BDUK Vouchers Evaluation: Impacts and Value for Money Assessment
Full Technical Report

A Report by Hatch, Belmana and Winning Moves

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Glossary

ASHE	Annual Survey of Hours and Earnings
BDUK	Building Digital UK
BCR	Benefit Cost Ratio
BSD	Business Structure Database, an Office for National Statistics dataset providing information on business characteristics and performance.
CDRC	Consumer Data Research Centre
DiD	Difference-in-difference. An counterfactual analytical technique which compares the change in an outcome variable for two groups, then assesses whether the difference between the two groups is statistically significant.
DSIT	Department for Science Innovation and Technology
FScore Model	This a DSIT model used to establish the estimated cost to build to every UK premise from known core gigabit broadband infrastructure points (such as exchange and cabinets). DSIT and BDUK use this model to determine benchmarks for those premises considered to be either commercial and non-commercial for the market to deliver. Previous versions of this model had been used to estimate the “final 20%” (the 20% hardest to reach locations for broadband connectivity). More detail on the assumptions, use risks and caveats is provided at Appendix A.
GBVS	Gigabit Broadband Voucher Scheme; the first voucher scheme for gigabit-capable broadband connectivity launched in 2018. The Scheme used the voucher product to prioritise connections for Small to Medium Enterprises, alongside connections for residential premises. The original scheme closed in May 2020.
Gigabit-capable broadband	Any technology that can deliver 1 gigabit-per-second download speed
IUC	Internet User Classification
LFFN	Local Full Fibre Networks Programme – the BDUK programme which included the initial testing of the voucher product for gigabit broadband connectivity; trialling the Gigabit Broadband Voucher Scheme (GBVS) in 4 areas before it launched as a separate national scheme.
LSOA	Lower Super Output Area: geographical areas for the purpose of local data analysis. LSOAs comprise between 400 and 1,200 households and have a usual resident population of between 1,000 and 3,000 people.
OA	Output area: geographical areas for the purpose of local data analysis. OAs have between 40 and 250 households and a resident population of between 100 and 625 people.

Project voucher	A project is a group of two or more premises (business or residential) that together constitute a supplier's build proposal. Vouchers are claimed against some of the premises proposed up to a pre-agreed overall budget value. Vouchers claimed for a project (project vouchers) will therefore tend to focus on a specific geographical area and a project enables suppliers to aggregate multiple voucher applications and increase the subsidy available (up to a pre-agreed project budget limit).
PSM	Propensity Score Matching – a statistical technique used to estimate the effect of a treatment, policy, or other intervention by accounting for the observable characteristics that can predict treatment.
RGC	Rural Gigabit Connectivity: the second voucher scheme launched in May 2019 and was focused on rural areas.
SME	Small and medium-sized enterprises – business voucher eligibility was restricted to SMEs and referred to in the report as 'small businesses.
Standard voucher	Standalone vouchers where an application was submitted for a single premise.
Superfast broadband (SFBB)	Any technology that can deliver more than 30 megabits-per-second.
SWB	Subjective Wellbeing
Top-up vouchers	Vouchers which have received additional subsidy from a participating local authority which increase the maximum value of voucher support.
Ultrafast broadband (UFBB)	Any technology that can deliver more than 300 Mbps download speed.

1. Purpose of Report

1.1 This report provides the detailed findings and methodology for the second phase of the evaluation of Building Digital UK (BDUK)'s voucher schemes. A separate summary report focused on the key findings can be accessed below. (https://www.gov.uk/government/publications/bduk-vouchers-evaluation-impacts-and-value-for-money-assessment)

About the voucher product

1.2 Building Digital UK (BDUK), part of the Department for Digital, Culture, Media and Sport (DCMS) is responsible for delivering digital infrastructure programmes for the government. Its vision is that everyone in the UK can benefit from a better digital connection, including gigabit capable broadband.

1.3 Vouchers are one of a number of demand side interventions used by BDUK to increase coverage of gigabit capable broadband. Vouchers are available to households and businesses, and enable suppliers to reduce the capital costs of gigabit-capable broadband infrastructure. This enables suppliers to aggregate multiple vouchers in a pre-agreed local area until it is commercially attractive enough for them to deliver the gigabit-capable broadband infrastructure required.

1.4 Vouchers have been used as part of two BDUK programmes[1]:

- In 2018 the Local Full Fibre Networks (LFFN) programme launched a Gigabit-capable broadband Voucher Scheme (GBVS), which prioritised connections for Small to Medium Enterprises (SMEs). This nationally available scheme was closed to new applications in May 2020. This launched in 2017 and closed in 2021. As of December 2021, GBVS vouchers had been used to connect 29,400 premises.
- From May 2019, as part of the Rural Gigabit Connectivity (RGC) programme, BDUK adapted the voucher scheme to support the delivery of full fibre connectivity in rural areas. This voucher scheme was restricted to rural areas of the UK and closed to new applications on 31 March 2021, with some eligible voucher projects transferring to the new UK Gigabit Voucher Scheme. As of December 2021, RGC vouchers had been used to connect 23,100 premises.

1.5 There are two different types of voucher covered by the evaluation:

- Standard vouchers: these are standalone vouchers, only available for business premises during GBVS; applications for a voucher are submitted and approved for single premises on a case by case basis against a pre-approved supplier package.
- Project vouchers: these vouchers are part of a group of vouchers focused on a certain geographical area and delivered as part of a project alongside a number of other premises. A supplier will encourage multiple applications from the premises

[1] The legal environment has developed over the lifetime of the various voucher projects, with the projects being amended to follow the requirements in place at the time. These have been the De Minimis Regulation up until 31 December 2020; Article 3.2(4) of the Trade and Cooperation Agreement between the European Union and the United Kingdom as Minimal Financial Assistance (MFA); and Section 36 of the Subsidy Control Act 2022, again as MFA.

it wishes to build the infrastructure to, aggregating the subsidy up to a maximum pre-agreed budget. Only those agreeing to take a connection and claiming a voucher are considered 'voucher connections' but other properties upgraded by the project infrastructure may also take up a service and benefit from the cost reduction to the overall cost to build.

1.6 Voucher schemes differ to other BDUK programmes in a number of respects which creates challenges for the evaluation. While other interventions such as local area procurements increase broadband availability in large, contiguous areas, vouchers are highly scattered and have been used to connect premises in all parts of the UK, often benefitting individual premises, streets or neighbourhoods. As a result, the impacts of vouchers can only be evaluated at a very local level compared to other interventions.

About the evaluation

1.7 DCMS has appointed Hatch, Belmana and Winning Moves to undertake an evaluation of the Building Digital UK (BDUK) vouchers product, including both of the schemes above (hereafter referred to as the GBVS and RGC schemes).

1.8 The evaluation has a number of different elements:

- An **impact evaluation**. This needs to assess the additional coverage and premises passed[2] due to vouchers compared to areas that have not received support, and the outcomes and impacts generated for businesses and households.
- A **process evaluation** to understand how the impacts were achieved, and to identify any barriers and enablers to achieving objectives.
- A **value for money evaluation** to assess whether the schemes have delivered good value for money based on the costs and benefits compared to the original appraisal.

1.9 The key research strands are as follows:

1) Analysis of BDUK monitoring data, focusing on how vouchers have been used and in which locations.

2) Interviews with suppliers that have used vouchers to gain their perspectives on the impact of the programme and how it has influenced their investment decisions.

3) Counterfactual analysis of the additional impact of vouchers on the availability of different download speeds and take-up of services through changing download speeds.

4) Counterfactual analysis of the impact of vouchers on business and local economic performance.

[2] These are premises which, upon request from end users, an operator can provide broadband services (regardless of whether those premises are already connected to the network or not).

5) A business beneficiary survey to understand the benefits of upgraded connections for businesses, and the changes it has allowed them to implement.

6) A resident beneficiary survey to explore how upgraded connections have affected various aspects of households' quality of life.

About this report

1.10 This is the second of three reports to evaluate the impact and value for money of BDUK's voucher schemes. The main focus of the report is assessing the initial impacts of vouchers that can be measured to date, acknowledging that it is still too early to assess the full impact of the voucher schemes at this stage.

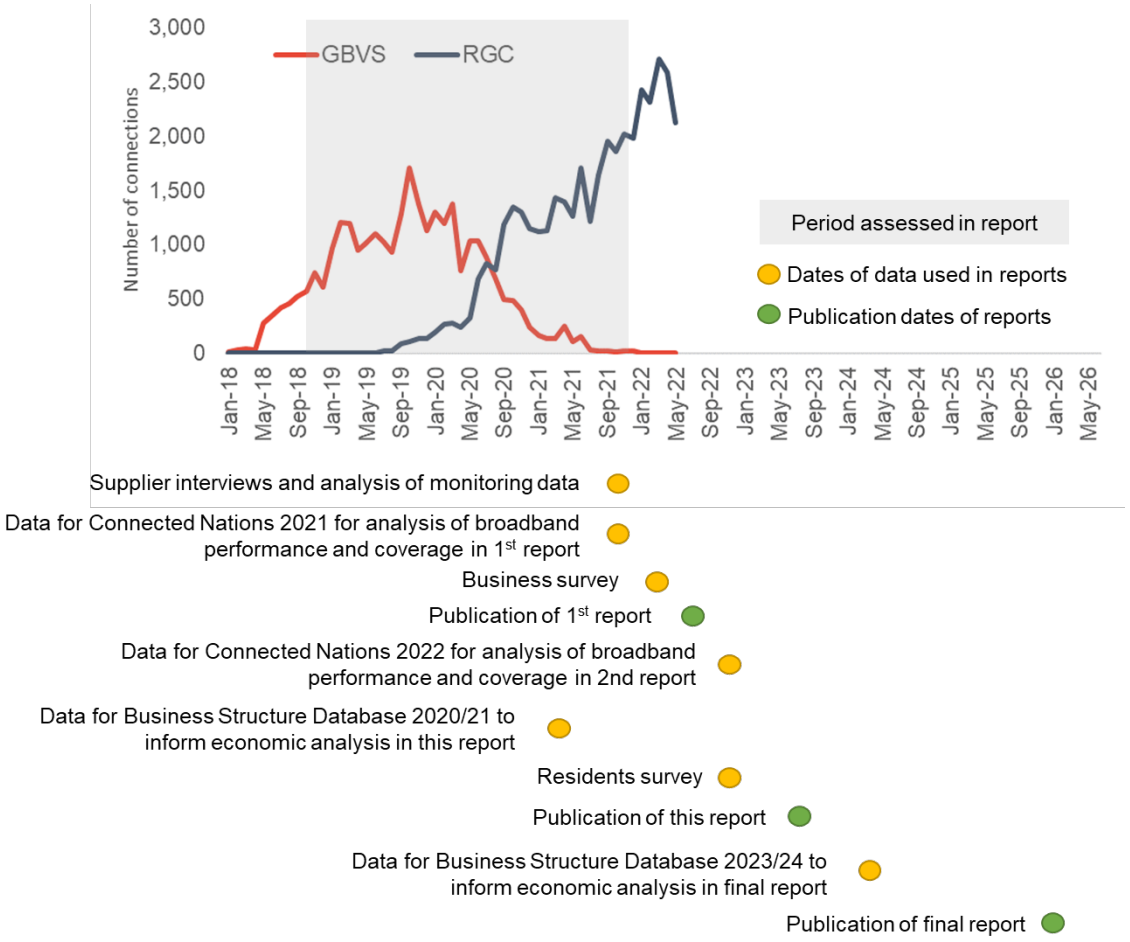
1.11 It includes the following:

- Updated counterfactual analysis of the additional impact of vouchers on availability of broadband technologies and download speeds.
- Counterfactual analysis of the additional impacts of vouchers on firm-level and area-level economic performance in businesses and areas that have received vouchers. This is used to quantify the additional economic impacts of the intervention to date.
- Analysis of the residential beneficiary survey undertaken by Winning Moves in 2022, which provides insights on the characteristics of households that received vouchers, their motivation for applying and the range of uses and benefits that they have derived from the upgraded connection.
- An assessment of the wellbeing benefits for households from receiving a voucher, drawing upon the findings of the residents survey and other studies which have quantified these types of benefits.
- An assessment of the environmental impacts of the voucher programmes due to reduced travel and changes in energy usage.
- An initial cost-benefit analysis which assesses the value for money of the voucher schemes to date.

1.12 This report follows on from the Initial Impacts and Benefits report published in August 2022 which included the initial analysis of impacts of vouchers on availability and download speeds and the findings of the business survey. The third and final evaluation report will update the analysis in this report and provide a full and final assessment of the impacts and value for money of the voucher schemes.

1.13 The chart below shows the dates of voucher connections for the GBVS and RGC schemes up to May 2023. It also shows the key dates for which data is available which can be used to assess the impacts of vouchers. It shows there is a long time-lag in the dataset used to assess economic impacts (the Business Structure Database), which means it will be difficult to assess the full impacts of vouchers until 2025/6 at the earliest.

Figure 1.1 Dates of voucher connections, dates of data



Source Hatch

2. Impacts of Vouchers on Local Area Broadband Performance and Availability

Summary of findings

- The counterfactual analysis of the effects of vouchers on broadband performance and availability in local areas has been hampered by inconsistencies in, and between each year of, Connected Nations data. This makes it difficult to compare change in coverage of UFBB and gigabit-capable broadband in treated and control areas on a consistent basis. Therefore, the main focus of the analysis is on local area broadband performance (average download speeds), which is less affected by these data inconsistencies.

Impacts on download speeds taken up by households and businesses

- Vouchers had a significant additional effect on average download speeds being used by premises. The median effect from models was 3.28 Mbps in 2019, 3.85 Mbps in 2020 and 27.89 Mbps in 2021. The larger effect in 2021 is due to the fact that treated areas received a larger number of vouchers, but also because there was an increase of take-up of faster speeds in all areas (unrelated to vouchers).
- There is a broadly linear relationship between the number of vouchers an area has received and the change in average download speeds in treated areas. There is no evidence to suggest there is an optimum number of vouchers in an area. That is, there is not a point at which the marginal effects of additional vouchers on average download speeds start to diminish.
- Vouchers delivered through the RGC scheme have had a greater effect on average download speeds than GBVS. The additional effect of vouchers was 10.8 Mbps for RGC areas for vouchers connected in 2020, compared to 0.12 Mbps for GBVS areas. For vouchers connected in 2021, the additional effect was 33.73 Mbps for RGC areas compared to 7.55 Mbps for GBVS areas. Most of this can be explained by the greater intensity of support in RGC areas (number of vouchers per OA). However, when we control for this and the number of premises in these areas, we find that each RGC voucher had a greater effect on average download speeds than GBVS areas.
- Areas that received project vouchers experienced a greater additional change in download speeds than those that received standard vouchers in each of the treatment years. This reflects the way that project vouchers were designed to work by providing connectivity to a number of premises in an area, including those that did not receive a voucher. When we control for the intensity of support and the number of premises in these areas, we find that, on average, project vouchers had a greater effect than standard vouchers on download speeds in 2020 and 2021, but a lower effect in 2019. The different results for 2019 could be explained by the fact that most project vouchers in this year were delivered through the GBVS scheme.
- Areas in close proximity to treated areas experienced similar improvements in speed, which may indicate vouchers had spill-over effects into neighbouring areas. However it could also reflect the fact that suppliers used vouchers in areas where

they were already expanding their network. To date, the analysis has not been able to identify which factor is driving this but this will be investigated further in the final evaluation.

Impacts on availability of broadband at different speed levels

- The following findings relating to vouchers' impacts on the availability of broadband are subject to the caveats outlined above. The results are skewed by inconsistencies in the Connected Nations data which means they may not offer an accurate reflection of the effects of vouchers.
- Vouchers had a significant positive effect on availability of UFBB, but only in 2020 (median effect of 2.1 percentage points). We do not find evidence of significant positive additional effects in other treatment years.
- Similarly, the only treatment year in which we identify a significant positive effect on availability of gigabit-capable broadband is 2020 (median additional effect of 4.5 percentage points). In the other years we find either no significant effect or a negative effect.
- We have not been able to draw clear conclusions about the effects of the two voucher schemes on availability of UFBB or gigabit-capable broadband. For vouchers connected in 2020, areas that received vouchers through GBVS experienced a larger increase in availability than RGC areas. For vouchers connected in 2021, the change in availability was higher in control areas than both RGC and GBVS areas, resulting in a negative effect for both schemes in all models.
- The results by voucher type were also mixed and inconclusive. Areas that received project vouchers experienced a larger increase in availability than standard voucher areas in 2019, but the reverse was true in 2020. In 2021, the change in availability was higher in control areas than both project voucher and standard voucher areas.

Purpose of chapter

2.1 The Initial Impacts and Benefits report (August 2022) measured the effect of vouchers on the performance and availability of broadband in local areas. It did this through counterfactual analysis. That is, it compared change in areas which have been supported by vouchers (treatment areas) with the change in similar areas that had not received support (control areas). By measuring the difference between treatment and control areas it allowed us to estimate the *additional* impact on coverage and performance that could be attributed to vouchers. That is, the change that would not have occurred without intervention. The geographical unit of measurement in the August 2022 report was lower super output areas (LSOAs) which have an average population of around 1,600 people.

2.2 The purpose of this section is to update the analysis with an additional year of data (to measure the effects of vouchers that were used to connect premises in 2021 in addition to earlier years) but also to repeat the analysis from the earlier report using output areas (OAs) as the geographical unit. OAs are much smaller than LSOAs, with a population of between 100 and 625 people. This allows the evaluation to undertake a more fine-grained assessment of the additionality of vouchers on performance and availability in

local areas which better reflects the highly targeted nature of voucher schemes (particularly the later RGC scheme where only specific areas were eligible).

2.3 The modelling has assessed the impact of vouchers on:

- **Performance**, as measured by the average download speeds which households and businesses receive through their broadband service. This uses the Connected Nations performance dataset which provides average download speeds at OA level.
- **Availability** (or coverage) of broadband at different speed levels (gigabit, ultrafast and super-fast broadband). This uses the Connected Nations coverage dataset, which provides OA level data on the proportion of premises that can access broadband at different speed levels, irrespective of whether they choose to do so.

Methodology and data limitations

2.4 Other than the change in units of geography, the methodology is still largely the same as the August 2022 report. This is described in full in the technical annex, but is summarised below:

- An OA is assumed to be 'treated' if it has at least one premise connected via a voucher.
- A technique called Propensity Score Matching (PSM) is used to identify control areas. The aim of PSM is to identify untreated areas that had a similar probability of receiving vouchers based on a range of characteristics. The most important characteristics for determining whether an area receives vouchers were identified through statistical modelling. These included rurality, the median estimated cost to connect premises[3], income and employment in digital sectors.
- We developed nine different models for comparing treatment and control areas. These differed in terms of:
  - whether broadband performance in the year before treatment was included as a variable in the model. Three different approaches were used; the first did not include pre-treatment broadband performance at all, the second included broadband performance levels (but not change) and the final approach included change in broadband performance.
  - the sample of OAs from which control areas were drawn for matching. Again, we used three pools of OAs. One used all untreated OAs in England and Wales[4], the second included all OAs but excluded those with

[3] Based on BDUK's FScore model which estimates the cost of connecting premises to the fibre network. The selection modelling showed that areas that received a voucher in 2021 had a higher average FScore than areas that received vouchers in earlier years, reflecting the fact that vouchers were increasingly targeted on non-commercial areas.

[4] The model does not include data for Scotland and Northern Ireland. This is due to these countries using different socio-economic datasets for small areas, which would have meant that the evaluation needs to construct separate models for these countries. We have a high level of confidence that the findings of this report also apply to Scotland and Northern Ireland, however

very high levels of employment[5], and the third was limited to OAs in the same exchange area as treated OAs[6]. We considered one additional pool based on cancelled vouchers but this was ruled out since a large number of cancelled vouchers are linked to projects which went ahead and therefore have a high probability of receiving access to gigabit-capable broadband anyway.

- By combining these different modelling approaches and sample pools, we developed nine different models for comparing treatment and control areas. All of the models were tested and found to be robust.

- Change in average download speeds and availability in treated and control areas was assessed using the Connected Nations dataset, which provides data down to postcode level. This allows us to quantify the difference in change between treated and control areas.
- If the difference in treated and control areas is statistically significant, we can be confident that the additional change in coverage or speed can be attributed to vouchers. If a number of models find there are significant differences, this increases our confidence that vouchers have led to additional effects.
- The report presents the range of estimates and the median result from the nine models. All of the models have been tested and found to be robust[7], so the reporting of the median result does not mean that this model is considered to be the most robust. This represents our central estimate but the value could lie anywhere within the range presented.

2.5 The Maryland Scientific Measurement Scale (SMS) can be used to assess the relative robustness of different methods of evaluation based on the extent to which the control group is robust and has dealt with issues of selection bias. The method used for this study, which combines PSM with difference-in-difference techniques should attain a score of 3. This is the minimum standard considered to be robust by the What Works Centre for Local Economic Growth.

the final evaluation report will include analysis of any differences in the context in which vouchers have been used in these countries or differences in economic performance that would need to be taken in to account.

[5] It was necessary to restrict the sample in this way because high employment levels was such a common characteristic of treated OAs that it was difficult to identify comparable untreated OAs. Where this sample was used we therefore excluded any treated OAs that had high employment levels from the modelling.

[6] The rationale for this pool was based on the hypothesis that exchange areas where at least one OA had been treated would have similar infrastructure to untreated OAs served by the same exchange.

[7] By this we mean that the effect of vouchers on broadband outcomes is not very sensitive to the exact specifications used. The results are consistent to different covariates and samples. The models do not show conflicting results, they change in a predictable and theoretically consistent manner. The adjusted R squared range of 0.18 to 0.33 is adequate and consistent with the values found in the literature on similar estimations in applied economics.

Inconsistencies in Connected Nations data

2.6 Connected Nations data (published by Ofcom) has been used to analyse changes in availability and performance of local area broadband over time. This is the most comprehensive dataset available for broadband infrastructure and performance in local areas, and the only one which is freely available. However it does have certain limitations which are explained here.

