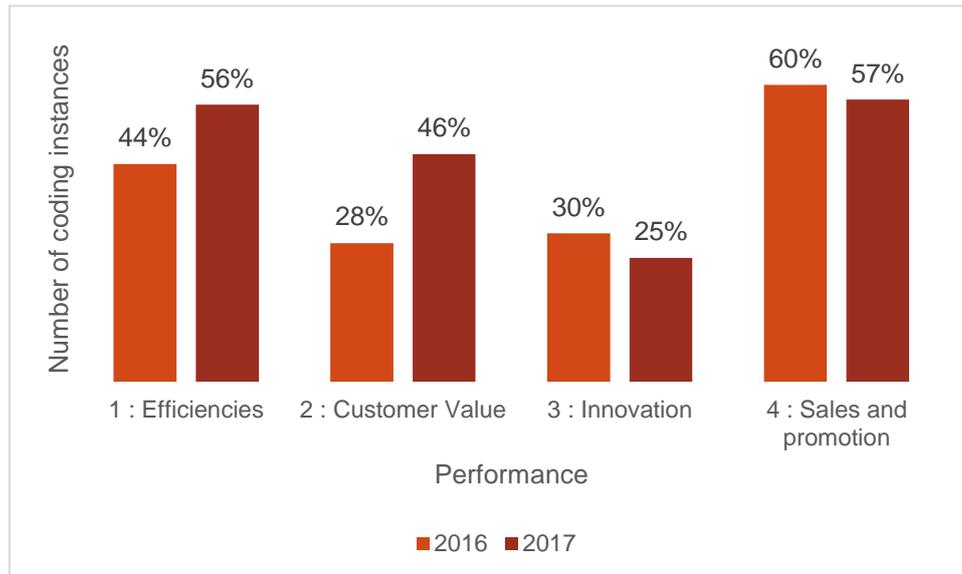
Table 2-1 2017 case study businesses

Company name	Business activity	Location	Sector	Employees (FTEs)
AOTV	Video production activities	SE Wales	Information and communication	c.1
Arad Research	Research consultants	SE Wales	Business and other services	7.5
Cefn Cae'r Ferch Farm	Farming & Holiday Cottages	North Wales	Manufacturing / Accommodation and food services	c.2
D&S Photographic Services	Commercial photography	North Wales	Business and other services	1
Celltest	Construction consultant	North Wales	Construction	148
Mango HR	HR consulting	SE Wales	Business and other services	c.5
Mona Tractors	Tractor retail and servicing	North Wales	Wholesale and Retail	40
Pitton Cross Campsite	Holiday accommodation	Mid and SW Wales	Accommodation and food services	7
Vault Construction*	Construction consultancy	Mid and SW Wales	Construction	5
West Wales Holidays	Holiday cottage rental	Mid and SW Wales	Accommodation and food services	4.5
Zip Clip Ltd	Manufacturer of high spec fixings & fastenings	Mid and SW Wales	Manufacturing	35

* Company requested anonymity, pseudonyms applied

All case studies were analysed using qualitative data analysis software (Nvivo), and coded under the efficiencies, customer value, innovation, and sales and promotion themes. To ensure validity and consistency in the coding process one researcher coded all case study transcripts, including those collected for the *Digital Maturity Economic Impact Report 2016* (22 case studies in total).

Figure 2-1 Business performance benefits from 2016 to 2017



The findings illustrated in Figure 2-1 reaffirm the continued emphasis on efficiencies and sales related benefits for case study businesses. The aforementioned themes remain the two most frequently discussed topics over the 2016 to 2017 case study periods. However, the results point to an increased focus on customer value in the 2017 case studies, realised through a greater emphasis on providing a competitive offering that responds to heightened customer demands. Overall, the analysis confirms the continued recognition of business performance benefits for businesses adopting superfast broadband and related technology over the 2016 to 2017 period.

Findings from the case studies are not intended to be generalisable 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.

2.2 Cost and time efficiencies

As in the 2016 case studies, cost and time efficiencies associated with improvements to the business process represent the most frequently identified area of performance enhancement. Such benefits were expressed in savings made across business processes, as well as improvements in service offerings. Combined, these benefits allowed the businesses to run more efficiently, reduce overheads and satisfy employee, customer and supplier demands. As such these benefits help to underpin other aspects of business performance described in sections 2.3-2.5 below.

While the adoption of new digital technologies is not without cost, all of the case study businesses were able to point to net performance benefits. The AOTV and Vault Construction case studies, for example, illustrated how a small monthly fee for broadband and associated cloud-based technologies enabled an overall reduction in costs where Voice over Internet Protocol (VoIP) was introduced. Such systems deliver voice communications and multimedia content over the internet, which reduces the need for multiple telephone line subscriptions, provides cheap national and international calls and enhances the flexibility of work space. These benefits are detailed by the Vault Construction case study:

“Another big advantage of the VoIP is if we move office then we just take the VoIP numbers, stick the box in another place, and once it’s connected to the internet we’ve got exactly the same number. It’s basic. Also the cost. In the old days we used to have a switch telephone system, which cost about £2,000 or £3,000 to buy. It needed all the wiring. VoIP is simple. I think the handsets cost about £30 each or less. The monthly costs are about £10/£15 or something. It’s peanuts.”

The dual benefits of enhanced broadband speeds alongside increasingly user friendly web technologies is identified in the Pitton Cross Campsite case study as a further way in which broadband can help businesses to reduce costs. While the business had traditionally taken a collection of photos at the start of the year for its website (to reduce the costs of uploading and hosting) the addition of superfast broadband has helped to improve the ease, and reduce the costs of updating its website significantly.

When quantifying cost savings, Zip Clip, a manufacturer of high spec fixings and fastenings, described how superfast broadband had helped it to reduce travel costs. Such costs were previously an unavoidable aspect of the sales process for the business. By adopting superfast broadband, however, the business was able to offset the initial investment in equipment (some £2,500) against a significant reduction in travel (600-£700 per trip)

In addition to reduced overheads, the adoption of standard or superfast broadband has directly benefited the workplace. This is evidenced through greater employee efficiency and flexibility and the removal of barriers to business growth. One commonplace workplace benefit is a reduction in frustrations associated with accessing digital services (see D&S Photographic and Mango HR case studies). Workplace morale and efficiency was impeded by the long time lag experienced while undertaking everyday business processes. As a manager at Mona Tractors explained:

“Where I think broadband has changed it for us... We connect to our franchise partner’s web pages (to access product information), but before superfast broadband the system just used to hang for what seemed like hours. It didn't make the customer experience –sat in front of me – a positive one, it didn't make us professional. Now we can achieve that.”