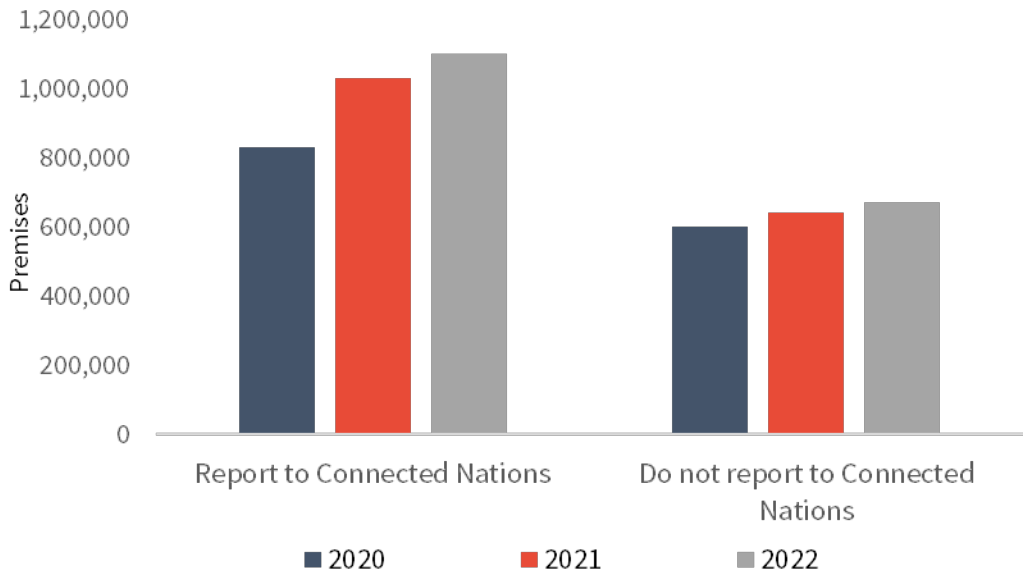
2.7 Connected Nations collects information from the following sources:

- **Availability**: data on coverage of fixed broadband services is collected from a list of fixed network suppliers (61 in 2022 but fewer in earlier years). Each operator provides information on the technology available for individual addresses, together with predictions of download and upload speeds. This is combined with Ordnance Survey AddressBase data to estimate the proportion of premises that can access broadband at different speed levels if they choose to do so (SFBB, UFBB, gigabit).
- **Performance**: data is collected from the same list of suppliers (and the retail providers that they provide services to) on the maximum measured speed on each active line. This is therefore based on the speeds that households or businesses actually access.

2.8 According to BDUK's monitoring data, 374 different suppliers have used vouchers but only 33 of these appear on Connected Nations' list of suppliers in 2022. This is because Ofcom only collects data from suppliers large enough to engage with a regulatory process without it becoming disproportionately burdensome. The list of suppliers does include all of the largest users of vouchers; 64% of the connected vouchers in BDUK's database were issued to suppliers who report to Connected Nations. Nevertheless, this still leaves over a third of vouchers where we would not expect to see any resulting change in availability or performance reflected in Connected Nations data.

2.9 This means Connected Nations understates both the number of premises which can access different speed thresholds and average download speeds in areas where the supplier does not provide data. This can be observed by comparing the change in availability of UFBB in output areas where the voucher subsidy went to a supplier who reports to Connected Nations with those where the supplier does not (see Figure 2.1).

Figure 2.1 Number of premises with access to UFBB in output areas that have been supported by BDUK vouchers



Source Belmana using BDUK and Connected Nations

2.10 It is important to note that this issue will affect control areas as well as treated areas, and there is no way of assessing which is more affected. We do not have complete information on the areas served by suppliers who do not report to Connected Nations; only the areas where vouchers have been used. It is therefore possible that control areas include many premises that can access UFBB or gigabit-capable broadband which is not captured by Connected Nations.

2.11 This means the treatment group in the counterfactual modelling cannot be restricted to only OAs that received a voucher via a supplier who reports to Connected Nations (for instance by focusing only on areas where Openreach have used vouchers). This would risk overstating the additional effects of vouchers as we have no way of applying a similar restriction to control areas. The modelling therefore includes all vouchers regardless of whether the supplier reports to Connected Nations, but this comes with the caveat that this underreports gross change in local area broadband performance and availability, and may under or over-report net-additional effects.

2.12 Other limitations of Connected Nations relate to the consistency of the data over time. Although Ofcom aims to ensure that each report and dataset is as accurate as possible at a point in time, the nature of the way in which data is collected makes it very difficult to ensure consistency over time. This is in part due to the fact that the suppliers who report to Connected Nations changes each year. For example, the list of suppliers who provided data to Connected Nations 2022 includes 14 suppliers who did not provide data to Connected Nations 2021 and omits four suppliers who did. There may also be errors or missing data in the detailed local data provided by these suppliers at different points in time which are difficult for Ofcom to detect. In other cases, there may have been a delay reporting when an area received coverage. These data issues may not be important if undertaking longitudinal analysis for large areas with thousands of properties. However

they become a much greater issue when carrying out longitudinal analysis for small areas such as OAs.

2.13 There is evidence that inconsistencies are present in the Connected Nations data for a large number of the output areas where vouchers have been used. Table 2.1 shows the percentage of OAs supported with a voucher in 2020 and 2021 that experienced a change in the number of premises that can access UFBB and gigabit-capable broadband in the year after support, and whether this increased or decreased. It also shows the proportion experiencing a change in average download speeds.

2.14 The results show that a substantial proportion of treated OAs experienced either no change or a decrease in the number of premises that can access UFBB and gigabit-capable broadband, according to Connected Nations. For vouchers connected in 2020 less than half (47%) of treated OAs show an increase in the number of premises able to access UFBB. This applies to OAs where the supplier reports to Connected Nations as well as those where they do not. In some cases, the proportion of treated OAs showing an increase in coverage is actually lower for those were the supplier reports to Connected Nations (see gigabit coverage for vouchers connected in 2021).

2.15 Given the fixed nature of broadband services, it is unlikely that local areas would experience a decrease in the number of premises that can access UFBB or gigabit-capable broadband. This suggests that inconsistencies in different versions of Connected Nations are the most likely explanation. There is some evidence that this disproportionately affects areas supported by vouchers. For example, only 9% of all output areas in Great Britain experienced a fall in the number of premises that can access UFBB between 2020 and 2021 according to Connected Nations, compared to 16% of treated OAs. The equivalent figures for 2021-22 are 5% and 9%.

2.16 This offers further evidence that Connected Nations only captures a proportion of the effects of vouchers, and that the data on coverage of UFBB and gigabit-capable broadband is subject to inconsistencies which are likely to distort the results of the modelling.

2.17 In contrast, the proportion of treated OAs that experienced a decrease or no change in average download speeds is much lower. Over 95% of areas experienced an increase in the year after support in both 2020 and 2021. In both years this was broadly consistent with the national average.

2.18 The data on average download speeds is also likely to be subject to a degree of reporting error and inconsistencies between different versions of Connected Nations, but since this is based on the average of measured speed tests for all properties in an OA, this is less prone to large fluctuations than the estimate of the number of premises able to access minimum speeds. This means it is a more stable indicator, and the modelling results are less likely to be distorted by areas experiencing a fall in average download speeds.

2.19 For these reasons, we have greater confidence in the reliability and consistency of data on download speeds than coverage, and believe this should be the primary focus when measuring the additional effects of vouchers. The chapter still presents analysis of the effects of vouchers on availability of broadband at different speed levels, but this is subject to the caveats above.

Table 2.1 Percentage of output areas that experienced a change in local area availability or performance in the year after support

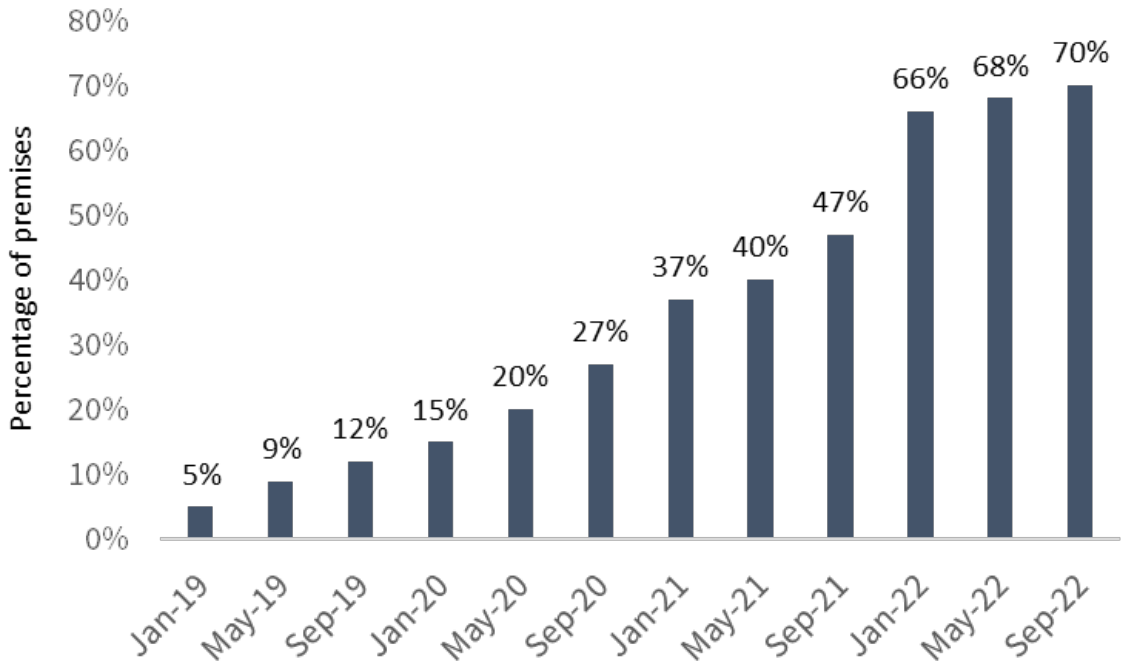
		Vouchers connected in 2020			Vouchers connected in 2021		
Indicator	Change in Connected Nations	Areas where supplier does not report to CN	Areas were supplier reports to CN	Total (all areas)	Areas where supplier does not report to CN	Areas were supplier reports to CN	Total (all areas)
Number of premises with access to UFBB	Decrease	21%	20%	20%	6%	13%	11%
	No change	37%	29%	32%	41%	31%	33%
	Increase	43%	51%	48%	54%	57%	56%
Number of premises with access to gigabit-capable broadband	Decrease	10%	12%	11%	3%	12%	10%
	No change	43%	30%	35%	32%	30%	30%
	Increase	47%	58%	54%	65%	58%	60%
Average download speed	Decrease	4%	5%	5%	5%	2%	3%
	No change	0%	0%	0%	0%	0%	0%
	Increase	96%	95%	95%	95%	98%	97%

Source: Hatch analysis of Connected Nations

Virgin Media network upgrades

2.20 Between September 2020 and January 2022, Virgin Media made a technological upgrade which meant all premises on its network (15.5 million premises) were able to access gigabit-capable broadband. This made a substantial contribution to the large increase in the proportion of premises that can access gigabit-capable broadband over this period, from 25% in September 2020 to 65% in January 2022.

Figure 2.2 Percentage of premises in England that can access gigabit capable broadband



Source Connected Nations

Note: Connected Nations does not publish data on the proportion of premises with access to gigabit capable broadband prior to 2019

2.21 At a local level, this network-wide upgrade (unrelated to vouchers or any expansion in Virgin Media's network) resulted in a substantial increase in the proportion of homes that were able to access gigabit-capable broadband, in some cases increasing from zero to 100%. This large increase in coverage makes it difficult for the modelling to detect additional effects of vouchers in any output areas where Virgin Media has a presence. Furthermore, if areas supported by vouchers were more or less likely to include premises supplied by Virgin Media, that would bias the results of the modelling and under or over-estimate the effects of vouchers.

2.22 To control for this, the evaluation has used the SamKnows database to identify all Virgin Media supplied exchanges. We have then identified all of the output areas served by these exchanges and removed these from the models (for both treated and control areas). This has only been done for the analysis of changes in the availability of gigabit capable broadband. The network upgrades do not affect any of the other outcome variables including availability of UFBB and average download speeds.

Numbers of vouchers in treated areas

2.23 Table 2.2 shows the number of OAs which received a voucher for the first time in 2019, 2020 and 2021 and the number of vouchers each area received. It shows there was considerable variation in the level of voucher support in treated OAs, and that this has changed over time. In 2019 and 2020 around 70% of output areas received only one voucher while only 5% received more than ten. In 2021 only a third of treated OAs received one voucher, and 20% received more than ten. On average there were 2.8 vouchers per treated OA in 2019 and 2020 and 7.5 in 2021, meaning the number of vouchers per OA was nearly three times higher (2.7) in 2021. This is due to most vouchers in 2021 being delivered through projects which enabled suppliers to aggregate multiple points of demand in a specific area and therefore connect a larger number of premises, including premises which did not receive a voucher.

2.24 This means the level of subsidy provided to broadband suppliers was much higher in some treated OAs than others, and we might therefore expect impacts on local area broadband performance and availability to be greater in those areas that received a higher level of support.

2.25 The treatment/control group approach described above is unable to measure the effect of increasing the level of voucher support because it uses a binary treatment variable; OAs are either treated (if they have received at least one voucher) or untreated (if they have received zero vouchers). We have therefore supplemented the counterfactual modelling with analysis of gross change in broadband speeds and coverage of different technologies, comparing the change in outcomes for areas that have received different levels of support.

Table 2.2 Number of treated OAs by number of vouchers

Number of vouchers in OA	2019	2020	2021
1	69%	72%	33%
2-5	22%	18%	31%
6-10	4%	4%	16%
11-15	2%	2%	6%
16-20	1%	1%	5%
Over 20	2%	2%	9%
Total vouchers	8,654	9,698	10,129
Total treated OAs	3,143	3,435	1,356
Average vouchers per OA	2.8	2.8	7.5

Source: Hatch analysis of BDUK vouchers data

Effects of vouchers on local area broadband performance

Headline results

2.26 Table 2.3 shows the gross change in average download speed in areas treated with vouchers in the year after support, and how much of this is due to the additional effects of

vouchers. That is, the change which is over and above the change experienced in control areas.

2.27 All nine models found that the change in average download speeds was significantly higher in treated areas than control areas in each year of support (based on a 1% significance level). However the additional speed change was greatest (by a large margin) for areas treated in 2021; the median additional effect from the nine models was +27.9 Mbps for areas supported in 2021, compared to +3.28 Mbps in 2019 and +3.85 Mbps in 2020. The 'additional change range' column shows effects were significantly higher for areas supported in 2021 than the other years in all nine models (ranging from +25.8 Mbps to +30.97 Mbps).

2.28 This suggests the additional effects of vouchers on broadband speeds were between seven and eight times higher for areas supported in 2021 than those supported in earlier years. This is much higher than the difference in the number of vouchers per OA (2.7). At first glance, this suggests that the higher intensity of support in 2021 has led to a disproportionately large improvement in local area broadband performance.

2.29 It should be noted, however, that the proportion of the gross speed change which is due to vouchers (shown in the 'median additionality estimate' column) was only between 2.6 and 2.7 times higher in areas supported in 2021 than areas supported in 2019/2020. This is due to the fact that control areas also experienced a much larger increase in average download speeds between 2021 and 2022 than in earlier years (reflecting higher take-up of faster speeds by businesses and households). Therefore the results suggest that, once we control for growing demand for higher average download speeds, the additional effects of vouchers are broadly in line with the intensity of support that has been provided in different years.

2.30 It is also worth noting that these results are much higher than if the analysis is undertaken for LSOAs (which was the approach in the 2022 report). These also show statistically significant additional effects, but the additional change is lower than 1.5 Mbps in all models and treatment years. This shows that, by focusing the analysis on smaller areas it is able to more accurately pick up the effect of voucher use, while the larger number of premises in LSOAs means the effects of vouchers are more diluted and therefore more difficult to detect.

Table 2.3 Additional change in output area average download speeds in year after support (Mbps)

Treatment year	Gross change in treated areas	Models significant	Median additional change	Additional change range	Median additionality estimate
2019	14.78	9 of 9	3.28***	1.94 to 4.57	22.2%
2020	18.06	9 of 9	3.85***	3.04 to 4.35	21.3%
2021	48.24	9 of 9	27.89***	25.88 to 30.97	57.8%

Source: Belmana

Note: Results for the three models considering three different samples. Significance levels are 1% (***), 5% (**) and 10% (*).

2.31 We have also conducted analysis of the change in average download speeds over two years from the point of support. This is only possible for vouchers connected in 2019 and 2020 because output area level data on broadband performance is not yet available for 2023.

2.32 Table 2.4 shows that all nine models find that areas with vouchers continue to maintain a statistically significant effect on average download speeds, and this applies in both years of support (2019 and 2020). The scale of the additional effect also increases in terms of Mbps, although again this is also due to take-up of faster speeds by households and businesses over time.

Table 2.4 Additional change in average download speeds two years after support (Mbps)

Treatment year	Gross change in treated areas	Models significant	Median additional change	Additional change range	Median additionality estimate
2019	31.21	9 of 9	4.04***	3.07 to 6.85	12.9%
2020	44.31	9 of 9	7.41***	6.32 to 9.36	16.7%

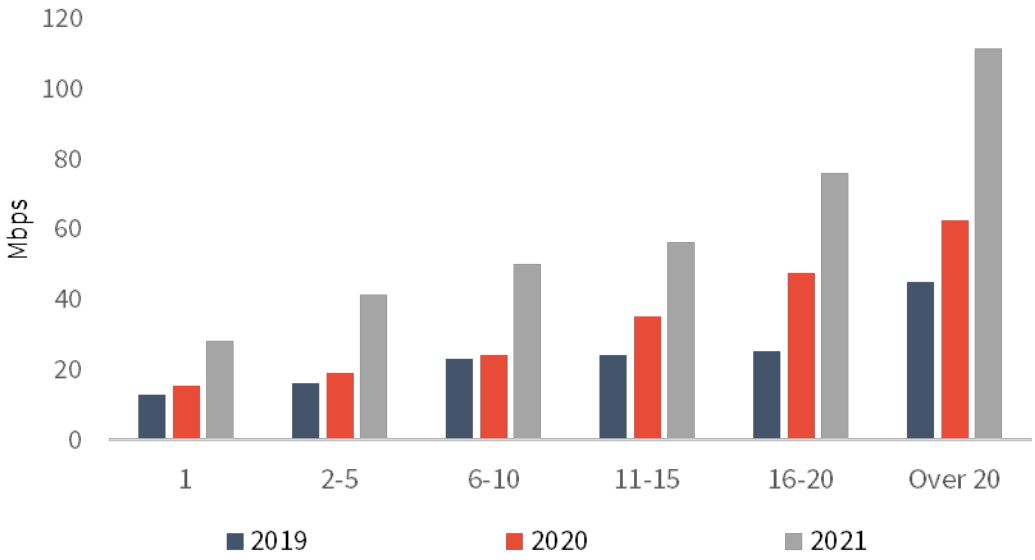
Source: Belmana

Note: Results for the three models considering three different samples. Significance levels are 1% (***), 5% (**) and 10% (*).

Numbers of vouchers and effects on average download speeds in local areas

2.33 Figure 2.3 shows there is a clear relationship between the number of vouchers that an area has received and the gross change in average download speeds in local areas in the year after support. This is true for each year of support. It also shows that areas that received a similar number of vouchers in 2019 experienced a lower increase in average download speeds than areas supported in 2020 and a much lower increase than areas supported in 2021. Again, this provides further evidence of the growing take-up of faster broadband speeds over time.

Figure 2.3 Gross change in output area average download speeds in year after support by number of vouchers



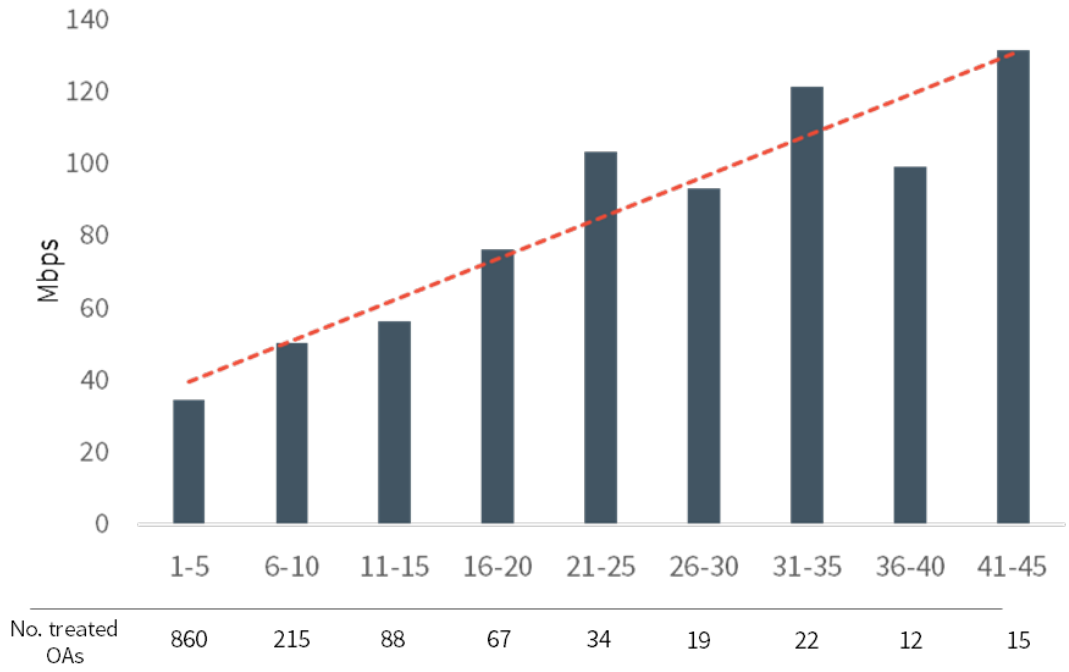
Source Hatch analysis of Connected Nations

2.34 Figure 2.4 shows the gross change in average download speeds for areas treated in 2021 but this time using consistent intervals for the number of vouchers used in areas[8]. It shows there is a broadly linear relationship between the intensity of support and gross change in average download speeds (although we would caveat that this analysis is based on small sample sizes in some cases).

2.35 This means there is no evidence to suggest there is an optimum number of vouchers in an area (a point at which the marginal effects of additional vouchers start to diminish). This may occur above 45 vouchers per OA, but the sample sizes become too small for us to be able to assess this.

[8] This analysis does not include output areas that have received more than 45 vouchers in 2021 as the sample sizes become too low (fewer than ten OAs).

Figure 2.4 Gross change in average download speed for output areas supported in 2021 by number of vouchers (2021-22)



Source Hatch analysis of Connected Nations

* data on average download speeds was weighted by the number of premises to control for the large range of sizes in OAs

Differences by scheme and voucher type

Scheme

2.36 Table 2.5 shows the additional effects of vouchers on average download speeds, but distinguishes between areas that received vouchers through the RGC and GBVS schemes. This table focuses specifically on vouchers connected in 2020[9] and measures the change in speeds over one year (2020 to 2021).

2.37 This shows that vouchers had a far greater additional effect on average download speeds in RGC areas. All of the models tested found that the change in average download speeds was higher in areas that received vouchers through the RGC scheme than control areas, ranging from 9.75 to 11.87 Mbps. In each case the difference was statistically significant at the 1% level meaning we have a high level of confidence that vouchers have had an additional effect.

2.38 In contrast, the change in average download speeds in areas that received vouchers through the GBVS scheme was not significantly different than control areas in all but one

[9] We have not done the analysis for 2019 as the RGC scheme launched towards the end of that year and the number of areas supported through the RGC scheme was very low.

of the models (ranging from -1.15 to 1.3 Mbps). This means the change in average download speeds is likely to have occurred in the absence of the GBVS voucher scheme.

Table 2.5 Impact of vouchers connected in 2020 on change in output area average download speed by scheme (2020 to 21)

Scheme	Mean effect (Mbps)	Range of effect (Mbps)	Models significant
RGC	10.80***	9.75 to 11.87	6 of 6
GBVS	0.12	-1.15 to 1.3	1 of 6

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*).

2.39 Table 2.6 repeats the analysis for vouchers connected in 2021. Again, RGC areas experienced a much greater additional effect on average download speeds than GBVS areas. This increase in speeds was between 30.21 and 36.81 Mbps higher than control areas in areas supported through the RGC scheme, and between 4.53 and 10.55 Mbps higher in GBVS areas. In this treatment year, all models found that vouchers had a statistically significant positive effect on average download speeds.

Table 2.6 Impact of vouchers connected in 2021 on change in output area average download speed by scheme (2021 to 22)

Scheme	Mean effect (Mbps)	Range of effect (Mbps)	Models significant
RGC	33.73***	30.21 to 36.81	6 of 6
GBVS	7.55***	4.53 to 10.55	6 of 6

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*).

2.40 The greater magnitude of effects in RGC areas could be explained by the fact these areas have received a higher level of support. This can be assessed by comparing the net additional speed change per voucher per 100 premises in RGC and GBVS areas. It is necessary to weight by the number of premises as an increase in average download speeds is of greater value if a larger number of premises have benefitted.

2.41 Table 2.7 shows how this has been calculated for the two schemes in areas where vouchers were connected in 2020 and 2021. It shows that the net additional change per voucher per 100 premises in 2020 was 0.13 Mbps for GBVS areas and 1.99 Mbps in RGC areas. This means that, on average, each RGC voucher led to a larger increase in download speeds than GBVS areas once we control for the number of premises in treated areas. This is also true for vouchers connected in 2021; each RGC voucher led to a net-additional increase of 5.4 Mbps per 100 premises compared to 3.6 Mbps per 100 premises in GBVS areas.

Table 2.7 Net additional change per voucher per 100 premises for RGC and GBVS scheme

Treatment year	Indicator	RGC areas	GBVS areas
2020	Net additional change (Mbps) - a	10.80	0.12

	Number of premises in treated areas	35,879	656,315
	Number of vouchers	1,946	5,861
	Premises per voucher - b	18.4	112.0
	Net additional change per voucher per 100 premises (Mbps) – (a x b)/100	**1.99**	**0.13**
2021	Net additional change (Mbps) - a	33.73	7.55
	Number of premises in treated areas	120,762	51,515
	Number of vouchers	8,219	1,085
	Premises per voucher - b	14.7	47.5
	Net additional change per voucher per 100 premises (Mbps) – (a x b)/100	**5.41**	**3.61**

Source: Hatch analysis

Voucher type

2.42 Analysis of impacts by voucher type shows that areas receiving project vouchers experienced a much larger additional increase in average download speeds than areas that received standard vouchers in each of the treatment years. In one of the treatment years (2020), all of the models found that the change in average download speeds was actually lower in areas that received standard vouchers than in control areas, and in 2021 only one of the models found a statistically significant difference. There is therefore good evidence that project vouchers have been more effective at increasing speeds than standard vouchers. This is likely to reflect the way in which project vouchers were intended to work, by aggregating demand from businesses and households in an area and providing access to a larger number of premises than just the voucher recipients.

Table 2.8 Impact of vouchers on change in output area average download speed by voucher type

Treatment year	Scheme	Mean effect (Mbps)	Range of effect (Mbps)	Models significant
2019	Project	6.41***	4.92 to 8.37	6 of 6
	Standard	2.38***	1.46 to 3.04	6 of 6
2020	Project	8.56***	7.63 to 9.61	6 of 6
	Standard	-1.38	-2.78 to -0.11	3 of 6
2021	Project	29.58***	26.57 to 31.93	6 of 6
	Standard	3.00	0.28 to 6.09	1 of 6

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*).

2.43 Table 2.9 calculates the additional change per voucher per 100 premises for project and standard vouchers. This shows that, on average, standard vouchers delivered a greater speed change per 100 premises than project vouchers in 2019 (3.3 vs 1.1 Mbps). However, the reverse was true for vouchers connected in 2020 and 2021; each project voucher delivered an average speed change of 2.1 Mbps for every 100 premises in 2020 and 5.6 Mbps for every 100 premises in 2021. In both cases this was significantly higher than standard vouchers.

2.44 It should be noted that project vouchers connected in 2019 were delivered mostly through the GBVS scheme, which had fewer restrictions on eligibility and were therefore used in more commercial areas. This could explain why we get different results for vouchers connected in 2019 compared to later years.

Table 2.9 Comparison of net-additional change and intensity of support in areas receiving project and standard vouchers

Treatment year	Indicator	Areas receiving project vouchers	Areas receiving standard vouchers
2019	Net additional change (Mbps) - a	6.4	2.4
	Number of premises in treated areas	65,126	491,908
	Number of vouchers	3,936	3,496
	Premises per voucher - b	16.5	140.7
	Net additional speed change per voucher per 100 premises (a x b)/100	**1.06**	**3.37**
2020	Net additional change (Mbps) – a	8.6	-1.4
	Number of premises in treated areas	132,115	542,485
	Number of vouchers	5,321	2,486
	Premises per voucher – b	24.8	218.2
	Net additional speed change per voucher per 100 premises (a x b)/100	**2.13**	**-3.05**
2021	Net additional change (Mbps) - a	29.6	3.0
	Number of premises in treated areas	157,782	38,877
	Number of vouchers	8,262	1,042
	Premises per voucher - b	19.1	37.3
	Net additional speed change per voucher per 100 premises (a x b)/100	**5.65**	**1.12**

Source: Hatch analysis

Spatial effects

2.45 As well as benefiting the OA in which they are issued, vouchers may also have positive spill-over effects on average download speeds in neighbouring areas. This is because:

- project areas may be split across multiple output areas, with the premises connected via a voucher being located in a different OA to those which did not receive a voucher
- vouchers enable broadband suppliers to extend the fibre network, which in turn reduces the cost of connecting nearby areas.

2.46 This was investigated by comparing average download speeds in treated areas with untreated OAs which are in close proximity. The analysis is shown in Table 2.10. For areas receiving vouchers in 2019, all areas within 5km of treated OAs experienced a statistically significant increase in average download speeds relative to control areas, although this tended to be lower for areas that were further away. For areas connected in

2020, the analysis found limited evidence of average download speeds increasing at a faster rate than control areas within 600m of treated OAs, but much stronger evidence of additional effects for areas between 800m and 5km.

2.47 This offers some possible evidence of spill-over effects for areas in close proximity to those which received vouchers. However, it is also possible that this was not an effect of vouchers, but a reflection of the fact that some suppliers used vouchers in areas where they were already expanding their network, in which case we would expect to see increases in speed in nearby OAs (i.e. where they have built out from). Vouchers may have allowed them to go further than they otherwise would, but the increase in average download speeds would have occurred anyway and therefore could not be attributed to vouchers.

2.48 It is very difficult to assess which of these factors explains the results of the spatial analysis with the data available. Further research would be needed to investigate whether this was due to spillover effects or the results of the expansion of networks which would have happened anyway. This will be investigated in the follow-up evaluation.

Table 2.10 Change in average download speeds of varying distance from treated OAs

	2019			2020		
Distance	Treated	Control	Difference	Treated	Control	Difference
0-200m	14.78	10.58	4.20***	19.49	18.87	0.62
Less than 400m	15.37	10.8	4.56***	19.74	17.28	2.46*
Less than 600m	14.75	11.41	3.34***	21.28	19.81	1.48
Less than 800m	14.78	11.83	2.95***	21.17	18.08	3.09**
Within I km	15.45	11.97	3.48***	18.05	13.56	4.50***
Within 2km	14.78	12.36	2.42***	18.1	13.6	4.50***
Within 3km	14.7	11.95	2.76***	18.1	13.67	4.43***
Within 4km	15.33	12.05	3.28***	18.1	14.16	3.94***
Within 5km	14.58	12.64	1.93***	18.06	14.37	3.69***

Source: Belmana. Note: Results are shown for Model I only. Significance levels are 1% (***), 5% (**) and 10% (*)

Effects of vouchers on availability

2.49 The analysis of availability measures the effects of vouchers on the proportion of premises able to access superfast broadband (SFBB; min speed of 30 Mbps), ultrafast broadband (UFBB; min speed of 100 Mbps) and gigabit capable broadband (1 Gb or 1,000 Mbps).

Superfast Broadband

2.50 OAs that received vouchers experienced a significantly larger increase in the number of premises that can access SFBB than control areas, indicating that vouchers have had an additional effect. This ranged from a median of 4.1 premises where the voucher was connected in 2021 to 7.6 premises in areas with vouchers connected in 2019. This

demonstrates that vouchers have improved connectivity for premises with the slowest speeds.

2.51 These results are skewed by inconsistencies in Connected Nations data which shows around a third of treated OAs experienced either a fall or no change in the number of premises that can access SFBB. Therefore the gross change is likely to be significantly higher than this analysis implies.

Table 2.11 Additional change in number of premises that can access SFBB in treated output areas after one year

Treatment year	Gross Change	Models significant	Median Additional Change	Additional Change Range
2019	86	9 of 9	7.73***	4.59 to 10.09
2020	72	8 of 9	5.51***	4.49 to 7.05
2021	73	9 of 9	4.17***	2.26 to 6.20

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*).

Ultrafast Broadband

2.52 Table 2.12 shows the gross change in availability of UFBB in treated areas and how much of this is due to the additional effects of vouchers. The table shows mixed results. The only year in which we identify a statistically significant positive effect from vouchers (a larger increase than in control areas) is in 2020. All nine models show an additional effect, ranging from 0.9 to 2.4 percentage points and a median effect of 2.1 percentage points.

2.53 For 2019, only one model finds a statistically significant effect and, in 2021, six models find a significant effect. In both cases, the models show a negative effect meaning the increase in availability of UFBB was lower in treated areas than control areas. This therefore provides very inconclusive evidence about the additional effects of vouchers on availability of UFBB.

Table 2.12 Additional change in availability of UFBB in treated OAs after one year

Treatment year	Gross change (percentage points)	Models significant	Median additional change	Additional change range
2019	5.11	1 of 9	-0.30	-1.62 to 0.55
2020	6.95	9 of 9	2.12***	0.87 to 2.42
2021	7.11	6 of 9	-1.39*	-2.74 to 0.13

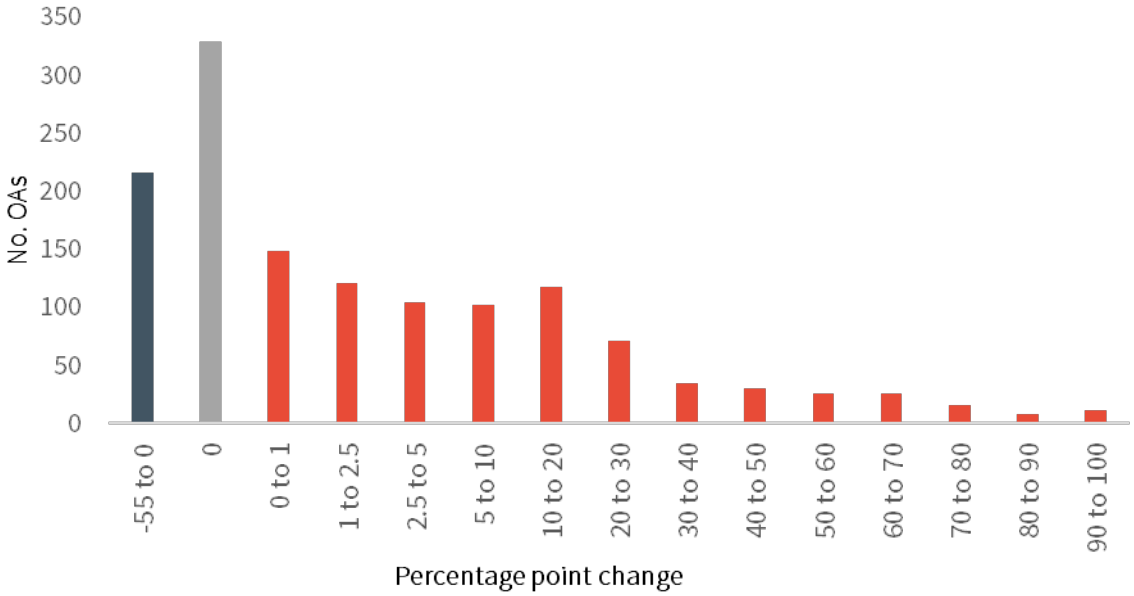
Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*).

2.54 As noted above, we do not believe that these results are an accurate reflection of the effects of vouchers. This is due to inconsistencies in Connected Nations data which result in an underestimate of gross change in treated areas (see paragraphs 2.12 to 2.19).

2.55 To illustrate this, Table 2.12 shows the gross change in availability of UFBB for areas supported in 2021 was 7.1 percentage points. Figure 2.5 below shows that this average gross change figure is skewed by the large number of treated OAs where Connected Nations shows either no change or a fall in the proportion of premises that can access UFBB. This applies in areas where the supplier reports to Connected Nations as well as those where they do not. If we excluded these OAs from the analysis, this would increase the gross change for areas supported in 2021 to 17 percentage points.

2.56 The control areas also include output areas where Connected Nations shows either a fall or no change in availability of UFBB. Where there is no change we have no way of determining whether this is accurate or due to inconsistencies in the data. If treated areas are less affected by inconsistencies in Connected Nations data, that would bias the results of the modelling and under-estimate the additional effects of vouchers.

Figure 2.5 Distribution of OAs treated in 2021 by change in availability of UFBB in year after support

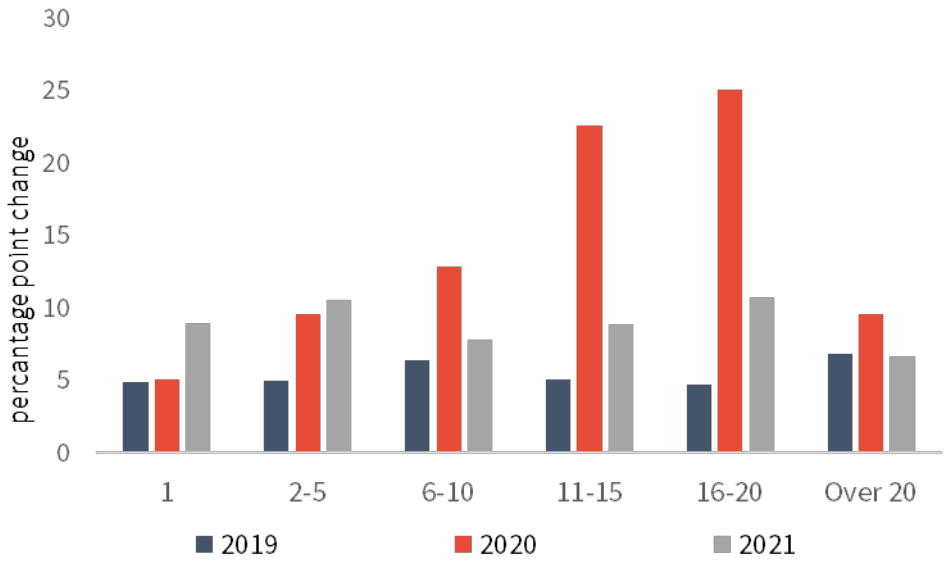


Source Hatch analysis of Connected Nations

Numbers of vouchers and effects on availability of ultrafast broadband

2.57 Figure 2.6 shows some evidence of a relationship between the number of vouchers an area has received and the gross change in availability of UFBB. However this is only evident for areas that received support in 2020, and even in these areas the relationship is not as strong and consistent as it is for change in download speeds (for example, see the low increase in availability for areas that received over 20 vouchers). Again, this can be explained by inconsistencies in the Connected Nations data which skews the average gross change figure.

Figure 2.6 Gross change in output area availability of UFBB in year after support by number of vouchers



Source Hatch analysis of Connected Nations

Differences by scheme and voucher type

2.58 The results have been analysed by voucher scheme in Table 2.13. For vouchers connected in 2020, all models found that the change in availability due to vouchers was significantly higher in GBVS areas than RGC areas (12.41 percentage points compared to 0.05). For vouchers connected in 2021, the change in availability was higher in control areas than both RGC and GBVS areas, resulting in a negative effect in all models.

2.59 These results are inconsistent with the analysis of average download speeds which showed a far greater increase in RGC areas. Again, it suggests the results have been skewed by inconsistencies in the Connected Nations data which have disproportionately affected RGC areas.

Table 2.13 Impact of vouchers on output area availability of UFBB in year after support by voucher scheme

Treatment year	Scheme	Mean effect (Mbps)	Range of effect (Mbps)	Models significant
2020	RGC	0.05	-0.38 to 0.38	0 of 6
	GBVS	12.41***	10.3 to 14.25	6 of 6
2021	RGC	-2.53**	-5.12 to -0.37	4 of 6
	GBVS	-3.20***	-6.68 to -0.45	4 of 6

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*).

2.60 The results by voucher type show that areas receiving project vouchers experienced a much larger increase in availability of UFBB than those receiving standard vouchers in 2020, but a smaller increase for 2019. For vouchers connected in 2021, both groups of

areas experienced a lower increase in availability than control areas, resulting in a negative effect in most models.

2.61 These results are also skewed by inconsistencies in Connected Nations data, which makes it very difficult to draw conclusions about the effects of vouchers on availability of UFBB.

Table 2.14 Impact of vouchers on output area availability of UFBB by voucher type – change after two years in areas supported in 2019 and 2020

Treatment year	Voucher type	Mean effect (Mbps)	Range of effect (Mbps)	Models significant
2019	Project	-0.26	-0.91 to 0.0	1 of 6
	Standard	0.66**	0.01 to 1.77	3 of 6
2020	Project	6.95***	5.31 to 8.34	6 of 6
	Standard	-0.44	-1.01 to -0.05	1 of 6
2021	Project	-3.18***	-6.42 to -0.58	5 of 6
	Standard	-1.82	-4.49 to 0.41	2 of 6

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*).

Gigabit-capable broadband

2.62 The August 2022 report found no evidence that vouchers had a significant additional effect on the availability of gigabit-capable broadband in supported areas. Since then we have undertaken further analysis which suggests this was partly influenced by Virgin Media's network upgrade, which meant many areas experienced a large increase in availability of gigabit-capable broadband which was unrelated to vouchers or any expansion of the network. We have therefore removed output areas which are served by Virgin Media from both the treatment and control groups (see paragraphs 2.20 to 2.22).

2.63 Table 2.15 shows that the updated analysis does identify some statistically significant additional effects on availability of gigabit-capable broadband, but only in areas supported in 2020. All nine models found a significant positive effect, ranging from 3.6 to 6.0 percentage points with a median effect of 4.5 pp. For areas supported in 2021, all models found a negative effect. That is, the change in availability of gigabit-capable broadband between 2021 and 2022 was lower in treated areas than control areas.

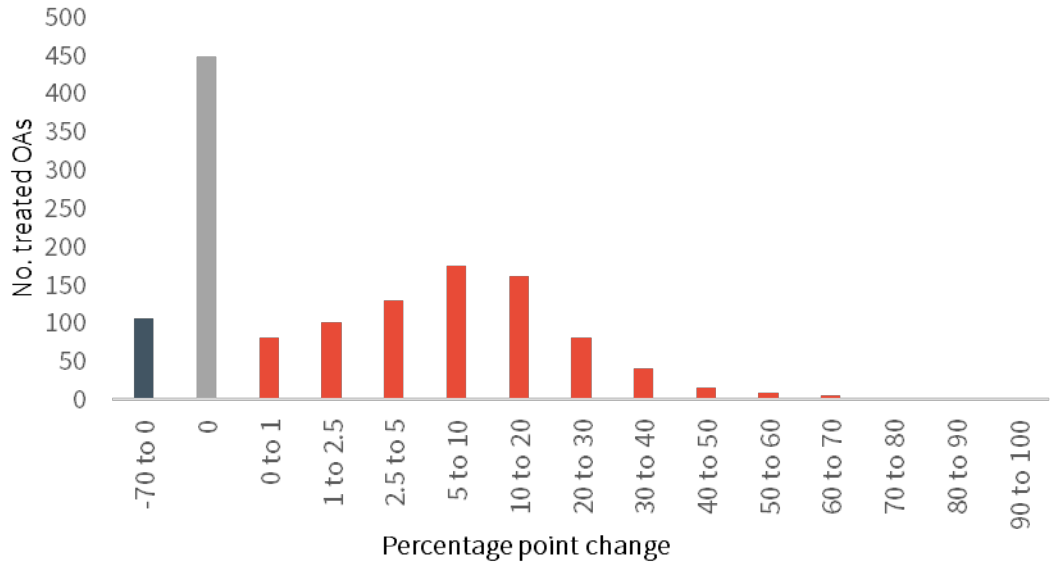
Table 2.15 Additional change in output area availability of gigabit-capable broadband in year after support

Treatment year	Gross change (percentage points)	Models significant	Median additional change	Additional change range
2019	7.83	1 of 9	0.78	-0.51 to 1.44
2020	13.79	9 of 9	4.50***	3.58 to 5.96
2021	8.43	4 of 9	-1.56	-3.39 to -0.14

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*).