Other case studies point to the benefits attained by broadband adoption when reassessing office requirements and working patterns. The Mango HR case study illustrated how the use of digital technologies, in particular cloud-based software, enabled a greater degree of flexibility through remote working:

“The remote working side of it means I haven’t got to have an expensive office that I have to pay for. As we grow, I can have more people based remotely.”

A further workplace benefit looks to the ability to work more efficiently in teams. This was identified by Arad Research, who argued that the process of editing reports (their primary product) was aided by the ease with which collaborative document editing could be undertaken using cloud-based technologies. Such efficiencies produced small but repeatable time savings over time.

2.3 Customer value

Superfast broadband provides the basis for offering customers new ways to place orders, access information about products and services and make contact with businesses. These communication-related benefits were particularly important to accommodation-based businesses, which is consistent with the findings from the 2016 case studies. The Pitton Cross Campsite case study provides a prominent example. Here the business argued that superfast broadband had become a necessary feature to the business activities of its client base. Customers had expressed a desire for access to a broadband connection. The business was able to offer that because it knew a demand existed and, as a result, was able to enhance the customer experience.

Cefn Cae'r Ferch Farm similarly saw customer value in offering superfast broadband to its customers, highlighting its role in family and business activities:

“...coming on holiday with children the best way to keep them entertained, out of your sight and from under your feet is give them good internet speed and they'll be happy. Even if they want peace and quiet, visitors do want to check their emails, maybe for business matters, and their social media.”

Having access to fast broadband and associated digital services also influenced customer value in non-accommodation based services. Mango HR, for example, saw the adoption of superfast broadband and technologies as an essential part of its competitive offer to tech-based companies:

“...obviously, a lot of the tech companies already have superfast. They know what they’re talking about. We needed to be on the same level as them and to be able to work efficiently.”

Superfast broadband and associated technologies is becoming an essential requirement for businesses across Wales, especially as ‘tech knowledgeable’ customers are demanding more. Therefore, in order to compete in the market, businesses are having to make incremental advances to meet the rising expectations. Arad Research addressed these rising expectations when explaining:

“I expect our competitors would also be benefiting from similar developments, and also our clients will be aware of them, as expectations increase as the possibilities for technology increase. So it’s made working easier, probably made us more productive and efficient, but actually they are very important to remain competitive within the field.”

The lack of superfast broadband had been a limiting factor in several case studies. West Wales Holidays, for example, described how they had been unable to adopt video technologies in their website due to slow speeds. This was an area where it perceived it was potentially falling behind competition and damaging customer value.

2.4 Innovation

Innovating through the introduction of new products, processes and services, organisational forms or marketing, represent important mechanisms by which business can improve their productivity and growth prospects. Here the case studies illustrated a number of different ways by which innovation based on the use of superfast broadband was occurring. As in the 2016 case studies the form of innovation was primarily ‘new to the company’ (i.e. based on the application of existing technologies), rather than ‘new to the world’ (OECD/Eurostat, 2005).

Superfast broadband augmented the innovation of communication channels between employees, customers and suppliers. Zip Clip detailed the important role of its ‘Total Live Communication’ (TLC) system that enables instant communication between the head office and engineers working onsite. By developing a communication system that operates through live streaming the business has cut out the need for specialists to travel to each construction site, increasing the overall efficiency of its business model.

Business to customer transactions also saw the benefit of innovation in communication channels. The Cefn Cae'r Ferch Farm case study showed how the business utilised video to reach more customers through social media. This relied on the production of short videos for its holiday cottage social media pages, focusing on countryside and animal themes. While originating as an experiment, it resulted in Facebook videos achieving several thousand viewings, driving more new traffic to the business website with the potential to increase bookings.

Other forms of innovation identified were broader in scope and linked to new 'business models'. These are defined by Teece (2010) as 'defining the manner by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit' (p.172). Here Mango HR's approach to disrupting traditional HR business models, by aligning itself with its tech-based clients, was enabled by superfast broadband and adoption of associated cloud-based technologies.

2.5 Sales and promotion

Despite the case study businesses' continued anecdotal reference to sales and promotional benefits, businesses struggled to attribute specific sales quantities to the adoption of superfast broadband and enabled digital technologies. This reflects the complex processes by which such returns are generated and the difficulties in disaggregating returns from developments elsewhere in the business and the wider market place.

The case of AOTV, however, provided an example of how financial benefits can be achieved and measured. In this business, the volume of data associated with its product (video images) meant that it had traditionally distributed it to clients via the postal system. This added extra costs associated with the purchase of a hard drive, plus shipping. The business has seen a vast reduction since the adoption of superfast broadband and use of cloud-based data sharing:

"...whenever I do a shoot I can upload the day's SD card of 64GB, 128GB, to the client overnight. I can just leave it uploading, instead of spending under £100 on a hard drive, and then £20 a shipment."

By switching to a cloud-based alternative, savings of up to £600 a month could be made by cutting out the distribution of hard drives. While these expenses were previously passed directly to the customer, the elimination of these costs helped the business to become more competitively priced.

The adoption of digital technologies to improve the sales process was also evident in Cefn Cae'r Ferch Farm's use of Facebook to help promote and sell its sheep. The specialised nature of the market for its Texel sheep meant that:

"...if you put something in the Farmers' Guardian or the Farmers' Weekly or whatever, it costs you. It takes time to phone the adverts in and you don't really know if the pedigree Texel sheep breeders are looking at it, but I've got five hundred Texel breeder friends on my Facebook page so there's a big, big chance they will see it if the picture is good."

A further benefit to sales and promotions is realised by an extension of the sales and communication reach overseas. Case study businesses reported the importance of video conferencing to client relationships and sales in the US market. Such technologies can help businesses to maintain contact with customers and international partners. AOTV, for example, indicated that being able to distribute their product via fast internet connections meant that they were able to meet new targets imposed by their US client (see also D&S Photographic case studies). Similarly, Mango HR argued that they probably wouldn't have been able to secure business with their US client *"if we weren't able to be able to speak to them on videoconferencing and talk to them and do the work online with them"*.

Almost all case study businesses discussed the promotional benefits achieved from access to superfast broadband. The engaging and creative use of social media platforms was considered a precursor to business performance, providing a cost effective means of communicating with customers and clients both nationally and overseas. Pitton Cross Campsite acknowledged the necessity for businesses to use Facebook, as a means to promote its products and services to customers:

While Facebook is commonly used to engage customers, other forms of social media, such as LinkedIn are used by businesses establishing business-to-business (B2B) relationships. Zip Clip identified the international reach of these connections, seeing LinkedIn as *"a great source of making contact with your customer base, particularly overseas."*

Similarly, case study businesses noted the importance of maintaining up-to-date and high quality websites, providing essential sales and promotional functions. In addition to processing online sales, Pitton Cross Campsite discussed how access to faster broadband speeds provided unexpected benefits in terms of flexibility and creativity when updating their website:

"...having faster broadband means we can take the website on board ourselves and we can go in and alter and do things to it, and it doesn't take you half an hour to upload a photo. It's so fast, you just click and it's done and you don't wait for it."

Zip Clip also highlighted the freedom for businesses to update their website, allowing businesses to adapt to market changes:

"We're just developing it into a new website. We're constantly changing it. The current website has been running for about two years, so we're finding it's getting out of date, so we're changing that again. The market is changing very, very quickly now and we've got to keep pace with that and keep ahead of it."

The sales and promotional gains are wide-ranging, extending across the business processes, revenue streams and communication-related channels. The diversity of benefits are realised internally within the case study businesses, as well as helping to build national and international portfolios.

2.6 Summary

Building on the *Digital Maturity Economic Impact Report 2016*, the case studies undertaken in 2017 provided further evidence of the performance benefits achieved by businesses adopting superfast broadband. These results show that businesses in all sectors can gain benefits through cost and time savings, customer value, innovation and sales. The incremental cost and efficiency savings remain the most prominent of the performance benefits, creating the means by which businesses are then able to enhance customer value, innovate and increase sales.

A noteworthy theme that runs throughout the 2017 analysis is the improved communication channels that are derived by adopting superfast broadband. Communication-related benefits arise under each performance benefit discussed above. The communication-related benefits look to the ways in which businesses are able to improve their ongoing interactions with employees, customers and suppliers whether it be locally, nationally or internationally. The case studies demonstrated the pivotal role of superfast broadband in enhancing the speed, efficiency and effectiveness of these multifaceted communication streams.

A further area of development looks to the necessity of superfast broadband and enabled technologies when businesses are seeking to keep pace with competitors and to meet the rising demands of suppliers and customers alike. Therefore, access to superfast broadband and the corresponding digital technologies is becoming a prerequisite for business success, as opposed to an asset.

While the findings indicate a number of performance benefits attained by adoption of superfast broadband, calculating the precise impact of these changes on businesses is challenging. A key reason for this restriction is the difficulty of isolating the added value of these technologies and superfast broadband adoption, as opposed to other contributory factors in the business model. Despite this, all of the case studies point to a selection of net benefits to performance following the adoption of superfast broadband and enabled digital technologies.

Future economic impact reports will be based on revisits to the 2016 and 2017 sample of case studies, alongside a selection of new Welsh businesses, building a longitudinal analysis of how business performance benefits evolve over time.

Full results of the case studies can be found at <http://www.cardiff.ac.uk/superfast-broadband-project/case-studies>

3. Business efficiency analysis

The impacts of SMEs' adoption of broadband-enabled technologies can be analysed at a range of different levels. This includes the firm level, the industry level and the scale of the overall Welsh economy. This section examines the firm level impacts of digitalisation using a production efficiency analysis. Specifically, business efficiency analysis aims to investigate what types of businesses are most efficient and then considers how far the access to, and use of, ICT resources is making SMEs relatively more efficient through time.

3.1 Introduction

One of the objectives of the SFBE research programme was to seek to identify connections between digital maturity levels and business efficiency. The earlier *Digital Maturity Survey for Wales 2017* (WERU, 2018) presented descriptive results showing the business performance of the respondent SMEs according to their digital maturity levels. This *Digital Maturity Economic Impact Report* further examines the relationships between SME productivity and a set of variables which describe different dimensions of digital maturity and variations in efficiency by industry, region, firm size and type of broadband used.

In the following section, an econometric analysis technique was used to estimate production efficiency of SMEs and examine connections to digital maturity levels, standard or superfast broadband adoption and other business characteristics.

3.2 Methodology

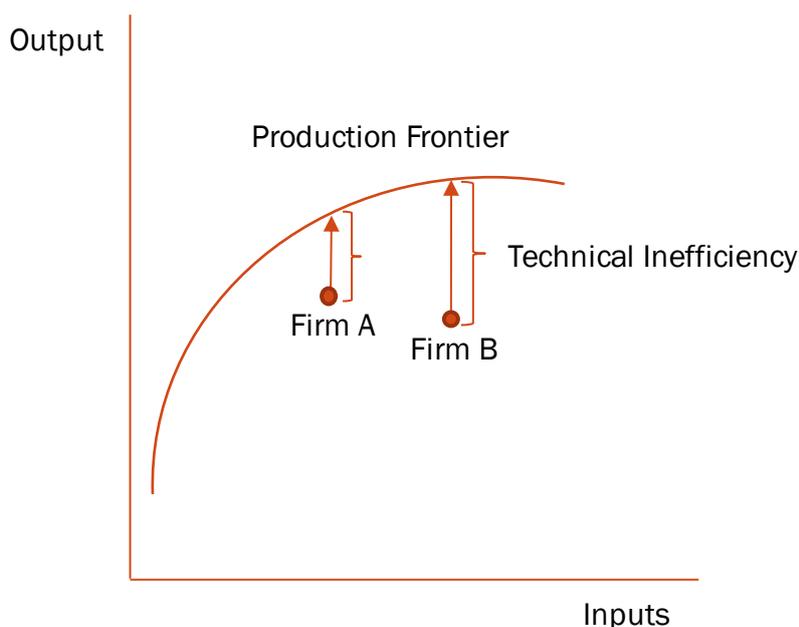
Technical efficiency analysis is a useful econometric approach to measure the performance of businesses. This is commonly used to track changes in industrial and national productivity and to assess how closely businesses might move towards a production frontier over time.

The Stochastic Frontier Analysis (SFA) method is employed in this section to estimate the efficiency with which businesses convert a set of resources (i.e. inputs) to produce outputs¹. Fundamentally this method compares the relationship between a set of inputs and an output used in the production process against the maximum output attainable from each input level – the production frontier. Hence, it represents the current state of technology in the industry. Firms that operate on the production frontier are technically efficient, while firms that operate beneath the frontier are technically inefficient (a simple representation is given in Figure 3-1).

¹ The methodology used is described in detail in Coelli et al. 2005 and Kumbhakar et al. 2015

In what follows, a stochastic production frontier model was used to estimate technical (output-oriented) efficiency – that is, the ratio of actual output to the maximum possible output. This ratio is bounded between 0 and 1, with a value of 1 implying that the firm is fully technically efficient. Hence, the level of technical efficiency of a firm is calculated as 1 – technical inefficiency component (i.e. the inverse distance from the production frontier). The ratio is then expressed in percentage terms, with 100% suggesting that the maximum output is produced by a technically efficient firm.