2.64 Again, we would caveat that this data is subject to the same inconsistencies in Connected Nations data which distorts the results of the modelling. Figure 2.7 shows a very high proportion of OAs which received a voucher in 2021 show no change in availability of gigabit-capable broadband, according to Connected Nations. This is in direct conflict with voucher scheme data that shows that at least one premise in the OA received a gigabit capable connection.

Figure 2.7 Distribution of OAs treated in 2021 by change in output area availability of gigabit-capable broadband in year after support



Source Hatch analysis of Connected Nations

Differences by voucher scheme and type

2.65 For vouchers connected in 2020, all models found that the change in availability of gigabit capable broadband in RGC areas was not significantly different to control areas, indicating no effect. In contrast, areas that received vouchers through the GBVS scheme experienced a larger increase than control areas (ranging from 10.85 to 15.44 percentage points) with all models finding a significant effect.

2.66 For vouchers connected in 2021, the change in availability was higher in control areas than areas that received vouchers through either of the schemes, resulting in a negative effect in all models. The same caveats as above apply to these results.

Table 2.16 Impact of vouchers on output area availability of gigabit-capable broadband by voucher scheme – change after one year

Treatment year	Scheme	Mean effect (Mbps)	Range of effect (Mbps)	Models significant
2020	RGC	0.82	0.01 to 1.48	0 of 6
	GBVS	13.13***	10.85 to 15.44	6 of 6
2021	RGC	-2.02	-5.49 to -0.67	1 of 6
	GBVS	-3.04	-7.13 to -1.44	5 of 6

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*).

2.67 The results by voucher type show that areas receiving project vouchers experienced a larger increase in availability of gigabit-capable broadband than those receiving standard vouchers in 2019 and 2020. For vouchers connected in 2021, the increase in availability was higher in control areas than areas that received either of the types of voucher, resulting in a negative effect. The same caveats as above apply to these results.

Table 2.17 Impact of vouchers on output area availability of gigabit-capable broadband by voucher type – change after one year

Treatment year	Voucher type	Mean effect (Mbps)	Range of effect (Mbps)	Models significant
2019	Project	3.34***	1.95 to 4.36	5 of 6
	Standard	0.65	0.04 to 1.42	0 of 6
2020	Project	12.17***	10.38 to 13.99	6 of 6
	Standard	-1.17	-1.68 to -0.51	0 of 6
2021	Project	-2.71**	-6.72 to -1.13	2 of 6
	Standard	-3.65	-6.84 to -2.05	1 of 6

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*).

Conclusions

2.68 The counterfactual analysis of the effects of vouchers on broadband performance and availability has been hampered by inconsistencies in, and between each year of, Connected Nations data. This makes it very difficult to compare change in coverage of UFBB and gigabit-capable broadband in treated and control areas on a consistent basis.

2.69 The main focus has therefore been on vouchers' effects on broadband performance, as measured by the change in average download speeds. The modelling shows a positive picture about the additional impacts of vouchers. All of the models found that treated areas experienced additional speed improvements in the year after treatment which can be attributed to vouchers. These additional effects were between 3 and 4 Mbps in areas that received vouchers in 2019 and 2020, and between 25 and 30 Mbps for areas treated in 2021. The much larger effect in 2021 can be explained by the greater intensity of support, with more vouchers connected per treated OA, but also the growth in take-up of faster broadband speeds which occurred in treated and control areas between 2021 and 2022, and is unrelated to vouchers.

2.70 Overall we have found a broadly linear relationship between the number of vouchers an area has received and the change in average download speeds. We have therefore found no evidence of an optimum number of vouchers in an area (a point at which the marginal effects of additional vouchers start to diminish).

2.71 This updated analysis has also found much clearer evidence that the RGC scheme and project vouchers have had a greater additional effect on average download speeds in local areas than the GBVS scheme or standard vouchers. A large reason for this is that these areas have tended to receive more vouchers on average. However, even when we control for this and the number of premises in treated areas, the results still show that RGC and project vouchers have had a greater effect on local area average download

speeds than GBVS and standard vouchers. The only exception is for vouchers connected in 2019 where each standard voucher, on average, resulted in a higher increase in average download speeds than project vouchers. This could be explained by the fact that most project vouchers in 2019 were delivered through the GBVS scheme, and standard vouchers were for business use only in that year. GBVS areas also tended to be used in more urban and commercial areas which were likely to have higher starting average download speeds than the more rural areas where most RGC vouchers were used.

3. Business and Economic Impacts

Summary of key findings

- This section analyses the economic impacts of vouchers to date. It is still too early to assess the full impacts of vouchers due to time-lags in economic datasets and insufficient time having elapsed for businesses to realise the full benefits of their broadband upgrade. This is particularly relevant to those vouchers delivered through the RGC scheme. The results should therefore be interpreted as the initial impacts of vouchers that can be measured at this stage..

Firm level analysis

- The firm level analysis also only relates only to the impacts on voucher recipients themselves and does not include benefits for other businesses who have also upgraded their broadband as an indirect result of vouchers. It also does not capture all economic benefits for businesses (e.g. due to cost savings, which the business survey indicated was an important benefit). The analysis therefore underestimates the impacts on businesses.
- Businesses that received vouchers grew their employment by 6.1% in the year of support, by 9.9% by the 2nd year and by 14.5% by the third year. In each case this was higher than the change in employment in the preferred control group, although the difference was only statistically significant in the first two years (four percentage points in the 2nd year). The difference was not statistically significant in the third year. This could be explained by the fact that the only businesses in this cohort were those who received their voucher in 2018/19 through the GBVS scheme.
- Although businesses that received vouchers increased their turnover in each of the three years, this was slightly lower than the increase among businesses in the preferred control group (although the difference was not statistically significant). Similarly, the change in turnover-per-employee was higher in the preferred control group than businesses that received a voucher. This means it has not been possible, at this stage, to detect a measurable effect on turnover or productivity. This could be explained by measurability challenges and the fact that the period of analysis includes the Covid pandemic which had a significant impact on turnover for many businesses which is difficult to fully control for.
- Businesses that received vouchers did outperform the wider business population across all of these measures. This was also the case when we restricted the sample to businesses with similar characteristics (e.g. size, sector, innovativeness). It is only when we compare voucher beneficiaries to similar businesses with cancelled standard voucher applications or similar businesses from the same area that performance has been similar or worse. This suggests that access to gigabit-capable broadband does have significant benefits for business performance, but that businesses in the control groups have found alternative ways of securing an upgrade.
- We find that the additional jobs created by businesses receiving vouchers have been in higher productivity roles, evidenced by the fact that workers moving into these

roles have enjoyed a wage premium equivalent to £1,362 per worker (in 2018 prices). Applying this to the business population as a whole (27,536 by the end of December 2021), we estimate that the total improvement in productivity is around £37.5m (in 2022 prices).

Area level analysis

- The area level analysis is subject to much greater uncertainty than the firm level analysis. Fewer than 2% of businesses in supported areas have received a voucher meaning the scale of intervention is very modest. This makes it difficult to robustly detect the effect of vouchers and to control for the wide range of other factors which affect area level performance. Furthermore, establishment level turnover data is not available for multi-site businesses meaning it has to be estimated. As such, the analysis of the effects of vouchers should only be treated as indicative.
- With these caveats in mind, the analysis shows areas that received vouchers experienced a fall in employment relative to the base year. However the fall in employment was lower than in both of the control areas, indicating that the fall would have been 1.8 percentage points higher were it not for the voucher.
- Turnover has also fallen over time in all areas, although not to the same extent as employment. Again, the decrease in turnover was lower in treated areas than control areas, although the difference was only statistically significant in the first year (+1.9%).

Purpose of chapter

3.1 This chapter applies counterfactual impact evaluation methods to measure the initial effects of voucher subsidised gigabit connections on businesses, including turnover, employment and other business performance measures. This focuses on

- Firm level impacts: measuring the change in the performance of firms that have received a voucher
- Area level impacts: measuring the aggregate change in turnover, employment and productivity in output areas which have received a voucher.

3.2 It is still too early to assess the full economic impacts of vouchers due to time-lags in economic datasets and insufficient time having elapsed for businesses to realise the full benefits of their broadband upgrade. This is particularly relevant to those vouchers delivered through the RGC scheme. The results should therefore be interpreted as the initial impacts of vouchers that are currently measurable. The full economic impacts of the voucher schemes will be assessed in the third and final evaluation report in 2026.

Firm level impacts

Methodology

3.3 The method is described in detail in the technical annex in Appendix B and summarised below:

- Businesses that have received vouchers have been identified in data at the ONS Secure Research Service[10] and linked to records in the ONS Business Structure Database (BSD). This provides data on a wide range of business characteristics which are measured consistently over time.
- PSM is then used to identify control groups of businesses with similar characteristics to those that have received vouchers. This includes a wide range of variables related to the characteristics of the business (e.g. size, sector), their location (e.g. urban/rural) and broadband characteristics (e.g. average download speed in the postcode, estimated cost to connect premise). We also included specific variables to control for the effects of the pandemic, such as whether a firm received furlough payments.
- We developed 15 different counterfactual models for comparing treated and control groups. These differed in terms of:
  - the variables used to match businesses, with some models including pre-treatment trends in turnover and employment growth over different time periods (in the years before the broadband upgrade).
  - the pools of businesses from which control groups were drawn for matching. One pool was the whole business population in England and Wales. A second was businesses who had applied for a standard voucher which was subsequently cancelled (the rationale for this is that it allows us to compare performance with similar businesses who have also shown an interest in applying for a voucher). The third pool was businesses from the same exchange area as businesses that have received a voucher. The advantage of this is that analysis can be focused on similar businesses from the same area and which have similar broadband infrastructure.
- The models were tested using a number of robustness checks. For example, whether businesses in the control group have similar enough characteristics to businesses that received vouchers, and whether the trends in employment and turnover in control groups were on a similar trajectory to businesses that have received vouchers before the broadband upgrade.
- The preferred model was the control group drawn from businesses with cancelled standard voucher applications, matched on the basis of their characteristics but not on pre-treatment trends. This was the model which was found to be the most robust based on the checks described above. It is also the only model which controls for 'selection bias' i.e. the unobservable characteristics which might influence whether a business applies for a voucher or not[11]. Nevertheless, we also

[10] This work contains statistical data from ONS which is Crown Copyright. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

[11] Although the voucher schemes have been supplier led, BDUK's terms and conditions state that all applications made on behalf of businesses must have the business's consent, meaning all businesses in the control group must have shown an interest in applying for a voucher.

compare the performance of businesses with a number of alternative control groups in the analysis, including:

- businesses drawn from the wider business population but matched on the basis of their characteristics
- businesses drawn from the same exchange area but matched on the basis of their characteristics

- The performance of businesses in the treated and control groups was tracked over time in the BSD, measuring changes in employment, turnover and productivity (turnover per employee). This allows us to quantify the difference in change in these outcome indicators between treated and control areas. If the difference is statistically significant, we can be confident that the additional change in outcomes can be attributed to vouchers.

Time period assessed

3.4 As of June 2023, the most recent year of data available in the BSD relates to the financial year 2020/21. It is based on a snapshot in time of the Inter-Departmental Business Register (IDBR) taken in around April 2021, with the reporting period for the firm generally being the most recent financial year. There are therefore time lags in the data which mean it is not possible to assess the effects of vouchers connected after April 2021. Any vouchers connected later in the 2020/21 financial year will also have had limited time to translate into a measurable impact on business performance.

3.5 This also means that the modelling results are based mainly on the effects of vouchers delivered through the GBVS scheme rather than the RGC scheme which were only used to connect premises from 2020 onwards.

3.6 In order to avoid reporting changes over time separately for individual cohorts of voucher recipients (i.e. businesses that received vouchers in 2019, 2020 and 2021), the change in outcomes has been analysed as a stacked dataset. This centres data on the year before the voucher support (t). The performance of each cohort is then expressed in terms of the numbers of years from support rather than in terms of calendar years. So t+1 is the year of connection, t+2 is the year after the date of connection and so on. This allows us to pool the cohorts and analyse how employment has changed relative to the base year.

Impact analysis

3.7 This section presents the results of the firm-level analysis, showing the impacts of vouchers on business beneficiaries' employment, turnover and productivity (turnover per employee).

Impact of vouchers on employment growth

3.8 This section estimates how much of the growth in employment in businesses that received a voucher is due to the broadband upgrade (over and above that experienced in control groups

3.9 Figure 3.1 compares the change in employment in businesses with vouchers with two control groups:

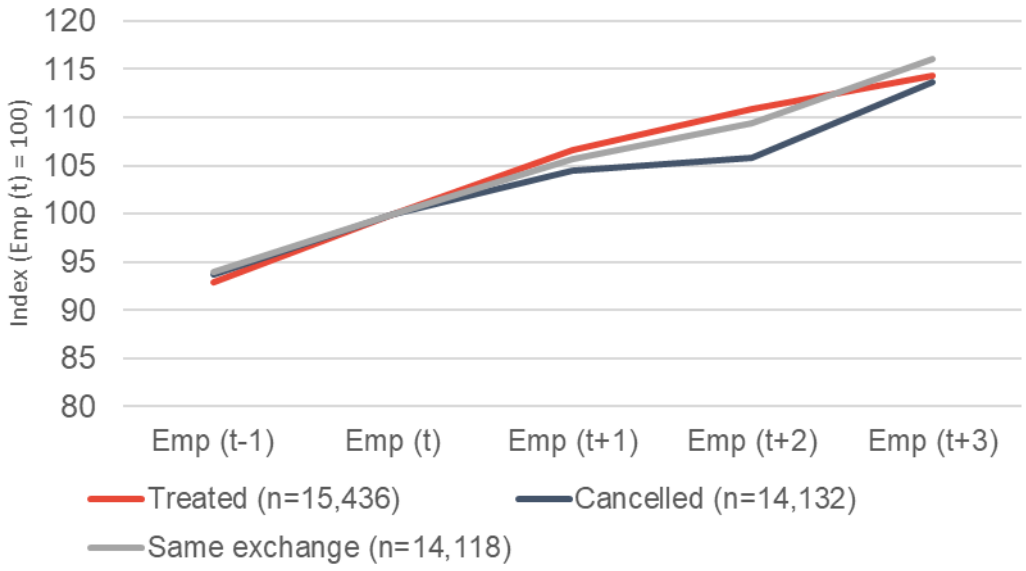
- The preferred control group, based on cancelled standard voucher applications, matched on the basis of their characteristics ('Cancelled' in the chart).
- An alternative control group, which includes businesses from the same exchange area, matched on the basis of their characteristics ('Same exchange' in the chart).

3.10 The first point to note is that businesses that received a voucher have performed well in terms of employment growth[12]. Relative to the base year, the log of employment growth in treated areas is 6.1% higher in the year of voucher support (t+1), 9.9% higher in the year after the voucher (t+2) and 14.5% higher two years after the voucher (t+3). This has been achieved over a period of unprecedented economic instability as a result of the Covid 19 pandemic and suggests businesses receiving vouchers have performed well.

3.11 However, the chart also shows that the performance of treated groups is very similar to that of control groups, both before the voucher (indicating these are good counterfactuals) and since the voucher. Relative to the preferred control group, employment growth was higher for businesses with vouchers in the year they received the voucher (t+1) and in t+2, but the gap had narrowed by year t+3.

3.12 This suggests businesses from these pools have certain advantages over other businesses that cannot be explained by their observable characteristics.

Figure 3.1 Employment change in voucher beneficiaries and control groups



Source Belmana

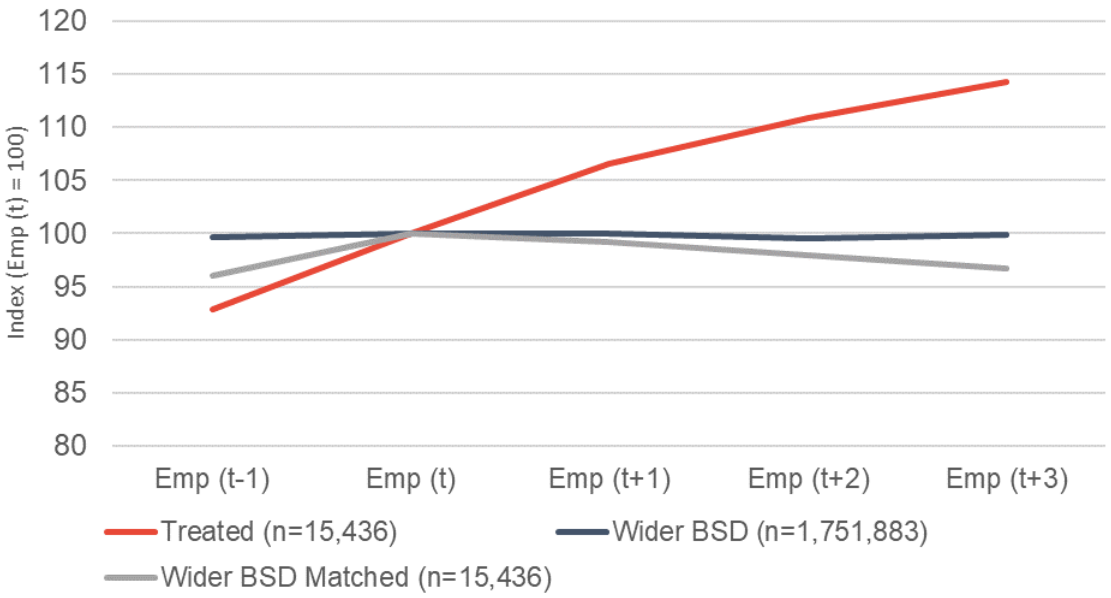
3.13 Figure 3.2 compares change in employment in businesses that received a voucher with two other groups:

[12] In Figure 3.1, the performance is indexed so that, in the base year, the value is set to 100. This and later figures use logged variables, so that any outliers do not unduly influence the estimation.

- the business population as a whole ('Wider BSD' in the chart)
- businesses from the wider BSD matched on the basis of their characteristics ('wider BSD matched').

3.14 This shows a very different picture to Figure 3.1. Businesses with vouchers have grown at a much faster rate than either the wider business population or businesses with similar characteristics (these actually perform slightly worse than the wider business base, with employment decreasing by 3% by year t+3).

Figure 3.2 Employment change in voucher beneficiaries and wider business population



Source Belmana

3.15 The different models therefore give very different results. Business voucher beneficiaries have out-performed the wider business base, including when we control for business characteristics. However, when compared to businesses from the same area or cancelled voucher applicants (the preferred control group), the gap in performance largely disappears.

3.16 There are a number of possible explanations for why this might be:

- Businesses in the preferred control group ('cancelled') and from the same exchange area may have received access to faster broadband anyway. The voucher schemes have been supplier led, so it is likely that suppliers have been expanding their networks in the local area where vouchers have been used and providing access to faster broadband to other premises that have not received vouchers, particularly where vouchers have been delivered as part of projects. This may explain why businesses in the same exchange area have experienced a similar performance to treated businesses. Similarly, cancelled voucher applications are also likely to have occurred in areas where suppliers are looking to expand their network. This has been tested by comparing speed changes in postcodes where business vouchers were connected with postcodes where

business voucher applications were cancelled (see Table 3.1). It shows that postcodes with voucher connections experienced a far greater average speed change than cancelled voucher postcodes. However cancelled voucher postcodes experienced a greater average speed change than the average for all postcodes. This offers some evidence that businesses with cancelled standard voucher applications have been able to upgrade their connection, although not to the same level as voucher beneficiaries.

- **There are other local factors explaining the strong performance of businesses.** Suppliers may have disproportionately targeted business vouchers on areas with strong performing local economies, potentially in anticipation of higher levels of demand, which might have contributed to the strong performance of businesses in the 'same exchange area' and 'cancelled' control groups. One of the purposes of including the 'same exchange area' control group was that it allows us to control for some of the local area-level factors which affect business performance that are difficult to observe in datasets.
- **There are firm level factors explaining the strong performance of businesses.** The desire to upgrade a business's broadband connection may be correlated with other unobservable characteristics which influence the growth of businesses (such as the growth ambitions of the business owner or their management/leadership skills). This may explain why the 'cancelled' control group has a similar performance to the treated group but would not explain why businesses from the same exchange area also perform just as well.

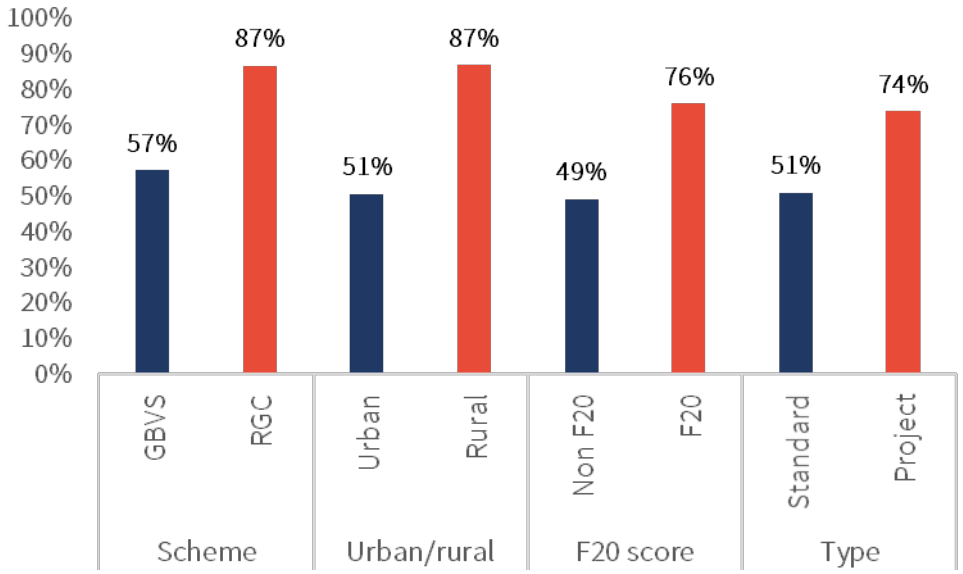
Table 3.1 Gross change in average download speeds between treatment year and 2021 (Mbps)

	2019	2020
Postcodes with connected business vouchers	66.9	48.9
Postcodes with cancelled standard business voucher applications	34.8	15.7
All postcodes	25.2	10.3

Source: Hatch analysis of Connected Nations

3.17 It should also be noted that the analysis focuses mainly on businesses who received vouchers through the GBVS scheme where there were few geographical restrictions on where vouchers could be used (compared to the RGC scheme). The findings of the business survey undertaken as part of the August 22 report showed that businesses receiving vouchers through GBVS were far less likely to say they had not upgraded their connection because it was not available where they are located than businesses that received vouchers through the RGC scheme (see Figure 3.3). This suggests these GBVS businesses had greater options for securing enhanced connectivity if they need it. Time lags in the data mean we are unable to assess differences between GBVS and RGC vouchers in this report but this will be assessed in the follow-up evaluation.