Figure 3-1 Conceptual framework of technical efficiency analysis



The research used data on inputs consumed and outputs produced in businesses that participated in the *Digital Maturity Survey for Wales 2017* and then employed statistical software to estimate the frontier. This then allowed each business' technical efficiency to be measured according to their distance from the optimal production frontier. The analysis then addressed whether different digital maturity levels and other factors might be important in explaining the variations in businesses' technical efficiency.

3.3 Technical efficiency of Digital Maturity Survey 2017 respondents

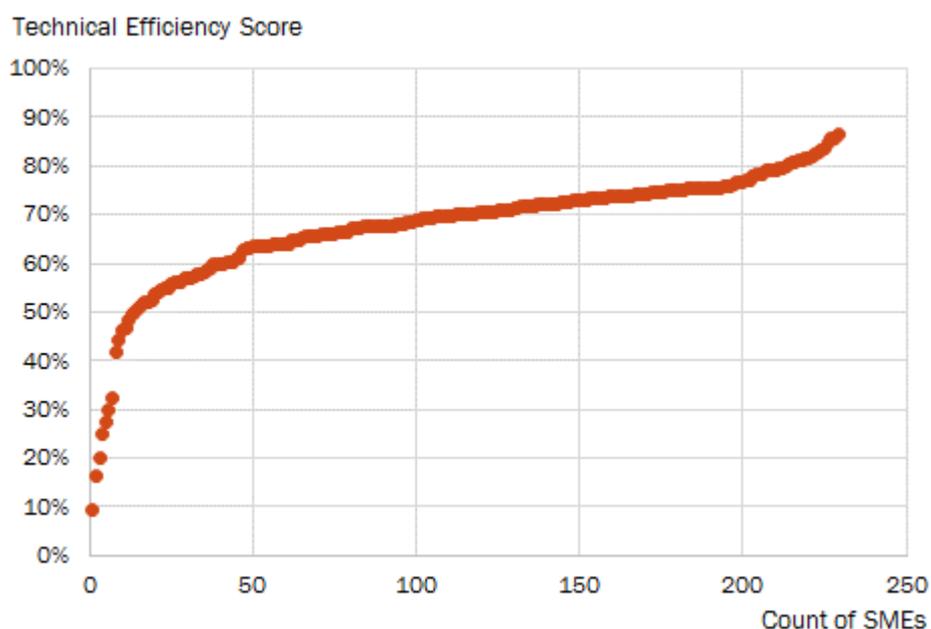
The first step in the analysis was to estimate the production efficiency of SMEs in the sample. This is assumed to be in terms of their ability to transform a given set of inputs into outputs. To do this, a stochastic frontier analysis technique was employed to estimate the following production function,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

$$\text{Output (Sales)} = \text{Input 1 (Employees)} + \text{Input 2 (Total Assets)}$$

Here the sales output is assumed to be a function of labour and capital inputs into the production process. Total assets refer to fixed assets and working capital. The data were collected from the Bureau van Dijk's *FAME* database and supplemented by self-reported data from the *Digital Maturity Survey 2017*. The figures reflect year 2017. It was necessary to remove some SME cases from the analysis when sales figures were missing as an output. The analysis was based on 229 SMEs where the necessary data were available, and the results confirmed that labour and capital were statistically significant determinants of sales performance.

An initial analysis of the distribution of technical efficiency scores across the sample of 229 businesses is summarised in Figure 3-2. The figure reveals that there is substantial variation in technical efficiency across the firms. That is, SMEs varied considerably in their proximity to the optimal production frontier, with estimated technical efficiency below 60% for 37 businesses (16% of the sample, 0-50 band), and above 80% for 18 businesses (8% of the sample, 200-250 band). The majority of SMEs (76% of the sample) had technical efficiency in the range from 60% to 80% (50-200 band).

Figure 3-2 Distribution of technical efficiency scores in the sample



Further analysis of the findings in Figure 3-2 revealed that:

- Welsh SMEs on average produced 68% of the maximum output available from their combination of human and capital assets. This means that nearly one third of the potential output was lost due to technical inefficiency (i.e. due to using capital and labour in a less than optimal way).
- The median (i.e. midpoint) technical efficiency was around 70%.
- The most efficient business was around 87% of the way to the production frontier.

In addition, a year-on-year comparison was conducted for a small sub-sample of survey respondents for which the data from 2016 were available (Table 3-1). The findings show that out of 40 SMEs that made up this sub-sample, 32 businesses experienced a positive growth in business efficiency in the year 2016-17, while 8 businesses experienced a negative year-on-year growth. On average, the year-on-year efficiency of the entire sub-sample increased by 22 percentage points. The results also suggest that superfast broadband users were likely to experience positive and negative productivity growth, indicating that superfast broadband *per se* may not always affect variation in productivity. Considering the small size of a sub-sample, the results should be taken as illustrative and with care needed in the interpretation.

Table 3-1 Illustrative results of year-on-year change of technical efficiency

	All SMEs for 2016 to 2017 analysis	SMEs with positive change 2016 to 2017	SMEs with negative change 2016 to 2017
Superfast broadband users	36	30	6
Standard broadband users	4	2	2
Total count	40	32	8
Average change in technical efficiency	+22 percentage points	+32 percentage points	-14 percentage points

3.4 Most and least technically efficient businesses, their digital maturity and other characteristics

Returning to the 2017 analysis of 229 SMEs, further work revealed that the best performing 5% of businesses (13 SMEs) in terms of technical efficiency:

- On average produced 83% of the maximum output from their inputs.
- Had technical efficiency in the range from 81% to 87%.

On the other hand, the worst performing 5% of businesses (13 SMEs) in terms of technical efficiency:

- On average produced 34% of the maximum output from their inputs.
- Had technical efficiency in the range from 1% to 49%.

Table 3-2 Digital maturity of the most and least technically efficient businesses

Performers based on technical efficiency	ICT Infrastructure Score	ICT Investment Score	ICT Capabilities Score	Digital Applications Score	E-Commerce Score	Digital Maturity Score

Most efficient 5%	8	3	7	28	9	55
Least efficient 5%	7	2	7	22	6	45

Analysis undertaken as part of the *Digital Maturity Survey 2017* shows that four clusters of Welsh SMEs can be identified in terms of their digital maturity. Ordered by their level of digital maturity (high to low) these are: Digitally Embedded; Active Exploiters; Passive Exploiters; and Digitally Disengaged.

Interestingly, as can be seen in Table 3-2, both the most and the least technically efficient businesses fell into the same Digital Maturity Cluster, namely Active Exploiters (level 3 of digital maturity, with scores in the range from 45 to 59). This suggests that digital maturity alone is insufficient to explain variation in productivity.