Figure 3.3 Percentage of businesses who had not upgraded their connection because it was unavailable where it was located



Source Winning Moves Business Survey

3.18 The degree to which employment growth rates differ were tested using difference-in-difference analysis. Table 3.2 shows the results of the analysis, comparing the employment growth in treated areas with the growth in the preferred control group (based on cancelled voucher applicants with similar characteristics) and the median level of growth from the 15 models.

3.19 In the year of support, employment increased by 6.1% in businesses that received a voucher compared to 4.5% in the preferred control group. This suggests the voucher support provided 1.6 percentage points of additional growth in employment. The additional growth in employment increases two years after support; employment growth was 4 percentage points higher in voucher beneficiaries compared to the preferred control group. Both these estimates of additional growth are statistically significant at 1% significance level, meaning we have high statistical confidence that there is a difference between the treatment and control group.

3.20 There is a catch-up in the counterfactual by the third year, as employment growth in the preferred control group is not significantly different to businesses that received a voucher. Although it should be noted that year three estimates require some caution in that sample sizes become smaller, as only the first cohort of voucher beneficiaries have been observed across three years (those that received vouchers in 2018/19).

3.21 The robustness of these estimates can also be checked. One check is the consistency of the preferred model with the median across the 15 models. This also identifies statistically significant effects in the year of support and second year, but not in the third year (although the scale of additional effects is slightly lower).

3.22 A second check is in Figure 3.2. The pre-support changes in employment in businesses that received a voucher (treated) are quite close to that seen in the preferred counterfactual (cancelled). This means that the divergence in performance seen in the

years after the voucher followed a period where both treated and matched control groups were on a similar trajectory. This increases our confidence that the preferred control group offers a robust counterfactual for treated businesses.

Table 3.2 Difference in difference analysis for firm-level employment impacts

Employment	Growth Treated	Preferred Counterfactual		Median Counterfactual	
		Growth	DiD	Growth	DiD
Yr of support	6.1%	4.5%	1.6%***	4.0%	1.5%***
Second year	9.9%	5.7%	4.0%***	6.2%	2.3%***
Third year	14.5%	13.6%	0.8%	10.5%	0.3%

Note: Significance levels are 1% (***), 5% (**) and 10% (*); estimates have been converted from log growth so will not add up as presented.

Impact of vouchers on turnover growth

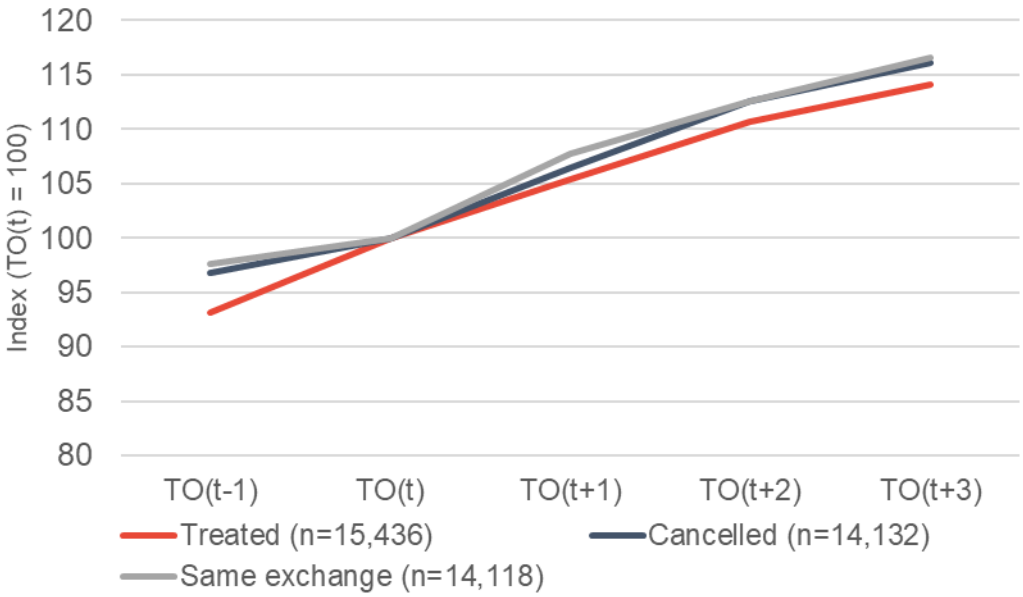
3.23 The figures below repeat the analysis, but this time focusing on change in real turnover in treated and control groups.

3.24 Figure 3.4 shows businesses that received vouchers performed strongly in the years after the connection. Relative to the base year, the log of turnover was 5% higher in the year after support (t+1), 10.6% higher in the second year (t+2) and 14% higher in the third year (t+3). As noted above, this coincides with the period of the pandemic, and suggests businesses that received vouchers have been able to successfully navigate the challenges brought on by the pandemic. This is consistent with the findings of the business survey undertaken as part of the earlier report, which showed 70% of businesses said their broadband upgrade had a positive effect on their ability to adapt and continue to do business during the pandemic, with 44% saying it had a major positive effect

3.25 However, the chart shows that, again, businesses in the preferred control group ('cancelled') and the 'same exchange' control group performed equally well.

3.26 The chart shows that the 'pre-treatment' trend in turnover for businesses that received a voucher is not as closely aligned with the preferred control group as it is for employment. However, the trend is more aligned if the analysis is taken back by a further year (so a two year pre-treatment trend rather than one). Overall, when we consider both turnover and employment, the pre-treatment trends are similar enough for the 'cancelled vouchers' control group to offer a robust counterfactual.

Figure 3.4 Change in real turnover in businesses that received vouchers and matched control groups



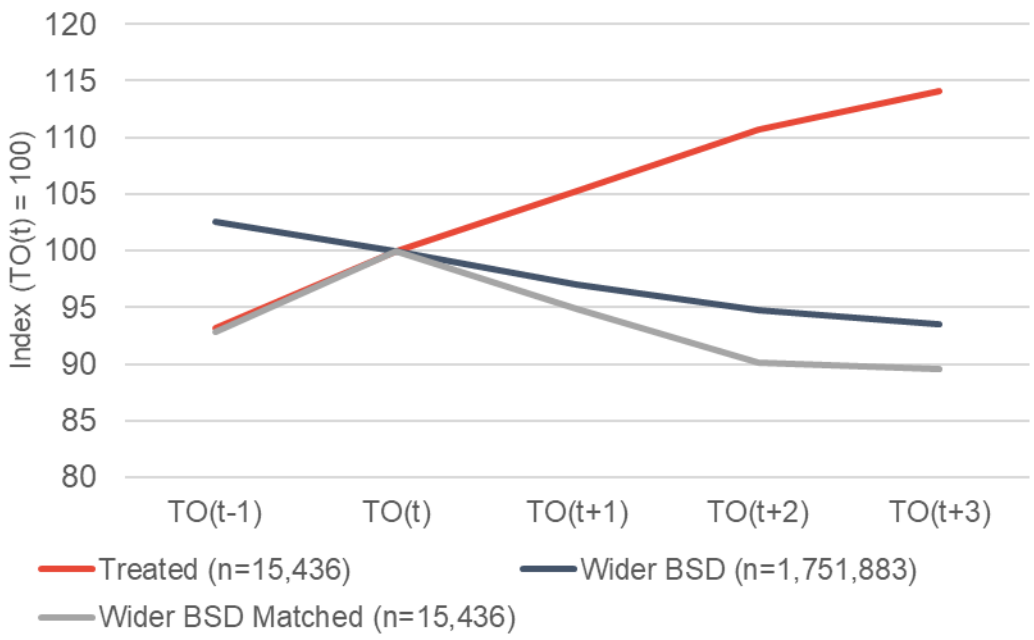
Source Belmana

3.27 Figure 3.5 shows that the growth in turnover was much higher in business voucher beneficiaries than it was for the business base as a whole ('wider BSD'), even after controlling for business characteristics ('wider BSD matched').

3.28 In both of these control groups, turnover falls over time. This is likely to be explained by the impacts of the Covid-19 pandemic which affects a number of the cohorts in different years. The effects of the pandemic are more pronounced for turnover than for employment where furlough payments are likely to have moderated any negative effects.

3.29 As was the case for employment, there may be a number of factors which explain the difference between the models which are all explained above.

Figure 3.5 Change in real turnover in voucher beneficiaries and wider business population



Source Belmana

3.30 Table 3.3 shows the results of the difference-in-difference analysis for turnover. Although turnover of businesses that received a voucher has grown at a strong rate, the level of growth was more than matched by businesses in the preferred counterfactual model (although the difference between these two groups of businesses is not statistically significant). Similarly, in the median counterfactual model, the level of turnover growth was not significantly different to voucher beneficiaries

3.31 Therefore, based on this evidence, we have not been able to identify any significant additional effects of vouchers on growth in turnover at this stage. Any growth observed in businesses that received a voucher could have been expected to have occurred in the absence of the voucher. The third and final evaluation report will assess whether there are any differences in RGC areas where businesses had fewer options for upgrading their broadband connection, and therefore we may expect additionality to be higher.

Table 3.3 Difference in difference analysis for firm level turnover impacts

Real Turnover	Growth Treated	Preferred Counterfactual (Cancelled)		Median Counterfactual	
		Growth	DiD	Growth	DiD
Yr of support	5.6%	6.5%	-0.8%	5.2%	0.3%
Second year	11.2%	12.5%	-1.2%	10.1%	0.4%
Third year	14.4%	16.1%	-1.4%	13.0%	-0.6%

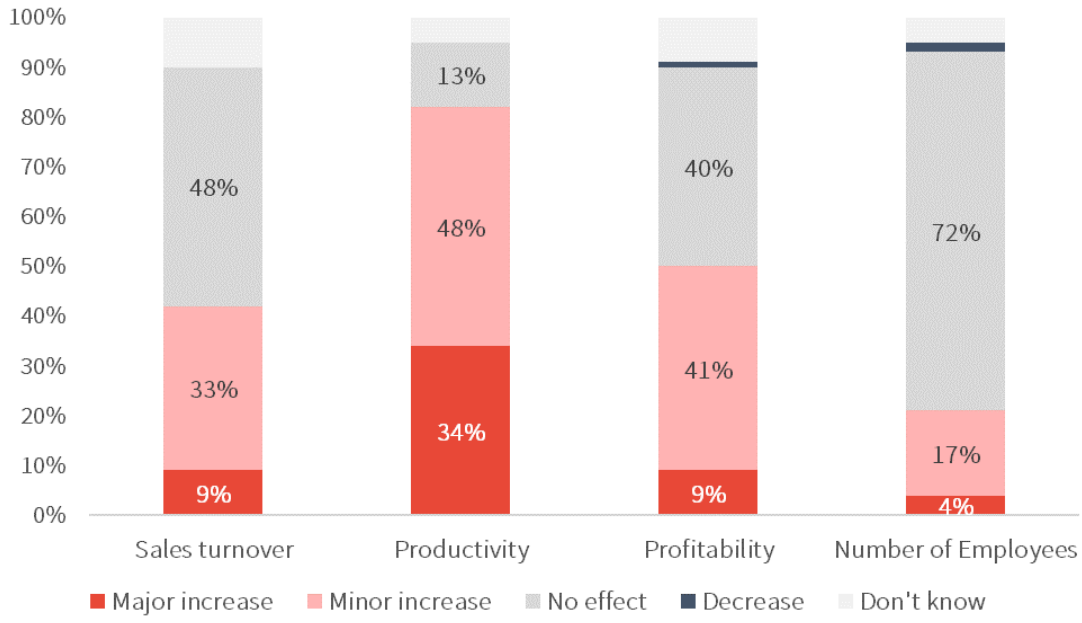
Note: Significance levels are 1% (***), 5% (**) and 10% (*)

Productivity outcomes of voucher support

3.32 This section considers the productivity associated with the additional employment seen in businesses that received a voucher. A first analysis looks at the growth in real productivity (turnover per employee) seen in voucher beneficiaries compared to the counterfactual. A second analysis then looks at the wages paid to employees (a proxy for productivity) focusing on those who switch jobs into businesses that received a voucher.

3.33 It should be noted that neither of these measures capture another type of productivity improvement which might have arisen for businesses, which relates to reductions in business costs. The findings of the business survey published in the first evaluation report showed that businesses were far more likely to report an improvement in productivity than an increase in turnover (82% and 42% respectively). This suggests productivity growth in beneficiary businesses has been driven mainly by reduced costs rather than improvements in labour productivity. These impacts cannot be assessed through analysis of the BSD but are potentially an important economic benefit.

Figure 3.6 Figure 4.24 Change in business metric reported by respondents (n=1,344)



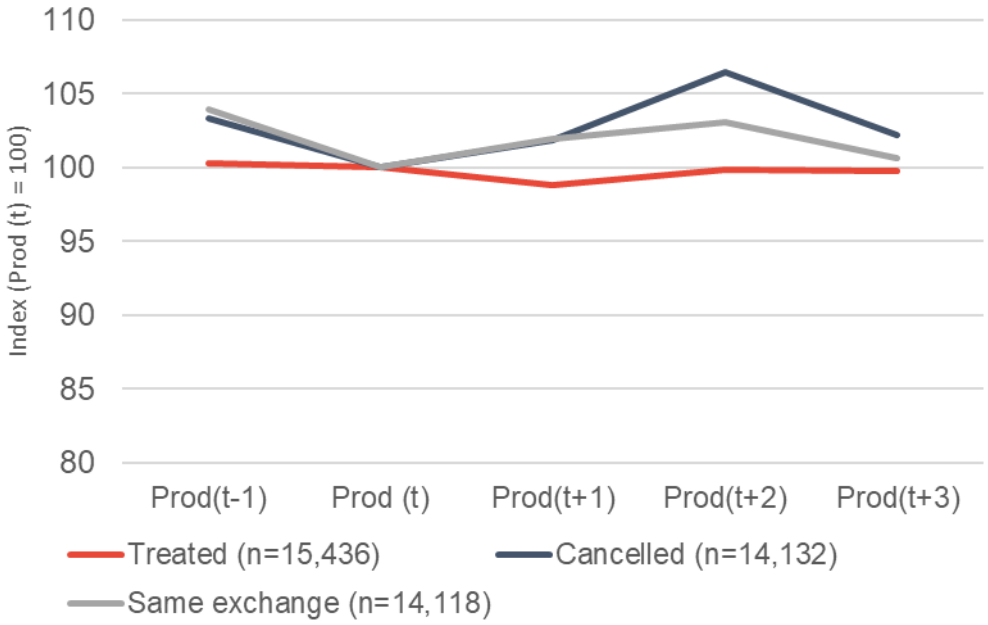
Source Winning Moves business survey

Turnover per employee impacts

3.34 Figure 3.7 shows that change in turnover per employee was broadly flat in businesses that received vouchers (a reflection of the fact that turnover and employment grew at broadly the same rate). When compared to business in the same exchange area and businesses whose application for a standard voucher was cancelled (the preferred control group), the change in turnover per employee was lower in businesses that received vouchers.

3.35 Again, it should be noted that the results are affected by the Covid-19 pandemic which had a greater effect on turnover than employment in many businesses because of the Job Retention Scheme.

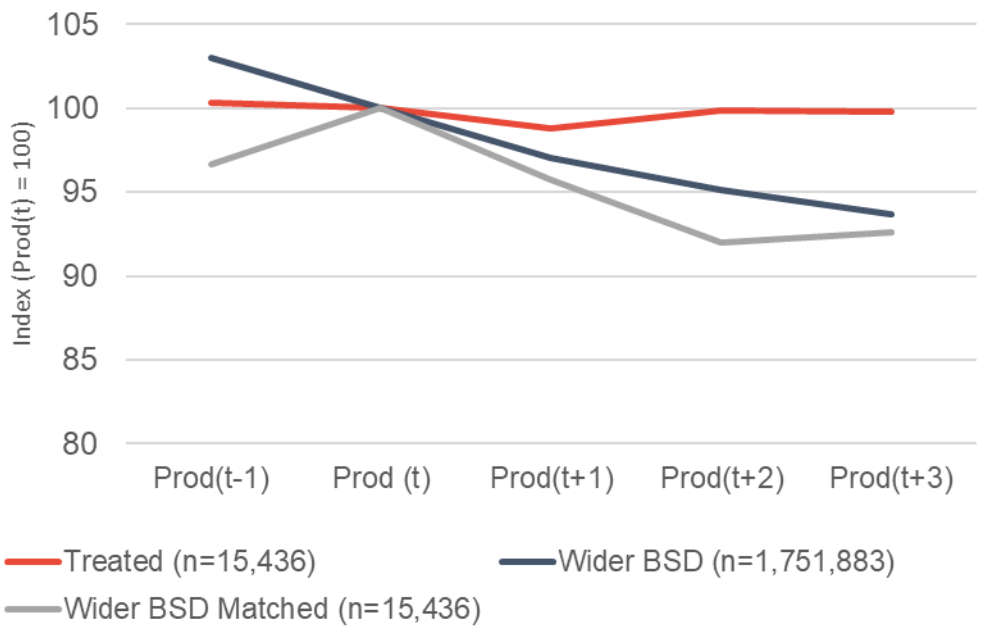
Figure 3.7 Change in real turnover per employee in businesses that received voucher and matched control groups



Source Belmana

3.36 Figure 3.8 shows that, again, businesses with vouchers outperformed the wider business base ('wider BSD'), even after matching to businesses with the same characteristics as voucher beneficiaries ('wider BSD matched').

Figure 3.8 Change in real turnover per employee in businesses that received a voucher and wider business population



Source Belmana

3.37 The difference-in-difference analysis in Table 3.4 shows that the growth in turnover per employee is significantly lower than the preferred counterfactual in the year that businesses receive a voucher and in the second year, but there is no statistically significant difference by the third year.

3.38 This measure of productivity suggests that while businesses that received vouchers are increasing employment, they have not been able to increase sales proportionately when compared to the similar businesses whose application for a voucher was cancelled. Looking across the different models, however, there is considerable variability in estimates, so much so that many estimates are not significant, and the median of the models provides a very different picture to the preferred.

3.39 It should also be noted that there are challenges associated with measuring change in turnover per employee and its usefulness for assessing change in productivity. Real turnover is only a proxy for value added, with its usefulness depending on several factors that cannot be controlled for. This means that it is imprecise and has high variance. Furthermore, division of an imprecise number by a second - in this case employment - multiplies that imprecision. There are also issues around the analysis period being affected by Covid. In some sectors, closure would have adversely affected turnover, but employment would have been protected to a large extent due to the Government's Coronavirus Job Retention Scheme. While the modelling has made efforts to control for this, the scale of the effects of the pandemic mean it is difficult to fully mitigate this.

3.40 Therefore, overall, it is unsurprising that there is considerable variance in the model estimates for turnover per employee. The next section looks at an alternative productivity proxy, the earnings associated with employment.

Table 3.4 Difference in difference analysis for firm level turnover-per-employee

	Growth Treated	Preferred Counterfactual		Median Counterfactual	
		Growth	DiD	Growth	DiD
Yr of support	-0.5%	1.9%	-2.3%***	0.5%	-1.0%
Second year	1.1%	6.4%	-5.0%***	2.8%	-1.7%
Third year	-0.2%	2.2%	-2.3%	0.6%	-0.8%

Note: Significance levels are 1% (***), 5% (**) and 10% (*)

Earnings impacts and the quality of jobs

3.41 The analysis has found that vouchers have a significant additional effect on employment in businesses that have received a voucher. The quality of this employment can be assessed by analysing the wages in these businesses. Workers are said to earn a "wage premium" if their wage is higher than it would be in a different business or occupation, given their ability, skills, and experience. A premium may arise if the worker is more productive, and the higher wage reflects this.

3.42 It is important to note that a wage premium does not mean the productivity of the firm that received a voucher (as measured by turnover per employee) has increased. The benefit of the voucher in this case relates to a worker moving from a less productive role in a different business to a more productive role in a business that has received a voucher. However this could happen without any increase in turnover per employee in the business that has received a voucher. It is therefore a different type of effect to an increase in firm productivity.

3.43 Wage premiums associated with vouchers can be estimated using panel data that tracks individuals over time as they move from employer to employer, and linking this to the data on business voucher beneficiaries. By following an individual, this approach can sidestep the fact that many employee characteristics are often unobservable and therefore difficult to control for when assessing changes in earnings. The approach then focuses on those employees that switch jobs between businesses that received a voucher and other businesses. Any change of wage rate is then attributable to the movement between unsupported businesses and those that received a voucher. This can be assumed because the worker characteristics are the same. Examples that use this approach include Disney and Gosling (1998, 2003), Girma and Gorg (2006)[13].

3.44 To analyse the earnings effects of vouchers, the study draws on the Annual Survey of Hours and Earnings (ASHE). This is ONS's principal source for earnings estimates, collected in April of each year, and uses data on about 120,000 full-time employees drawn in a manner that means an employee in a businesses who received a voucher is

[13] Disney, R., & Gosling, A. (1998). Does it pay to work in the public sector? Fiscal Studies, vol. 19 no. 4.

Disney, R.F., & Gosling, A. (2003). A new method for estimating public sector pay premia: Evidence from Britain in the 1990s. CEPR discussion paper no. 3787.

Girma, S., & Goerg, H. (2006). Evaluating the foreign ownership wage premium using a difference-in-differences matching approach. CEPR discussion paper no. 5788.

no more or less likely to be in the dataset. ONS surveys businesses about the pay, hours, occupation, age and gender of one per cent of all employees. The ASHE design tracks individuals, with the same one per cent surveyed each year, with individuals that have moved jobs being captured in their new employer's return. This allows the quality of jobs to be assessed both in terms of levels of wages and the transitions as individuals move into and out of the voucher beneficiary businesses. This latter feature can act as proxy for the quality of jobs.