3.5 Technical efficiency by other business characteristics

Table 3-3 shows variation in technical efficiency by Digital Maturity Cluster. The results suggest that the most digitally mature SMEs (Digitally Embedded) outperformed the least digitally mature (Digitally Disengaged) by an average of 8 percentage points, achieving 70% technical efficiency. The scores per digital maturity dimension indicate that Digitally Embedded were active users of digital applications and e-commerce, which might be linked to their technical efficiency. There is, however, no difference in terms of technical efficiency between Passive Exploiters and Active Exploiters, both clusters producing on average 68% of the maximum output.

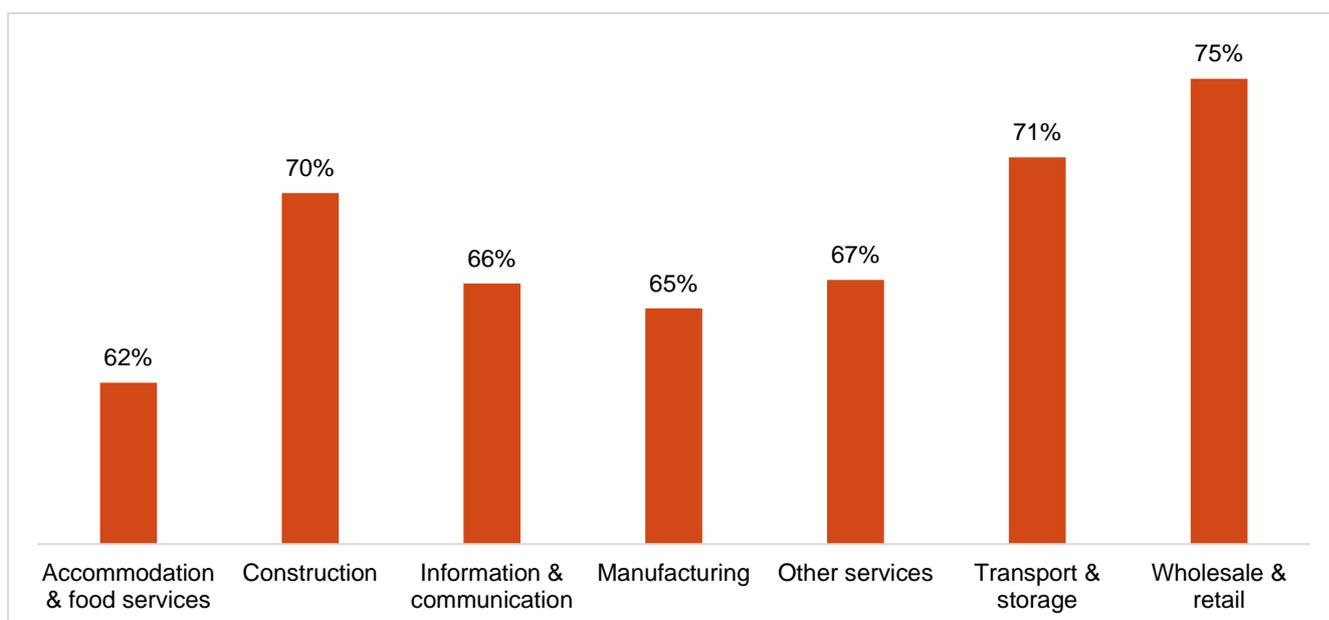
Table 3-3 Technical efficiency by Digital Maturity Cluster

Digital Maturity Cluster	Cluster Size	Technical Efficiency	ICT Infrastructure Score	ICT Investment Score	ICT Capabilities Score	Digital Applications Score	E-Commerce Score	Digital Maturity Score
Digitally Embedded	34	70%	9	4	7	38	11	69
Active Exploiters	71	68%	8	3	7	28	8	53
Passive Exploiters	99	68%	7	2	5	19	5	38
Digitally Disengaged	24	62%	7	1	4	9	3	24
Average	228 ²	68%	8	2	6	23	6	46

Furthermore, variation can be observed by industry, with wholesale and retail sector being the most technically efficient (75%) and accommodation and food services being the least technically efficient (62%).

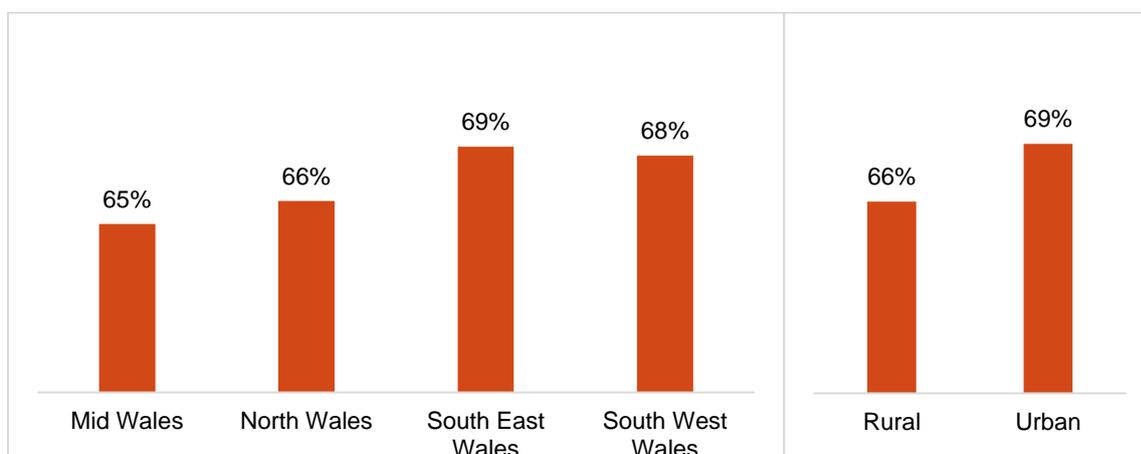
² One observation could not be classified

Figure 3-3 Technical efficiency by industry sector



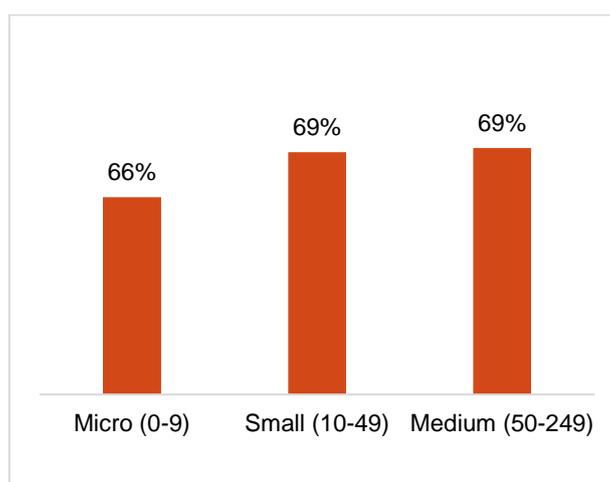
Variation was also prominent at the sub-regional level, although to a lesser extent, with technical efficiency in the range from 65% to 69% and the difference of 3 percentage points between rural and urban areas (Figure 3-4).