3.45 Businesses that received vouchers on average paid higher wages than other UK businesses in 2018, at £438 per week[14]. This covered 1,659 individuals in the 359 businesses included in ASHE. Across the whole of ASHE, the average was £391 per week, covering 171,535 individuals. The businesses with cancelled vouchers had wages similar to that seen in the wider business base, at £394 per week covering 1,411 individuals. Wages have been valued in terms of 2018 prices using a GDP deflator and are quite flat over time.

3.46 The panel structure of the ASHE data can be used to better understand the effect on wages of working in a business that received a voucher. Figure 3.9 compares earnings of job switchers to and from supported businesses to earnings of employees moving between other businesses. Switchers to and from supported businesses are included if the switch occurred in the year of first support or any year thereafter. There are five years of switching data used, looking at the ASHE panel 2016-21, and there are around 125,517 (18% of all ASHE employees) switches in total.

3.47 Figure 3.9 and Table 3.5 show that all job switchers, on average, receive a pay rise. There is a 7.5% rise in pay for the 124,492 movements between unsupported businesses in all periods. This is a usual result from tracking individuals over time in ASHE, which can be explained by people moving in to roles which make better use of their skills and experience and therefore offer higher levels of pay.

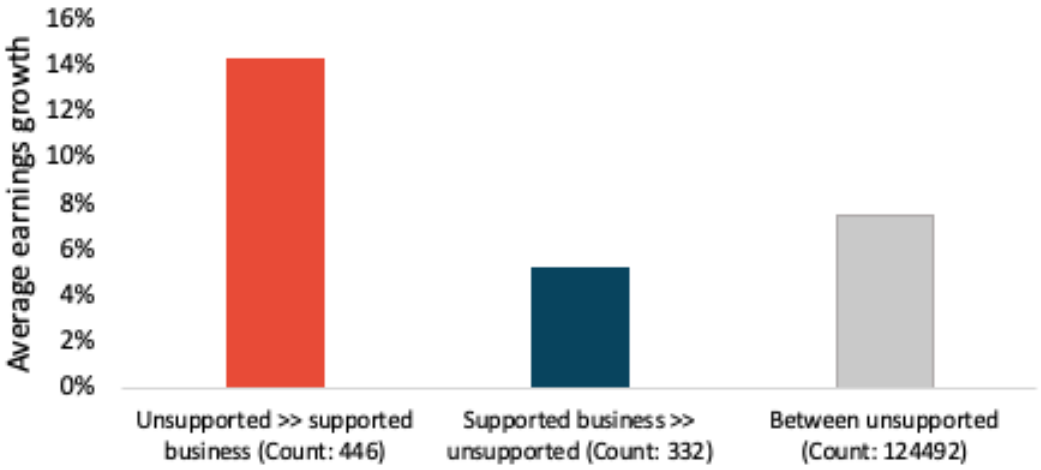
3.48 The data also shows that workers who moved from employment in unsupported business to ones that had received a voucher received an even larger pay rise of 14.2%, which is significantly higher than the average for job switchers. This suggests that – as the individual retains the same level of skills and experience (bar an additional year) - there is evidence of an above average level of wage change. There are fewer movements in the other direction, reflecting the fact that businesses that received a voucher are creating jobs. These movements are associated with a lower pay rise than general job switching.

3.49 This means that the additional jobs that have been created by business voucher beneficiaries have attracted a wage premium. That does not mean that the vouchers have *caused* the wage premium itself. The additionality of vouchers in this case relates to the jobs that have been created. However this analysis does show that these new jobs use the skills and experience of individuals more productively than was the case in the person's previous post. While that usually occurs when people change jobs, the effect in this case is higher. Since the jobs would not have been created without the voucher, these wage premiums can be counted as a net-additional impact of vouchers.

[14] This is based on a limited sample size and is therefore subject to a margin of error

3.50 This also means that the analysis is not inconsistent with the analysis of real turnover per employee above, in that the productivity effects measured here relate to the better matching of people to productive jobs as additional jobs are created, rather than the productivity enhancement within a firm itself.

Figure 3.9 Earnings changes as individuals move to businesses that received a voucher



Source Belmana analysis of ASHE

Table 3.5 Earnings changes as individuals move to businesses that received a voucher

	Growth	Count
Unsupported >> supported business	14.2%	446
Supported business >> unsupported	5.2%	332
Between unsupported	7.5%	124,492

Source: Belmana analysis of ASHE

National economic impacts

3.51 At the national level, it is likely that the effects of vouchers on employment will be largely neutral. While businesses that have received vouchers have expanded the size of their workforce, this will have come at the expense of loss of employment in other firms. Therefore, in line with the Green Book, we have assumed 100% displacement.

3.52 However, the Green Book also states that "productivity effects should be included in the calculation of UK costs and benefits where they can be objectively demonstrated. Productivity effects may arise from movement to more or less productive jobs". The analysis above demonstrates that vouchers have resulted in people moving to more productive jobs and can therefore be counted as an additional effect at a national level.

3.53 To quantify the scale of these effects we have applied the following steps:

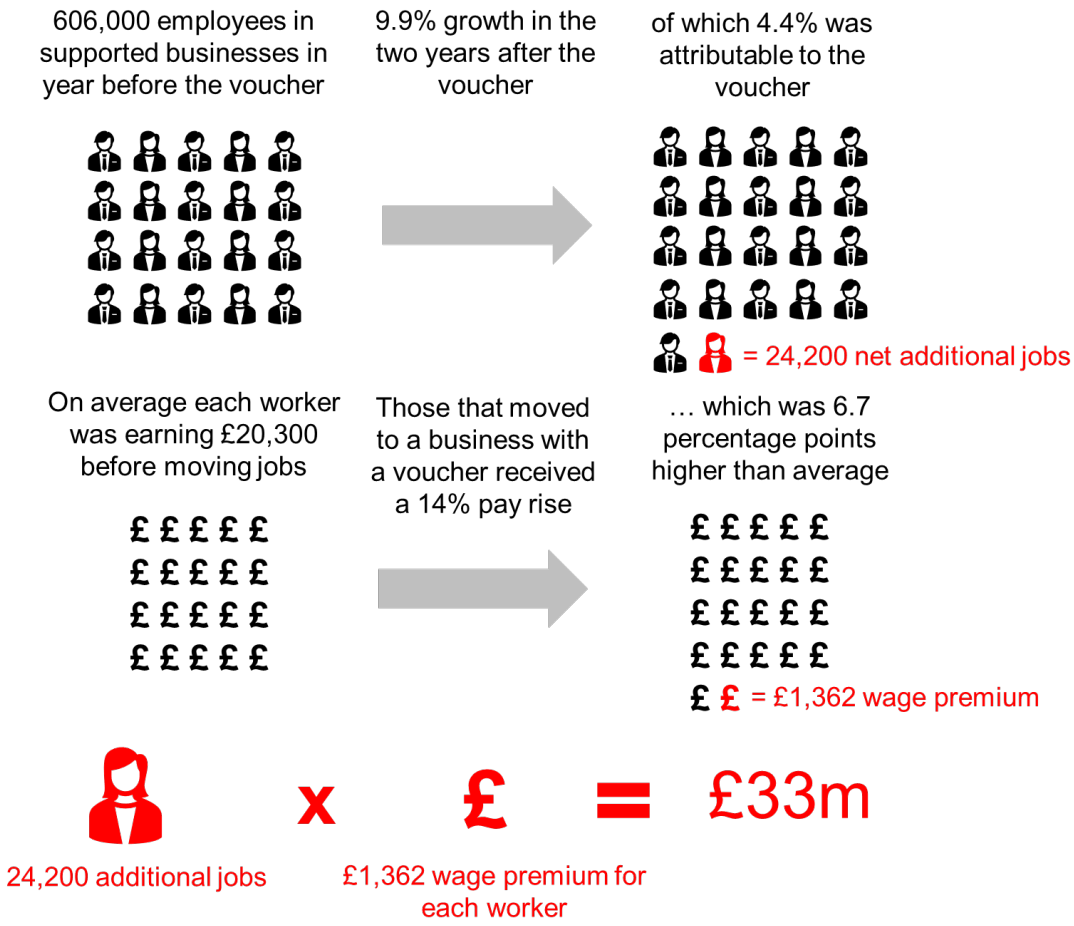
- BDUK's monitoring data shows 27,536 businesses received vouchers which were connected by the end of 2021. Table B.2 shows that, on average, businesses that

received vouchers had 22 employees[15]. If this applied to the whole business population, it would mean there were 605,972 employees in businesses that received vouchers in the year before the voucher.

- By the second year (the year after the voucher was connected), employment in business voucher beneficiaries had increased by 9.9% relative to the base year. Of this, 4.0% was additional (over and above the jobs growth in the preferred control area). Therefore it can be assumed that vouchers led to the creation of 24,238 additional jobs (605,972 x 0.04).
- The average salary for workers in the wider business base was £391 per week in 2018 (£20,332 per annum). Workers who moved to a business that received a voucher received a 14% pay rise, which was 6.7 percentage points higher than workers moving between unsupported businesses. Therefore the wage premium associated with each additional job was £1,362 (£20,332 x 0.067).
- Based on 24,238 additional jobs, the total improvement in productivity is therefore £33m in 2018 prices. Adjusting for inflation, this is equivalent to **£37.5m** in 2022 prices.

[15] Based on businesses which we could match to records in the BSD where there was data available in the year before the voucher was connected

Figure 3.10 Diagram showing how productivity effects have been calculated



Source Hatch

Area level analysis

Methodology

3.54 The method for the area level analysis is explained in detail in Appendix C and summarised below:

- The analysis has been undertaken at the level of output areas, the same local units of geography used to analyse changes in broadband performance and availability in Chapter 2. The OAs that benefited from support were identified by linking the businesses which claimed a voucher to the relevant output areas in the BSD.
- Like the firm level analysis, the data used to assess performance is from the BSD. However, here, observations for employment are at local unit level. These are the individual establishments which include all the shops, offices, depots and branches of multi-site businesses. This dataset also enables the tracking of

relocations and the opening of new locations. The BSD does not contain any turnover data at this level. For single site businesses, the enterprise level dataset is sufficient to understand the turnover for these businesses. For multi-site businesses, the turnover must be apportioned across the local units that make up the business. This was done using the employment data for local units. For example if a retailer has annual turnover of £1 million and ten shops, each with ten employees, it is assumed that each shop (local unit) has turnover of £100,000.

- PSM is then used to identify control groups of output areas with similar characteristics to those that have received vouchers. This includes the log of employment, the log of the number of local units, number of new local units, number of relocated local units, the log of employment from relocations measured on the base year as well as past growth. In addition, to eliminate unobserved differences due to spatial characteristics the comparable areas are also restricted to within a certain geography from the treated area (e.g., matching within region/local authority district).
- The various models considered different groups of these variables. From the estimated models a preferred and alternative model were chosen based on the quality of the matching - whether it managed to balance variables both those included and excluded in the model - as well as whether the comparison groups experienced similar past trends.
- The preferred model matched areas on the basis of employment levels, past growth in employment, sales/turnover, the level of new businesses created in an area before support, the level of relocations into an area before support and average download speed. The alternative counterfactual model used all of these variables except past growth in employment and the level of relocations into an area.
- The performance of output areas in the treated and control groups was tracked over time in the BSD, measuring changes in employment and turnover. This allows us to quantify the difference in change in these outcome indicators between treated and control areas. If the difference is statistically significant, this may be attributable to vouchers, subject to the caveats we explain below. .

Robustness of the analysis

3.55 The area-level analysis is subject to a number of important caveats:

- **Scale of intervention**: 15,436 business vouchers were included in the analysis, which were spread across 8,512 output areas, meaning there were 1.8 vouchers per output area. On average there were 101 local units per output area, meaning fewer than 2% of business establishments in treated areas received a voucher. There may be a small number of other businesses that have gained access as a result of the voucher, but this still represents a very modest scale of intervention, particularly when compared with the firm level analysis. This makes it very difficult to robustly assess the effect of vouchers on area level performance, given the wide range of other factors which could affect this.

- **Limitations of turnover data**: as described above, the BSD only provides sales data for enterprises rather than local units. Therefore, for multi-site businesses, it is necessary to apportion the sales data to all of the local units on the basis of their share of employment in the enterprise as a whole. We did consider restricting the analysis to single site enterprises, however this would not have provided a sufficiently large sample size. This means it is very difficult to accurately measure the effect of vouchers on the turnover of local units belonging to multi-site businesses.

3.56 As a result of the above, the analysis of effects on turnover should only be treated as indicative. The analysis of effects on employment is more robust but is still subject to much greater uncertainty than the firm level analysis.

Impact analysis

Employment

3.57 Figure 3.11 compares the change in employment in areas with business vouchers with the following other areas.

- The preferred counterfactual ('preferred' in the chart)
- The alternative counterfactual ('alternative' in the chart)
- All output areas in England and Wales ('all output areas')

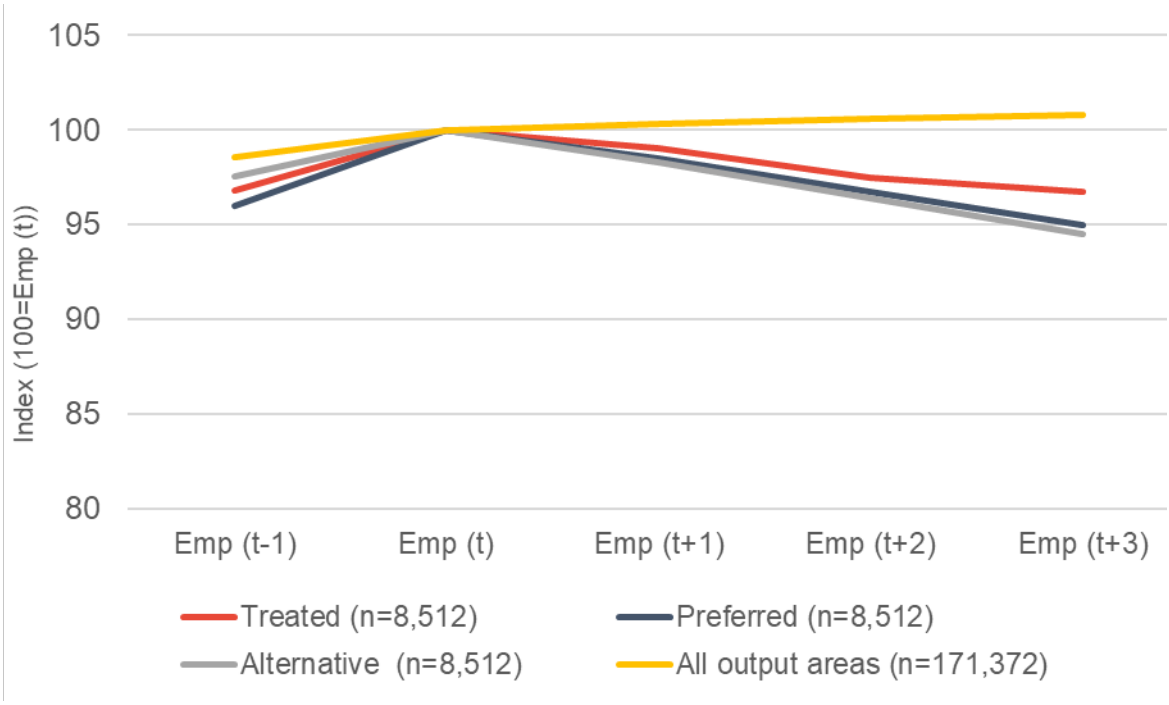
3.58 It shows that employment has declined in areas that have received business vouchers. Relative to year t (the year before the voucher was connected), the log of employment is 1% lower in year t+1, 2.5% lower in year t+2 and 3.3% lower in year t+3.

3.59 The chart also shows that areas with business vouchers have performed worse than the average for all output areas, but better than both of the matched control groups. In both the preferred and alternative control areas, employment declined by around 5% by year t+3.

3.60 The reasons for the relative performance compared to all output areas is not clear. It could be explained by the fact that the average for all output areas is skewed by high growth locations such as city centres and areas which have seen significant new development. Since vouchers have tended to be used outside city centres and in established business areas rather than new developments, this may explain these trends. It may also be due to the businesses in treated areas being more vulnerable to the effects of the pandemic than the average for all areas.

3.61 The chart does show that, when we match output areas on the basis of their characteristics, businesses with vouchers perform slightly better than the control areas. This suggests that receiving a business voucher may prevent part of the decline in employment that occurs in similar areas. If we consider this in the context of the firm level analysis, which showed a net additional effect on employment as a result of vouchers, this may suggest that receiving a voucher has helped businesses to navigate some of the challenges facing other businesses in the local area and, as a result, avoid further job losses.

Figure 3.11 Indexed log of employment change in areas with business vouchers and control areas



Source Belmana

3.62 The difference-in-difference analysis presented in Table 3.6 show that the fall in employment in areas with business vouchers was lower than the preferred control area, and that the difference was statistically significant at the 10% level in years t+1 and t+2 and at the 1% level in year t+3 (1.8%). This suggests vouchers had a statistically significant effect, although we would note the caveats above. It is difficult for the modelling to control for the full range of factors which affect area level performance, particularly given the effects of the pandemic, and the relatively modest scale of impact means the results are subject to uncertainty.

Table 3.6 Difference in difference analysis for area level employment impacts

Time period	Change in treated areas	Change in preferred control areas	Change in alt control areas	Difference with pref control areas	Difference with alt control areas
Year of support	-1.0%	-1.6%	-1.7%	+0.6%*	+0.7%*
2nd year	-2.5%	-3.2%	-3.6%	+0.7%*	+1.1%*
3rd year	-3.3%	-5.1%	-5.5%	+1.8%***	+2.3%**

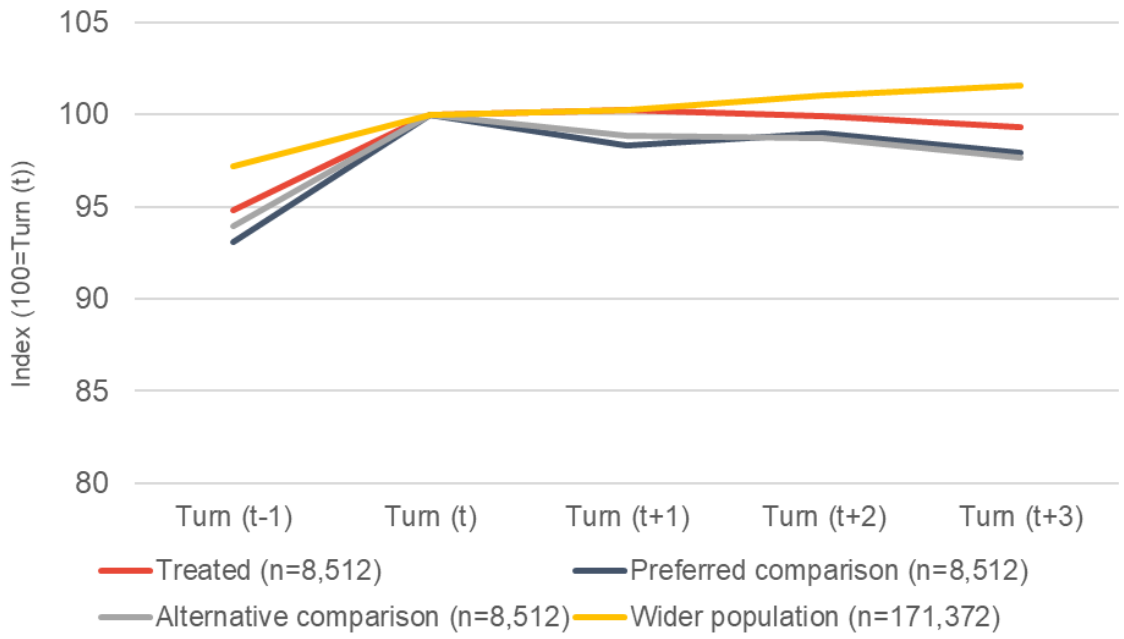
Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*)

Turnover

3.63 Figure 3.12 compares the change in turnover in areas with business vouchers and comparator areas. It shows a similar pattern to employment; there was a slight fall in turnover in areas with vouchers, but the fall was lower than in both the preferred and the alternative counterfactual. However, when compared to the average for all output areas, areas with business vouchers fared slightly worse.

3.64 Again, it is not clear why treated and control areas performed worse than average. This could be due to the effects of the pandemic being more pronounced in treated/control areas than average, or the fact that vouchers have tended to be used in established business locations rather than areas with significant new development.

Figure 3.12 Indexed log of turnover change in areas with business vouchers and comparators



Source Belmana

3.65 The difference-in-difference analysis presented in Table 3.7 show that the fall in employment in areas with business vouchers was lower than the preferred control area, and that the difference was statistically significant at the 5% level in year t+1 but not in year t+3. This may indicate that vouchers had a statistically significant effect, although we would note that these results are only indicative. Not only is it difficult to account for the range of factors which affect area level performance, but the turnover data is subject to further limitations due to the need to estimate turnover for multi-site businesses. This means the results are subject to significant uncertainty and should only be treated as indicative.

Table 3.7 Difference in difference analysis for area level turnover impacts

Time period	Change in treated areas	Change in preferred control areas	Change in alt control areas	Difference with pref control areas	Difference with alt control areas
Year of support	0.2%	-1.7%	-1.2%	+1.9%***	+1.4%**
2nd year	-0.1%	-1.0%	-1.3%	+0.9%	+1.2%
3rd year	-0.7%	-2.1%	-2.3%	+1.4%	+1.6%

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*)

Employment changes from relocations

3.66 The BSD data allows us to track businesses which move location and to identify those businesses which have registered for PAYE[16] and VAT[17] for the first time. These can be used to assess the change in employment which is due to businesses relocating into an area with vouchers and the change due to new businesses being started in treated areas.

3.67 In the years following support, a total of 136,700 businesses relocated to OAs which had received vouchers, cumulatively creating over 1.1m jobs. On average this is equivalent to around 16 local units and 134 jobs relocating to areas with vouchers. Table 3.8 shows how the employment created by these relocating businesses has built up over time for each cohort relative to the base year (the year before the voucher was connected). It shows that in most cases, the number of jobs that have been relocated to treated OAs in any given year have been lower than the base year. This applies to all of the cohorts except areas that received a voucher in 2017 (a very small cohort).