Figure 3-4 Technical efficiency by region



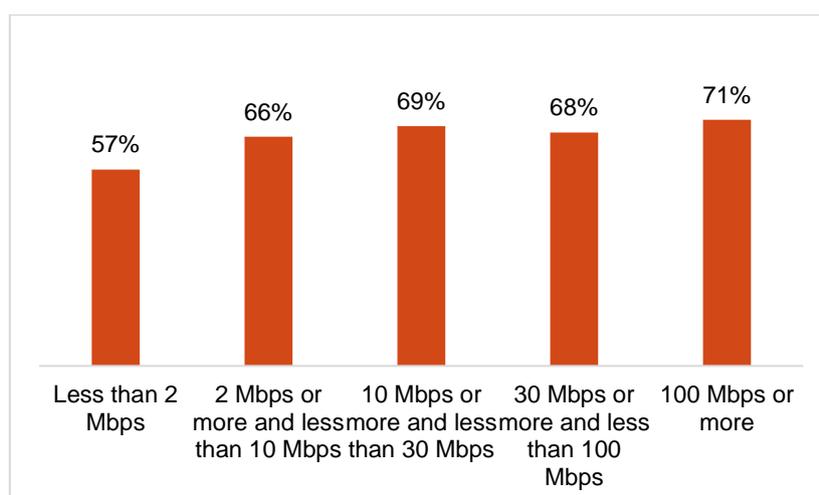
As expected, micro businesses tended to be less technically efficient, while small- and medium-sized businesses outperformed them by 3 percentage points (Figure 3-5).

Figure 3-5 Technical efficiency by firm size



Finally, technical efficiency varied significantly between the SMEs that had broadband speeds of up to 2 Mbps (57%) and the SMEs that had broadband speeds of over 100 Mbps (71%).

Figure 3-6 Technical efficiency by broadband speed



3.6 Summary

The efficiency analysis provides an opportunity to get granulated insights into the factors that may explain variations in businesses' productivity. Preliminary results suggest that digital maturity and adoption of superfast broadband alone are insufficient to explain variation in productivity. Therefore, the explanatory factors underpinning variations in efficiency merit further investigation via more advanced modelling techniques. The quality of the year-on-year comparative analysis should also 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.

4. Economic impact

One of the areas of interest arising from the *Digital Maturity Survey 2017* is how many SMEs in Wales might have been positively affected by having adopted both standard and superfast broadband. Moreover, it is also important to consider the potential regional scale of the sales and employment effects resulting from services levered by adopting standard or superfast broadband.

While the 2017 *Survey* garnered a significantly higher level of response than the 2016 *Survey*, there are still some problems in 'grossing up' findings from such the *Survey* to the population of Welsh SMEs. For these reasons the approach in this section is cautious. For example, while the 2017 *Survey* was representative in terms of industry sectors and location of SMEs responding, there could still be issues in that firms are more likely to report positive than negative effects on jobs and sales. In addition, while the total number of respondents in the 2017 *Survey* was 453, only a proportion of this number gave finer grained details of expected employment and sales effects resulting from adoption of broadband resources. Finally, for individual respondents, there is a strong element of subjectivity in terms of how they precisely assess the extent to which access to new services leveraged from broadband feeds through to a change in employment or sales. It is possible that respondents might have some difficulty in assessing the nature of the counterfactual (i.e. what would have occurred had they not adopted the broadband services).

4.1 How many Welsh SMEs might have been positively affected by the adoption of broadband-enabled services?

In this first part of the analysis there is no differentiation as to whether firms had adopted standard or superfast broadband. So here the objective is to initially estimate overall numbers of firms that might have been impacted by positive effects from broadband adoption. Below are some of the main findings from the 2017 *Survey* which identify the effects of access and adoption of standard or superfast broadband services on sales and employment in particular:

- A total of 324 of the 453 respondents (72%) answered the Survey question with respect to the effects of adoption of standard or superfast broadband services on sales. There is no indication of the economic effects of broadband on the remaining 28% of respondents which underlines that some caution is needed in interpreting what follows.
- Of these 324 firms, some 47.2% reported that turnover had increased as a result of access and adoption of standard or superfast broadband, and with just 1.2% revealing that their turnover had decreased. There was some variation of the effects of broadband by firm size-band (for example 70% of firms employing more than 50 people reported an increase, whereas this figure fell to around 11% for sole traders employing no FTEs).
- Overall some 93.4% of those firms reporting a positive outcome also believed that the effect was sustainable i.e. it would not be one-off with sales or employment reverting to prior levels in one year.

- Around two-thirds (101) of those reporting a positive turnover effect felt able to estimate the percentage increase. Around half reported the increase was up to 10%, and with a further 27 specifying a turnover increase of between 11% and 30%.

The points listed above can be used to draw some inference on the wider Welsh economy effects. Information is available in terms of the size analysis of all Welsh firms in terms of numbers of enterprises, employment, and sales (Table 4-1). The very large number of enterprises in the cohort employment between 0 and 9 people is particularly noticeable.

Table 4-1 Size band analysis of enterprises active in Wales in 2017

	Enterprises (000s)	Employment (000s)	Turnover (£bn)
Micro (0-9)	240.6	392.7	20.1
Small (10-49)	9.3	176.7	13.2
Medium (50-249)	2.1	136.4	14.2
Large (250+)	1.7	437.5	69.6
All	253.6	1143.3	117.1

Source: Welsh Government

The employment size bands used in the 2017 *Digital Maturity Survey* are very slightly different from those shown in Table 4-1. The *Survey* also defines employment in terms of full time equivalent (FTE) employees as opposed to employment (the base used in Table 4-1). Moreover, there are no large sized firms covered in *Digital Maturity Survey*. These issues noted, it is possible to draw some broad conclusions on the numbers of firms in Wales that might have been positively effected in terms of turnover and employment effects from broadband adoption.