Table 3.8 Employment change due to businesses relocating in to output areas with business vouchers

Cohort of support	2017 cohort (n=41)	2018 cohort (n=2,565)	2019 cohort (n=4,062)	2020 cohort (n=1,844)
Period of analysis	2017-21	2018-21	2019-21	2020-21
Base year	12,000	281,700	205,300	51,500
Yr of support	26,700	241,800	176,400	43,100
2 yrs	12,900	268,700	138,700	
3 yrs	25,000	210,100		

Source: Belmana analysis of BSD. Figures rounded to nearest hundred.

[16] Pay As You Earn. This is s the system which employers use to extract income tax and national insurance out of salaries.

[17] Value Added Tax

3.68 Table 3.9 compares the change in employment due to firms relocating with control areas. It shows that both control areas have also experienced a fall in employment from relocating businesses relative to the base year. In both cases the differences are not statistically significant, meaning vouchers have had no observable effect.

Table 3.9 Difference in difference analysis for employment due to businesses which have relocated to areas with vouchers

Cohort of support	Change in treated	Change in preferred	Change in alternative	Diff with preferred	Diff with alternative
Year of support (n=8,512)	-10.1%	-10.3%	-10.1%	0.2%	0.0%
2 years (n=6,668)	-13.1%	-13.6%	-8.3%	0.5%	-4.8%
3 years (n=2,606)	-24.0%	-25.6%	-22.0%	1.6%	-2.0%

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*)

Employment changes from new business starts

3.69 A total of 307,400 new businesses were started in areas with business vouchers, creating around 2 million new jobs. On average this is equivalent to 36.1 new businesses and around 231.1 jobs in each treated OA. However, relative to the base year, the annual employment contributed by new businesses has decreased for most of the business cohorts in each of the years following support (see Table 3.10).

Table 3.10 Employment change due to new business starts in areas with business vouchers

Cohort of support	2017 cohort (n=41)	2018 cohort (n=2,565)	2019 cohort (n=4,062)	2020 cohort (n=1,844)
Base year	42,200	605,000	370,500	131,600
Yr of support	37,500	492,300	307,500	61,700
2 yrs	56,000	451.200	210,500	
3 yrs	29,700	320,700		

Source: Belmana analysis of BSD. Figures rounded to nearest hundred.

3.70 The difference in difference analysis shows that both control areas have also experienced a fall in employment from new business starts relative to the base year. However the fall was higher than in areas with vouchers, with the difference being statistically significant at the 10% level in two of the years. This may indicate that vouchers have helped to moderate the decline. However, as previously noted, these estimates are subject to significant uncertainty given the wide range of other factors which could explain this.

Table 3.11 Difference in difference analysis for employment due to new business starts

Cohort of support	Change in treated	Change in preferred	Change in alternative	Diff with preferred	Diff with alternative
Year of support (n=8,512)	-10.1%	-13.5%	-14.5%	3.4%*	4.4%
2 years (n=6,668)	-22.2%	-23.3%	-21.5%	1.1%	-0.7%
3 years (n=2,606)	-30.0%	-35.2%	-32.4%	5.2%*	2.4%

Source: Belmana. Note: Significance levels are 1% (***), 5% (**) and 10% (*)

Conclusions

3.1 This chapter has looked at the effects of business vouchers on employment, turnover and productivity using counterfactual analysis (comparing the change in performance in treated areas and control areas). Analysis has been undertaken at two levels:

- **Firm level analysis**: the individual businesses that have received a voucher and the effect this has had on business performance.
- **Area level analysis**: the output areas that these businesses are located in

3.2 The firm level analysis shows that employment in businesses that received a voucher increased at a faster rate than in the preferred control group (based on firms that had cancelled voucher applications). This difference was statistically significant, indicating that a proportion of this employment growth is attributable to the voucher. If these results are representative of the wider business population, we estimate that this would mean over 24,000 jobs have been created by businesses as a result of receiving the voucher.

3.3 The firm-level analysis has shown that the additional jobs created in businesses that received a voucher have been in higher quality jobs that attract a wage premium for people moving in to these roles. This is an indicator that the jobs created through vouchers has resulted in movement from less to more productive jobs. We estimate the scale of these benefits to be £37.5m in 2022 prices.

3.4 The firm level analysis has, so far, not found evidence that vouchers have led to additional turnover or improvements in turnover per employee. Businesses that have received vouchers have performed better against these measures than the wider business population, including those with similar characteristics. However, when they are compared to similar businesses with cancelled vouchers or with similar businesses from the same exchange area, business performance has been similar or worse.

3.5 One possible explanation for this is that the results mainly reflect the impacts of the GBVS voucher scheme where vouchers were more likely to be connected in urban and commercial areas. Therefore, any businesses who wanted an upgraded connection (such as those who had a voucher application cancelled) were more likely to be able to secure an upgrade through alternative means. At this stage it has not been possible to assess differences between the GBVS and RGC schemes, however this will be a focus of the follow-up evaluation in 2024.

3.6 The area level analysis is subject to much greater uncertainty than the firm level analysis due to issues with turnover data for small areas and the fact that fewer than 2% of

businesses in supported output areas have received a voucher. That means the scale of intervention is very modest which makes it difficult to robustly detect the effects of vouchers, given the wide range of other factors which affect area level performance. With these caveats in mind, the results show that areas that have received vouchers have experienced a fall in employment and turnover, but that vouchers may have helped to avoid these falls being even greater.

4. Residential Survey Findings

Summary of key findings

- **Sample**: a total of 4,298 completed responses were received from residential voucher recipients, representing a 20% response rate. Based on a 95% confidence level, this means the results in the report have a margin of error of +/- 1.36%.
- **Residents' characteristics**: survey respondents tend to be older, wealthier and higher skilled than the UK population. 89% of respondents were over the age of 40 compared to a national average of 75% (based on the age of the household reference person), and 39% were retired compared to a UK average of 23% (based on total population[18]). This is likely to be explained by the fact that most residential vouchers have been used in rural areas which have an older population. Respondents were also less likely to live alone, and less likely to have children in the household than the UK average.
- **Motivations**: The main drivers for residents applying for the voucher were to access faster download speeds, to access a reliable line, and to access faster upload speeds. 88% of residents sought the upgrade for personal internet use, 55% sought the upgrade to work or run a business from home and 24% wanted the upgrade for educational purposes.
- **The voucher process**: Resident satisfaction with the voucher application process was high, with 88% of residents satisfied or very satisfied with the ease of the voucher process and 87% satisfied or very satisfied with the length of the process.
- **Satisfaction with upgraded connection**: Residents' satisfaction with their internet connection has increased following the upgrade. Whilst before the upgrade, between 26% and 36% of residents were satisfied with their connection, more than 90% of residents are now satisfied with the upgraded connection's reliability, download and upload speeds.
- **Use of the upgraded connection**: 96% of residents are making greater use of personal internet applications following their upgrade, with a significant proportion of over 65s using these for the first time. 62% are making greater use of their internet for educational purposes and the same proportion (62%) are making greater use of the internet for work or business purposes. The majority of residents using their connection for these applications also report that their upgrade was important in enabling them to do so. For instance, 88% of households using the internet for children's education said their upgrade was important in enabling them to do so. 91% of those using the internet to work from home said it was important in enabling them to do so.
- **Benefits**: Just over half of residents (53%) reported that the upgrade had increased their life satisfaction, and 7% reported that they feel less lonely after the upgrade. Being able to keep in touch with friends and family, stream entertainment services and use online banking are the main internet uses that have improved life

[18] There is currently no up to date data on the economic activity status of household reference persons. This will be available from the 2021 Census but has not been published yet.

satisfaction. 44% of residents said they have reduced their weekly travel as a result of their upgraded connection (three quarters of whom are people who work from home), 15% have found a new job or increased their salary and 8% have started a business. High proportions of households who are using the internet for educational or work purposes say it has improved their quality of life (83% and 86% respectively). There is also evidence of certain groups deriving particular benefits from the upgrade. For example, lone parents are more likely to have gained new skills or qualifications or found a new job.

- **Disbenefits**: Half of residents reported a disbenefit from their upgrade. The disbenefits affecting the greatest number of residents are the cost of upgrading (29%) and an increase in home energy usage (28%). Approximately one in ten have experienced an issue with their connection.
- **Covid 19 pandemic**: More than three quarters of residents (79%) say their upgrade has helped them to adapt during the pandemic. The main ways in which the upgrade has helped residents to adapt are being able to access entertainment services during lockdown, avoiding going to shops by shopping online and enabling members of the household to work from home.

Purpose of Chapter

4.1 This chapter presents the results of the survey of residents who received vouchers. This is a large and rich dataset which provides insights on the characteristics of households that have received vouchers, why they were motivated to apply, their satisfaction with the application process and the upgraded connection and the benefits they have derived from the upgrade. This helps to build a picture of how residents have benefited from the voucher schemes.

4.2 It also draws out the differences between groups including households with different characteristics (e.g. age, employment status, whether the household contains children), households in different locations (commercial and non-commercial areas) and households who received different types of vouchers (project/standard) or through different schemes (GBVS/RGC).

4.3 The survey also provides important evidence on what households would have done if the voucher had not been available, which we use to assess the additional effects of vouchers on wellbeing and other outcomes.

Method

4.4 The survey used a mixed-methods approach. An online survey was developed and sent to all 24,978 residential voucher recipients supported via the GBVS and RGC schemes where the premises were connected by the end of December 2021. This was based on the most recent vouchers data available to the evaluation team at the time.

4.5 Online survey responses were monitored, and telephone interviews were used to boost the number of responses and to minimise response bias from particular types of resident. For example, as the vouchers programme spanned several years from 2018 to 2021 there was a risk that residents who had received their voucher more recently were more

likely to respond compared to residents who had upgraded earlier in the programme period. This is due to later beneficiaries having better recollection of the upgrade and its benefits than earlier beneficiaries.

4.6 Telephone interviews were also used to contact households that had only partially completed an online response to the survey, to either complete over the telephone or to encourage them to complete their online response. It was also used more generally to encourage businesses to respond online if a telephone interview was not convenient for them. Telephone interviews also enabled residents who did not want to share their feedback online an alternative way of responding.

4.7 Residents were asked a range of questions to understand their household characteristics, motivations for using the voucher scheme, how they are using the internet, the benefits and disbenefits experienced from their upgrade and how it has helped them to adapt to the Covid-19 pandemic. A copy of the questionnaire is provided in Appendix C.

4.8 In total, 4,928 responses were received from residential voucher recipients, with 271 of these being fully completed by telephone. In total a 20% response rate was achieved from the total population of 24,979 vouchers[19]. Table 4.1 summarises the number of completed responses received from different groups of interest to DCMS. The table shows that, on the whole, the response rate across the groups was broadly representative of the population. However, to account for the small differences, such as a higher response rate from more recent vouchers, the data has been weighted using rim weighting[20].

4.9 Significance testing was conducted to identify any statistical differences in responses from key groups of interest. This focused on the following variables:

- **Voucher characteristics**: scheme, rural/urban, commerciality[21], year of application. This data was provided by BDUK.
- **Household characteristics**: age, household type and size, whether they have children or not, housing tenure and occupation. These characteristics were captured as part of the survey.

4.10 Where statistically significant differences are identified, to a 95% confidence interval, these are noted in the commentary.

4.11 Where relevant, findings from the residents survey have been compared with the findings from the survey of business voucher recipients conducted earlier in 2022.

[19] In total, contact details for 26,252 vouchers were provided and emailed the survey. Out of those, 3,625 emails bounced back / were unusable.

[20] Random Iterative Method, which involves giving greater or lesser weight to responses from different groups to ensure the sample is representative of the target population. It should be noted that it was not possible to weight by household characteristics such as age, income etc as this information on voucher recipients is not held by BDUK.

[21] Commerciality has been assessed based on BDUK's cost model, which estimates the cost to build to all premises in the UK. This has been matched to the survey respondents. Where the estimated cost to build is less than £615, the premise is considered to be 'commercial'. If it is over £615, it is considered to be 'non-commercial'.

4.12 The demographic characteristics of respondents were also compared to data for the UK population to understand how these compare to the national average. This drew upon a range of demographic and socio-economic datasets produced by ONS which are referenced in the chapter.

Table 4.1 Voucher population and survey responses

Category	Description	Population (n)	Population (%)	Survey responses (n)	Survey responses (%)
Voucher type	Project	24,955	99.90%	4,928	100%
	Standard	24*	0.10%	0	0%
Voucher scheme	GBVS	6,621	27%	1,125	23%
	RGC	18,358	73%	3,803	77%
Urban/rural	Urban	2,750	11%	401	8%
	Rural	22,228	89%	4,527	92%
Commerciality	Commercial	7,493	30%	1,327	27%
	Non-commercial	15,494	62%	3,337	68%
	Unknown	1,991	8%	264	5%
Year of connection	2018	534	2%	36	1%
	2019	2,767	11%	543	11%
	2020	9,801	39%	1,598	32%
	2021	11,875	48%	2,751	56%
	Unknown	2	0%		

Source: Winning Moves

*the small number of standard residential vouchers were in the early piloting stage, which wasn't continued into the main scheme launch. Residential vouchers have only been available as part of projects under both GBVS and RGC schemes.

Survey findings

Characteristics of respondents

4.13 This section describes the characteristics of residential voucher recipients based on the responses to the survey. Data is weighted as set out in the section above. Demographic data is not available for the population of residential voucher recipients so it is not possible to say whether the characteristics of survey respondents is representative of the residential voucher population. Where data is available, the analysis compares the characteristics to the UK population as a whole.

Age of respondents

4.14 Figure 4.1 shows the age profile of voucher recipients who responded to the survey and compares this to the age of household reference persons (HRPs)[22] for the UK as a whole. It shows a disproportionately high share of survey respondents were over the age of 40 (89%) compared to the UK population (75%). In contrast only 10% of respondents were aged between 18 and 39 compared to 25% of the UK population.

4.15 A key reason for the difference with the UK population is that residential vouchers have tended to be used in more rural areas (see Table 4.1) which have older populations; Census data shows 58% of people living in rural areas were aged 40 or over in 2021 compared to 49% in urban areas. This may suggest that the age profile of survey respondents is representative of the HRP population in those areas where vouchers have been used. However it is not possible to verify this as ONS has yet to publish sub-national data on the age of HRPs from the 2021 Census, which would allow us to compare the age of voucher recipients with HRPs in rural areas.

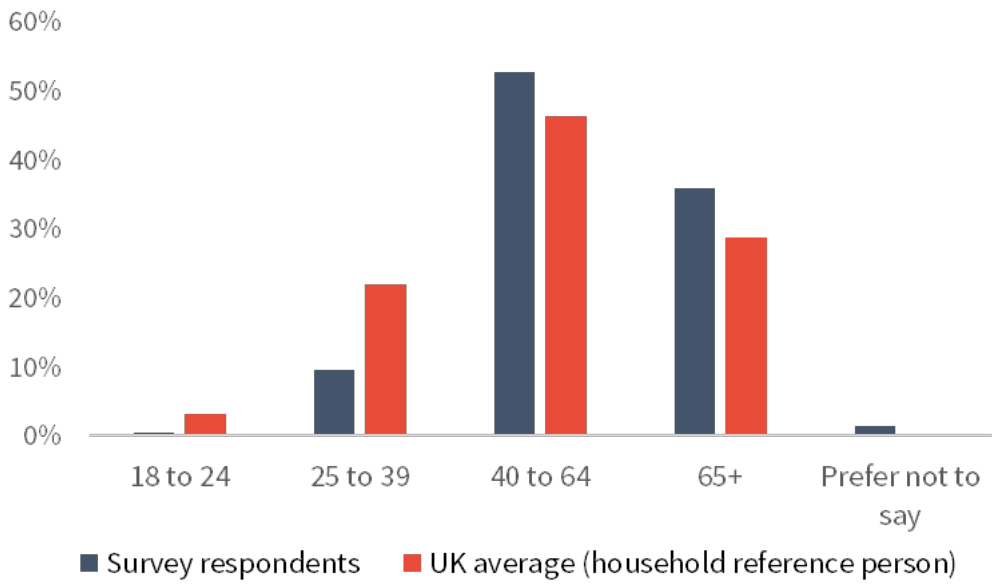
4.16 It is also possible that the age profile of voucher recipients is not representative of the local population, and the difference with the UK population is instead explained by older voucher recipients being more likely to respond to the survey. However there is limited evidence for this. While some studies have shown differences in response rates for different age groups, this is strongly influenced by the mode of survey. For web-surveys, which was the main method used in this case, a number of studies find that young people are *more likely* to respond than older people, particularly if they can complete it on their smartphone which was the case for this survey[23]. Although it should be noted that a number of these studies attribute this to varying levels of internet access which we know is not the case for voucher recipients.

4.17 This suggests that differences in survey response rates by age group do not explain why survey respondents tend to be older than the UK average. It suggests strongly that residential vouchers are more likely to have been used by older households, and that this is fully or partly explained by the age profile of the areas where they have been used.

[22] The household reference person is the member of the household in whose name the accommodation is owned or rented, or is otherwise responsible for the accommodation. Since most vouchers are likely to have been applied for by the household reference person, this is a better comparison than comparing against the age of the total UK population.

[23] See Cho et al (2013), Azeredo et al (2019) and Van Horn et al (2016)

Figure 4.1 Age of respondents (survey sample = 4,928)

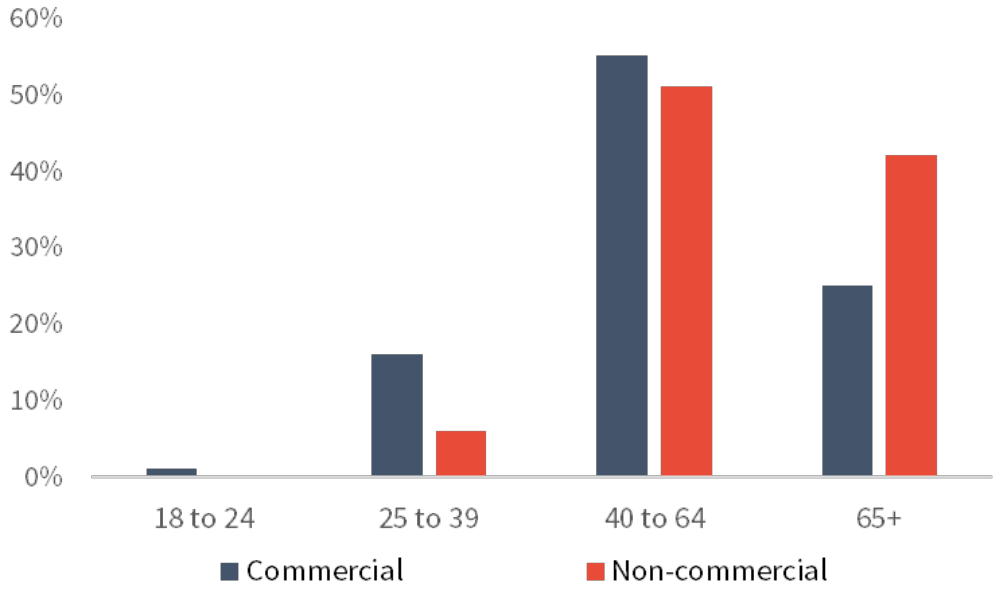


Source Winning Moves and ONS Mid Year Population Estimates

4.18 The age profile of residential voucher beneficiaries is even older in non-commercial areas (those households in the most remote or difficult to access locations where costs are greatest). Figure 4.2 shows that 42% of respondents in these locations were over the age of 65 compared to 25% in commercial areas.

4.19 This difference in demographics is important for understanding differences in survey responses between commercial and non-commercial areas in later sections. The high proportion of older households in non-commercial areas has an important bearing on how respondents are using the internet and the benefits they derive from it. This is analysed in paragraphs 4.67 to 4.83.

Figure 4.2 Age profile of respondents by commerciality category (n=4,928)



Source Winning Moves

Employment status

4.20 Just over half (57%) of survey respondents are economically active (either employed, self-employed or unemployed but seeking work). This is significantly lower than the UK average for people aged 16+ (63%)[24]. This is due to the large proportion of survey respondents who are retired (39%), which is significantly higher than the UK average (23%). This is a reflection of the older age profile of survey respondents.

4.21 If we exclude retired people from the sample, thereby focusing mainly on people of working age, the economic activity rate of survey respondents is 93% which is significantly higher than the equivalent for the UK (81%). This might be expected given that residential voucher recipients need to be in a secure financial position to pay for a fibre broadband subscription.

4.22 As above, it is not possible to say with certainty that this is representative of the residential voucher population. Some studies have found differences in response rates between groups with a different employment status (for example, employed people have been found to be more likely to respond than unemployed people). However, we have been unable to find any evidence that retired people are more likely to respond to a web survey than people from other groups. Therefore, we can be reasonably confident that vouchers have been disproportionately used by retired households.

[24] In this case it is not possible to compare with the economic status of HRPs as the data is not yet available from the 2021 Census.

Table 4.2 Economic status of survey respondents compared to UK population

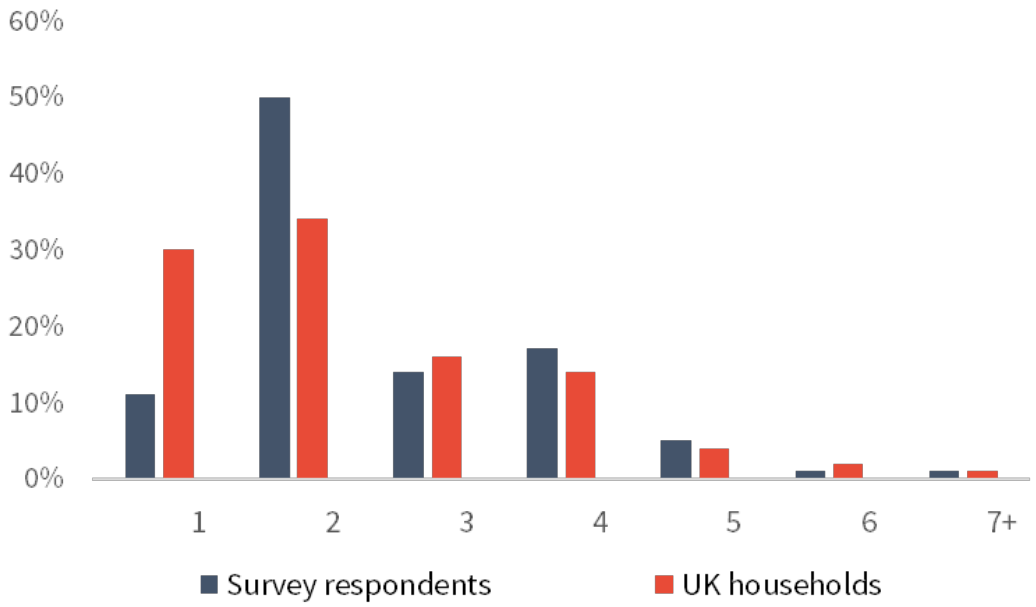
Employment status	Survey responses (n)	Survey responses (%)	UK population
Economically active	**2,809**	**57%**	**63%**
Employed	1,823	46%	53%
Self employed	493	10%	8%
Unemployed	50	1%	2%
Economically inactive	**2,020**	**41%**	**37%**
Retired	1,922	39%	23%
Student	0	0%	7%
Inactive for another reason	99	2%	7%
Prefer not to say	**99**	**2%**	
Total	**4,928**	**100%**	**100%**

Source Winning Moves and ONS (2022): Annual Population Survey

Size of household

4.23 The average household size across survey respondents is 2.6, which is larger than the UK average of 2.36. Half of respondents were from two person households (50%) compared to a UK average of 34%, while 38% lived in a household of 3 or more people. Only 11% of survey respondents lived on their own which is significantly lower than the UK average of 30%.