Table 4-2 How many Welsh firms are expected to have seen a turnover increase as a result of broadband access and adoption

	Welsh Enterprises (000s)	Assumptions based on <i>Survey</i> , i.e. est. % of firms seeing a positive and sustained sales increase from broadband ³	Estimated Welsh SMEs (000s) seeing a turnover increase due to broadband adoption	Example of how much Welsh SME turnover increases assuming a 1% increase in sales in positively affected firms in the size cohort (£m)
Micro (0-9)	240.6	44.4%	106.8	89.2
Small (10-49)	9.3	34.4%	3.2	45.4

³ That is the estimated proportion of firms in the size band seeing a positive sales increase that is sustained and with this derived from the *Survey*. For example if 47.7% of firms in the 0-9 size category saw a positive increase, and then 93% of these believed that the sales increase was sustainable then this would give a figure of around 44.4%.

Medium (50-249)	2.1	65.6%	1.4	94.7
All	252.0		111.4	229.3

Table 4-2 reveals that broadband leveraged services could have improved sales prospects for around 111,000 (44%) Welsh SMEs. It is noted that the Survey findings revealed that a small number of firms reported decreasing turnover as a result of broadband services adoption.

The next stage involves consideration of the extent of the change in sales. Analysis is limited by the smaller number of Survey respondents reporting the scale of turnover change due to broadband-enabled services. As revealed above, it is very difficult for businesses to be fully aware of the counterfactual, and with the prospect of successful broadband service enabled firms displacing economic activity in other Welsh firms. Notwithstanding it is important to reflect on the potential scale of impacts of increases in turnover attributable to broadband services adoption.

Table 4-2 adopts a very conservative position based on the large number of firms in the Survey sample that reported an increase of up to 10%. Even adopting the very conservative figure of a 1% increase in turnover attributable from access and adoption of broadband services suggests that the total sales in SMEs in Wales impacted positively by broadband services would be almost £0.23bn (Table 4-2). The Survey findings suggest that the true number could be a multiple of this. However, there is a need for care here because the Survey does not explicitly allow any inference to be drawn on how more successful firms efficiently using broadband services might be working to displace sales and economic activity in less efficient firms. Under these circumstances the conservative sales attribution assumption is more appropriate.

In a similar manner the analysis now turns to employment. The 2017 Survey revealed the following.

- A total of 335 of the 453 respondents answered the Survey question with respect to effects of adoption of standard or superfast broadband services on employment.
- Of these 335 firms some 24.5% reported that employment had increased as a result of access and adoption, and with just 2.0% revealing that their employment had decreased. There was some variation on the effects of standard or superfast broadband by firm size-band (for example 66% of firms employing more than 50 people reported an employment increase, whereas this figure fell to around 10% for the smallest firms. This is not surprising as larger firms have more potential for an employment increase given their existing scale of operations.
- Of those firms reporting an increase in employment 87.7% believed that the increase was sustainable rather than a one-off short term increase.
- Around 63% of those reporting a positive employment effect (52 firms) felt able to estimate what the percentage increase was with around half reporting the increase was up to 10%, and with a further 9 firms reporting an employment increase of between 11% and 30%. This illustrates that the number of firms able to put precise percentages around additional employment effects were quite limited.

Again a conservative 1% increase in employment is assumed. When the *Survey* findings are applied to the Welsh population of SMEs (Table 4-3) it could mean that some 32,100 SMEs have seen an employment increase resulting from the broadband adoption. Given the average employment size of each SME in each cohort in Table 4-3, then were a 1% increase to have occurred around 1,752 new employment opportunities would have resulted. Again this is likely to be conservative and with the *Survey* findings hinting at higher levels of new job creation, although some SMEs in the sample reported employment decreases. Yet, the material in Table 4-3 hints at how much Welsh employment would be created by a 1% increase caused by adoption of broadband services.

Before progressing with the analysis it is also important to note that while these estimates of direct effects are conservative they take no account of the multiplier effects (supply chain and household income effects) connected to new activity. In the future it will also be valuable to reflect on these additional employment and activity outcomes that arise from firms directly assisted by the Superfast Broadband Business Exploitation programme, and how these compare with some of the estimates made above.

Table 4-3 How many Welsh firms are expected to have seen an employment increase as a result of broadband access and adoption

	Welsh Enterprises (000s)	Assumptions based on <i>Survey</i> , i.e. est. % of firms seeing a positive and sustained emp. increase as a result of broadband (see note to Table 4.2)	Estimated Welsh SMEs (000s) seeing a sustained employment increase due to broadband adoption	Example of how much SME employment increases assuming a 1% increase in employment in positively affected firms in the size cohort
Micro (0-9)	240.6	11.7%	28.2	460
Small (10-49)	9.3	28.9%	2.7	513
Medium (50-249)	2.1	57.7%	1.2	779
All	252.0		32.1	1,752

4.2 Numbers of Welsh SMEs positively affected (sales and employment) by superfast broadband

The next section repeats the analysis above but with a focus on the firms which have adopted superfast broadband. Table 4-4 repeats some of the material in Table 4-1 on the population of Welsh SMEs, and their estimated employment and sales. However Table 4-4 also shows the *Digital Maturity Survey* findings in respect of the estimated proportion of firms in each employment size cohort which have adopted superfast broadband, standard broadband, and then those SMEs which remain with no broadband.

Table 4-4 Size band analysis of Welsh firms and superfast adoption

	Enterprises (000s)	Employment (000s)	Turnover (£bn)	Superfast Broadband	Standard Broadband	No Broadband
Micro (0-9)	240.6	392.7	20.1	42%	58%	0%
Small (10-49)	9.3	176.7	13.2	50%	50%	0%
Medium (50-249)	2.1	136.4	14.2	72%	26%	2%
All SMEs	252.0	705.8	47.5	42%	55%	3%

The 2017 *Survey* revealed that 42% of responding SMEs had adopted superfast broadband. A large proportion of *Survey* superfast enabled respondents were able to respond to how adoption of the resource had affected sales. In summary:

- A total of 179 of respondents who had adopted superfast broadband answered the *Survey* question with respect to effects of access to broadband services on sales.
- Of these, 86 firms (some 48.0%) reported that turnover had increased as a result of superfast adoption, and with none of these revealing that their turnover had decreased.
- Some 55 of those reporting a positive turnover effect felt able to estimate what the percentage increase was, with 54.5% reporting the increase was up to 10%, and with a further 23.6% specifying a turnover increase of between 11% and 30%.
- The vast majority of firms (around 93%) reporting a turnover increase related to adoption of superfast broadband believed that the turnover increase would be maintained (i.e. was not just a one off benefit).

Table 4-5 How many Welsh firms are expected to have seen a turnover increase as a result of superfast broadband adoption

	Enterprises (000s) in Wales	Assumptions based on <i>Survey</i> , i.e. estimated % of firms seeing a positive and sustained sales increase as a result of superfast broadband	Estimated Welsh SMEs (000s) seeing a turnover increase due to superfast adoption	Example of how much Welsh SME turnover increases assuming a 1% increase in sales in positively affected firms in the size cohort (£m)
Micro (0-9)	240.6	18.5%	44.5	37.2
Small (10-49)	9.3	17.9%	1.7	23.6
Medium (50-249)	2.1	44.6%	0.9	63.4
All	252.0		47.1	124.2

Table 4-5 adopts the same conservative position as earlier in terms of a sales increase attributable to adoption of superfast broadband. Table 4-5 shows the results of applying the *Survey* proportions of SMEs having superfast, and having gained a sustainable sales increase, applied to the overall population of Welsh SMEs. This shows that a little over 47,000 SMEs (almost 19%) would have seen positive sales effects resulting from adoption of superfast. (Subtracting this from the total of 111,400 firms in Table 4-2, leaves more than 64,000 SMEs with positive effects from standard broadband). Adopting the very conservative figure of a 1% increase in turnover attributable from access and adoption of superfast then the total sales in SMEs in Wales impacted positively by superfast would be around £124m. Again the *Survey* findings reveal that the real number could be a multiple of this. It is noted that around £124m of turnover in Wales would equate to an estimated £37-40m of gross value added (based on the relationship between firm sales and GVA in Wales derived from ONS data).

In a similar manner the analysis now turns to consider the SMEs seeing positive employment connected to the adoption of superfast broadband. The 2017 *Survey* revealed the following.

- A total of 186 of the 453 *Survey* respondents had adopted superfast broadband and were able to respond to survey questions on employment change.
- Of these 186 firms, some 28.5% reported that employment had increased as a result of superfast adoption, and with just 2.0% revealing that their employment had decreased. There was again some variation of the effects of broadband by firm size band (for example 58% of firms employing more than 50 people reported an employment increase, whereas this figure fell to around 15% for those employing between 2-5FTEs).
- Of those firms reporting an increase in employment, an estimated 93.3% believed that the increase was sustainable rather than a one-off short term increase
- Around 66% of those reporting a positive employment effect (53 firms) felt able to estimate the percentage increase, with around half reporting the increase was up to 10%, and with a further 7 suggesting an employment increase of between 11% and 30%.

As in the preceding analyses a conservative 1% increase in employment is taken as a conservative assumption for illustration purposes. Then when the *Survey* findings with respect to superfast and employment effects are applied to the Welsh population of SMEs it could mean that some 16,600 SMEs (almost 7%, Table 4-6) have seen a sustained employment increase resulting from superfast broadband adoption. Given the average employment size of each SME in each cohort in Table 4-6, then were a 1% increase to have occurred, around 1,056 new employment opportunities would have resulted. Again, and as above, this is likely to be conservative and with the *Survey* findings hinting at higher levels of new job creation.

Table 4-6 How many Welsh firms are expected to have seen an employment increase as a result of superfast broadband adoption

	Welsh Enterprises (000s)	Assumptions based on <i>Survey</i> , i.e. estimated % of firms seeing a positive and sustained employment as a result of superfast	Estimated Welsh SMEs (000s) seeing an sustained employment increase due to superfast adoption	Example of how much Welsh SME employment increases assuming a 1% increase in employment in positively affected firms in the size cohort
Micro (0-9)	240.6	5.9%	14.2	232
Small (10-49)	9.3	17.0%	1.6	304
Medium (50-249)	2.1	39.0%	0.8	520
All	252.0		16.6	1,056

4.3 Summary

There are always difficulties estimating the marginal economic effects of improvements in access to technology. It is accepted here that it is difficult for the Survey respondents to be precise on how broadband effects both employment and sales. However, encouraging from the Survey was that the respondents provided evidence of positive as opposed to negative effects, and with a high proportion of positive impacts expected to be sustained as opposed to short term. While the focus of the section has been on increases in sales and employment there is a need to be mindful that the technology could be having positive effects even were sales and employment in affected SMEs to be falling i.e. either the job and sales losses might have been worse without the adoption of broadband, or falling employment is connected with improving productivity. In this context it is important to consider the findings of this section, with that in the following sections which reveal performance and productivity impacts connected with firms adopting broadband services.

Even more difficult is drawing strong conclusions on the differential impact of standard as opposed to superfast broadband on business outcomes. For many of the responding firms, standard broadband was more than adequate to meet their needs. However, analysis of the Survey does reveal that of the responding firms that had adopted superfast, 48% revealed a sales increase, 28% an employment increase and 50% a profits increase. The respective figures for standard broadband adopters was 46%, 19% and 44%. This hints at more significant returns to superfast adoption (see Table 4-7).

Table 4-7 Percentage of Welsh SMEs benefitting from broadband adoption, by broadband type

	Sales increase	Employment increase	Profits increase
Standard broadband adoption	46%	19%	44%
Superfast broadband adoption	48%	28%	50%

5. Conclusions

The 2017 *Digital Maturity Economic Impact Report* was certainly assisted by the larger number of respondents to the 2017 *Digital Maturity Survey* which allowed the research team to better understand differences between clusters of firms based on the engagement with superfast broadband. However, elements of the economic impact assessment will be further enhanced where it is possible to get responses from the same businesses year-on-year, such that their progress can be accurately assessed through time. The case studies assist with this process but it is hoped in future years of the work that more can be done in assessing the evolution of the benefits from the adoption of standard and superfast broadband through time using the findings from the *Survey* itself.

The overall sense of this second economic impact report is that the research team have found plenty of qualitative evidence of business advantage from engagement and adoption of the superfast broadband resource, but with rather more difficulty in assessing effects in quantitative terms. The productivity analysis revealed differences between the least and most digitally engaged in the respondent sample, but with more difficulty linking levels of adoption of the superfast broadband resource to performance improvement.

However, this year the team were more confident in grossing up the findings from the *Digital Maturity Survey* to show how many SMEs in Wales could have been positively effected in terms of sales and employment increases, and the scale of expected increases, although with very conservative measures adopted in the approach.

Based on the conclusions from the 2017 analysis the research team in the next periods of the project will be focusing on gaining repeat survey responses from the firms who engaged with prior Digital Maturity Surveys, but also refining the performance and productivity analysis on individual sectors.

The Welsh Government has recently announced a range of measures to extend the reach of fast and reliable broadband coverage in Wales even further. A tender exercise is underway for the successor scheme with the aim of announcing the successful bidders during summer 2018 with deployment work commencing as swiftly as possible after that. The Welsh Government's Access Broadband Cymru and Ultrafast Connectivity Voucher Schemes continue to be available for those currently without access to superfast broadband. This presents the prospect, over the coming years, of the Survey sample picking up on more firms who have adopted the valuable resource that is superfast broadband.

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