Figure 4.3 Number of people in households (n=4,928)



Source Winning Moves and ONS (2021): UK Household Survey

Household type

4.24 Table 4.3 shows the characteristics of households that responded to the survey. Almost half (44%) of survey respondents live in a household with a couple with no children. Almost four in ten (38%) live with children; (34%) are a couple with at least one child and 4% are lone parents with at least one child. Smaller proportions of respondents are from a one person household, two or more unrelated adults or a multi-family household.

4.25 It is not possible to say with certainty whether this is representative of the voucher population. A comparison with UK household data shows survey respondents were significantly more likely to live in a household containing a couple and significantly less likely to live in a single person household.

Table 4.3 Household type

Household type	Survey respondents (n=4,928)	UK Households
One person household	11%	29%
A couple with no children	44%	28%
A couple with at least one child	34%	28%
Lone parent with at least one child	4%	10%
Two or more unrelated adults	2%	3%
Multi-family household	5%	1%

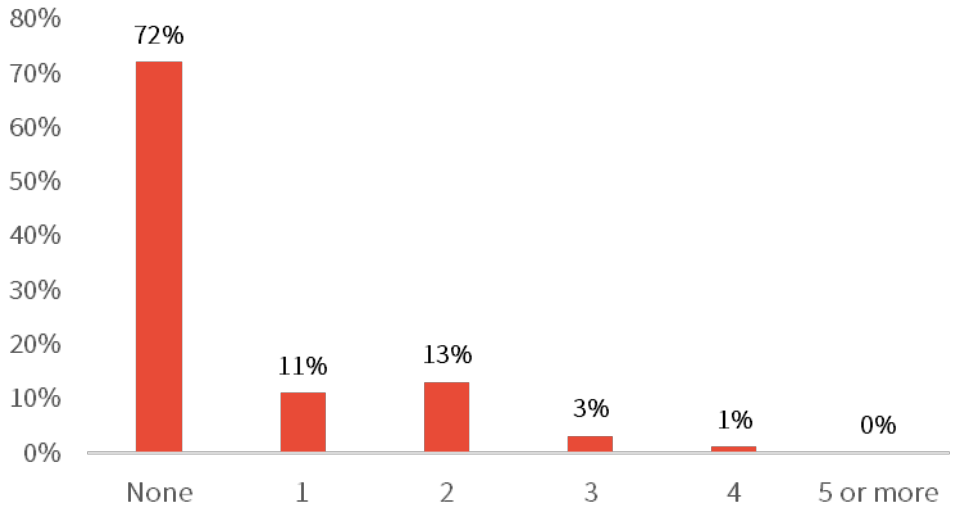
Source: Winning Moves and ONS (2021): Families and Households

Children in full time education

4.26 Just over one quarter (28%) of survey respondents have one or more children in full-time education within their household. Although a direct comparison to national data is not available, the Families and Households data (2021)[25] shows that 39% of UK households include one or more children, suggesting that the respondent sample has a lower proportion of households with children compared to nationally.

[25] https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/bulletins/familiesandhouseholds/previousReleases

Figure 4.4 Number of children in full-time education in household (n=4,928)



Source Winning Moves

Household income

4.27 Survey respondents were drawn from a broad range of income groups[26]. However Figure 4.5 shows that the distribution was skewed more towards higher income households, with 20% reporting a household income of over £80,000; significantly more than any other income band. To put this in to context, in 2021 the median salary (for an individual) in the UK in 2021 was £31,400 and the average household disposable income (after tax) was equally £31,400[27]. A high proportion of respondents were from older age groups and therefore more established in their careers. This may explain part of the difference but is unlikely to explain all of it.

4.28 The chart shows that a quarter of respondents did not wish to report their income. If these are excluded from the sample, it is estimated that more than three quarters of respondents (76%) live in households with an income over £30,000 (roughly the national median).

4.29 A number of studies have shown that response rates to web-surveys are generally lower among lower income households than higher income households[28], which may mean the sample is skewed towards higher income voucher recipients.

4.30 However, there are also a number of reasons why we might expect vouchers to have been disproportionately used by higher income households. Analysis undertaken in the first phase of this evaluation showed that vouchers had tended to be used in areas that are less deprived than the median. Even when we focused just on LSOAs in rural areas, this found that 70% of vouchers had been used in areas in the fifth to eighth decile of

[26] It should be noted that we have assumed respondents have provided a 'before tax' income value as the survey question did not specify.

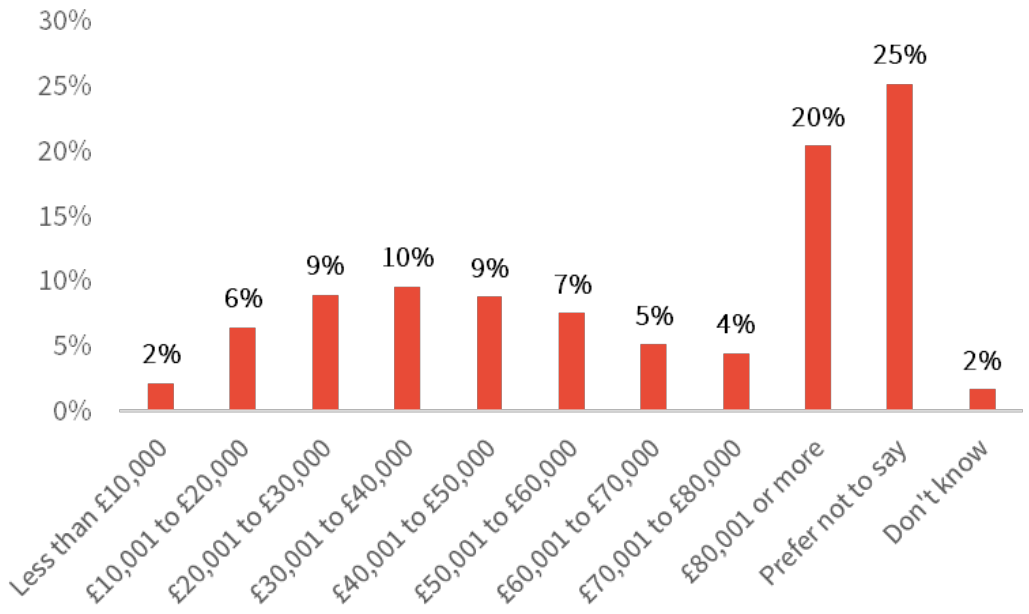
[27] https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours

[28] See Yu and Yu (2012) which conducted a meta-analysis of 98 studies

deprivation (where the first decile is the most deprived). A number of suppliers interviewed during the first phase of the evaluation also reported that they specifically target households in wealthier areas as take-up is likely to be higher. This suggests that the high proportion of wealthier households using residential vouchers may be a natural outcome of the fact that voucher schemes are supplier-led.

4.31 Nevertheless, it should also be noted that lower income households have also benefited from the voucher scheme, even if the proportion is lower than higher income groups.

Figure 4.5 Household income of survey respondents (n=4,928)



Source Winning Moves

Tenure

4.32 85% of survey respondents reported that they own their property (either outright or with a mortgage), which is significantly higher than the average for UK households (64%)[29]. 53% of respondents own their home outright, which is more than double the UK average (21%). In contrast, only 10% of respondents rent their home (either privately or from a council/housing association) compared to 36% of households in the UK. Again this offers evidence that residential voucher recipients tend to be from more financially secure households.

[29] This may be expected as homeowners are likely to have a greater incentive to improve their broadband connection than people who are in rented accommodation and may only be there for a short period of time (and face greater restrictions on making changes to the property)

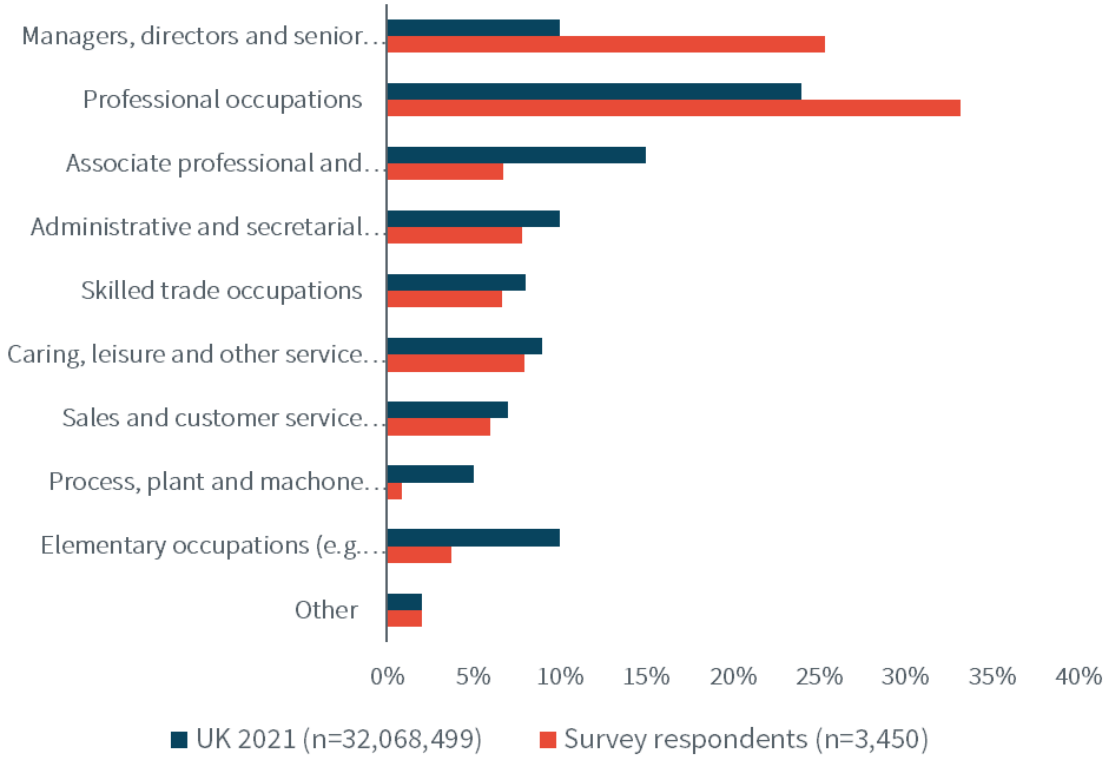
Figure 4.6 Housing tenure

Source Winning Moves and ONS: People in households by housing tenure and combined economic activity status of household members: Table I - Office for National Statistics (ons.gov.uk)

Occupations

4.33 Survey respondents are, on average, employed in higher skilled occupations than the rest of the UK population. Of those that have one or more adults in employment within their household, (n=3,450) 58% work in either a managerial or professional occupation (the two highest skilled groups) compared to 34% in the UK as a whole. In contrast only 11% are employed in the three lowest skilled groups (sales and customer service; process, plant and machine operatives, and elementary occupations) compared to 22% in the UK as a whole. The fact that

Figure 4.7 Occupation of survey respondents (n=3,450)



Source Winning Moves and ONS Annual Population Survey

Use of the internet

4.34 All survey respondents are regular users of the internet. Almost all (98%) survey respondents said that they go online at least once a day, when connected to their home internet, with the vast majority going online multiple times a day. The remaining 2% said they go online two or three times per week.

4.35 These findings can be compared with ONS's survey of internet access and use for the UK population as a whole[30]. This found that 89% of adults used the internet daily in 2020. This means voucher beneficiaries are more likely than the general population to be frequent internet users[31]. The fact that voucher beneficiaries are frequent users could also be seen as positive in that that the benefits of usage should take effect quickly.

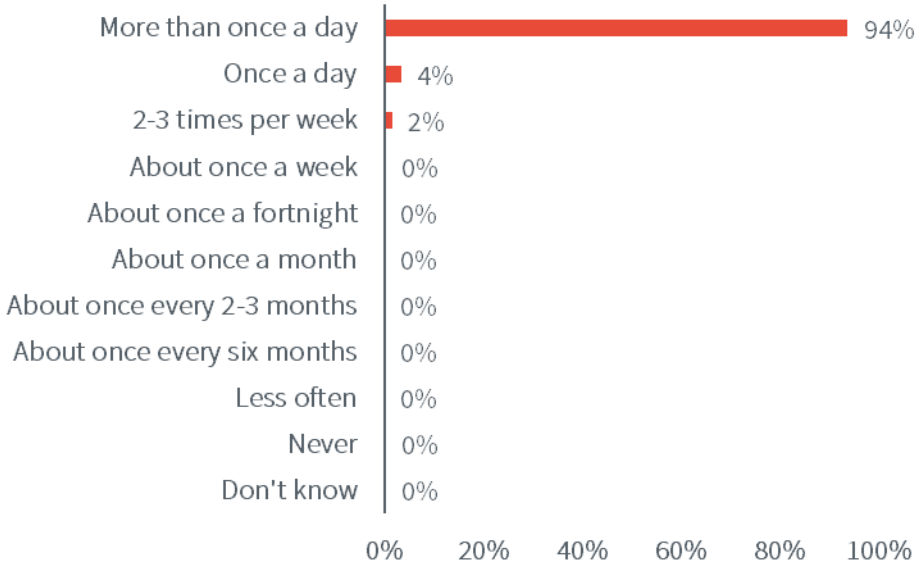
4.36 There is also evidence that vouchers have helped those who rarely go online to engage more with the internet. For example, 89% of respondents who said they use the internet

[30] Internet access - households and individuals - Office for National Statistics (ons.gov.uk)

[31] It should be noted that the ONS survey data is for 2020 while the vouchers survey was undertaken in 2022. The ONS survey shows that the proportion of people who are daily internet users increases year on year. Therefore we would expect the proportion in 2022 to be higher than this data suggests.

less frequently than once a day said they were making greater use of the internet for personal and leisure uses.

Figure 4.8 Thinking about when you are connected to your home internet, how often do you personally go online? (Exclude internet access from mobiles and smartphones if you are accessing the internet via your mobile) (n=4,928)



Source Winning Moves

Motivations and goals

Decision to apply for a voucher

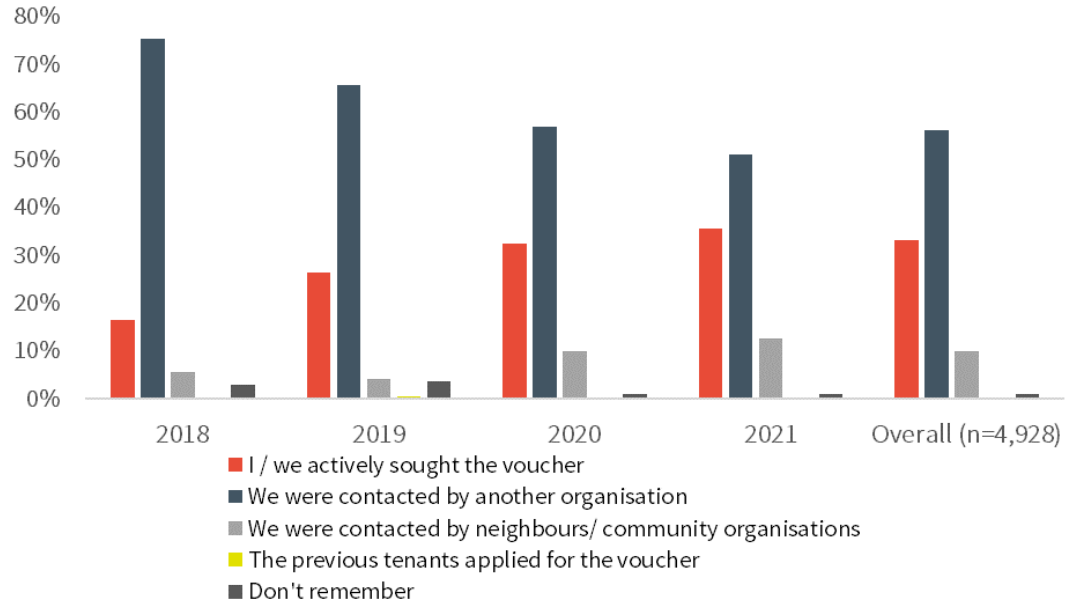
4.37 Residents were asked whether they actively sought the voucher themselves or whether they were contacted by another organisation. One third of residents (33%) said that they actively sought the voucher. This proportion is broadly in line with the proportion of businesses that said they contacted a broadband supplier about an upgrade (30%) in the survey of business voucher recipients.

4.38 Over half (55%) of residents said they were contacted by another organisation – this is a higher proportion compared to the third of businesses (32%) that said they were contacted by a broadband supplier. 10% of residents specifically mentioned they were contacted by neighbours or a local community group.

4.39 Figure 4.9 shows the proportion of residents that were contacted by another organisation about the voucher scheme decreased from 75% of 2018 applicants to 51% of 2021 applicants. Conversely, the proportion of residents that have actively sought the voucher has increased over time, from 16% of residents in 2018 to 36% of 2021 applicants. This may suggest later voucher recipients were more motivated to apply for a voucher than

earlier recipients and have been more proactive in seeking out new connectivity[32]. It should also be noted that a large proportion of these later voucher recipients who actively sought the voucher reported that they had heard about the voucher scheme through a neighbour or friend.

Figure 4.9 Did you actively seek the voucher yourself or were you contacted by another organisation?



Source Winning Moves

4.40 The majority of survey respondents (56%) found out about the voucher scheme through their broadband supplier (see Figure 4.10). Over a quarter (26%) found out about the scheme through a neighbour, community group or through friends and family. Much smaller proportions of residents first heard about the scheme through a local authority or an online search, advertisement or through social media.

4.41 There were a number of statistically significant differences in how residents heard about the voucher scheme:

- A higher proportion of GBVS recipients (62%) heard about the scheme through a broadband supplier than RGC voucher recipients (54%). In contrast, a slightly higher proportion of RGC recipients (8%) heard about the scheme through a local authority compared to 4% of GBVS recipients.
- The proportion of residents hearing about the scheme through a broadband supplier has decreased over time; 75% of residents that applied for a voucher in 2018 heard about the scheme through a broadband supplier compared to 74% in 2019, 60% in 2020 and 48% in 2021. In contrast, the proportion of people who

[32] Over time suppliers have increasingly linked to the voucher scheme through their own website, allowing them to identify and aggregate demand themselves. This could also explain why a higher proportion of beneficiaries in later years reported that they actively sought the voucher themselves.

heard about it through a neighbour, community group or friend increased from 22% to 30%. This suggests that the voucher schemes have been increasingly successful in raising awareness of the benefits of vouchers through word-of-mouth, while earlier schemes were more dependent on marketing of suppliers. However, it may also indicate that suppliers were already aware of pre-existing demand, which they could serve in the early phases of the voucher scheme. This is likely to have diminished over time, resulting in a pattern which is more representative of the flow of demand.

- A slightly higher proportion of residents that are employed (59%) heard about the scheme through a broadband supplier compared to 51% of retired residents. In contrast, retired residents were more likely to have heard about the scheme through a community group or through a neighbour, family or friends.

Figure 4.10 Where did you first hear about the voucher scheme (n=4,928)

Source Winning Moves

Motivation for applying for a voucher

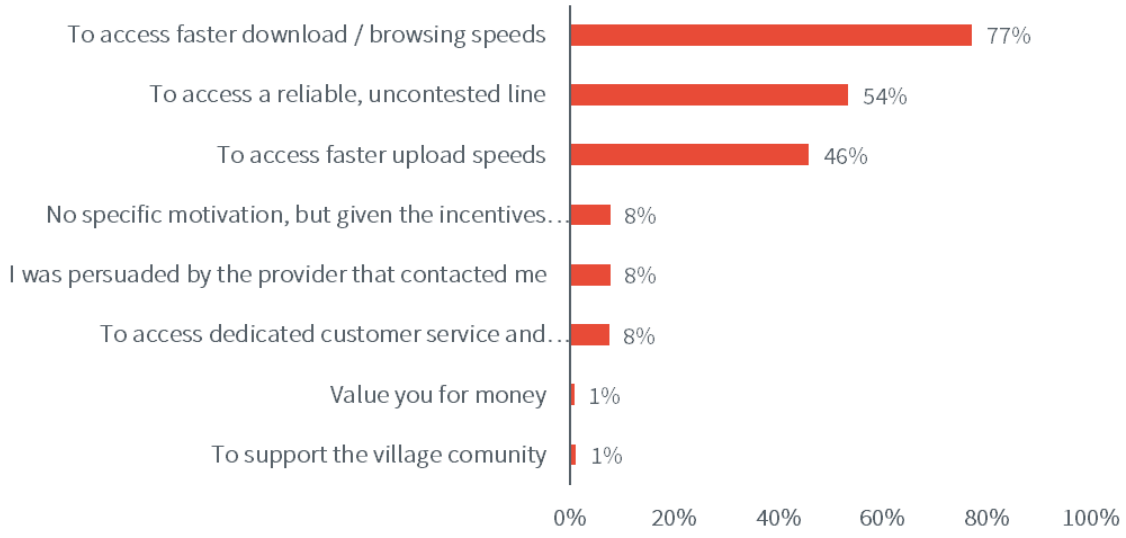
4.42 The main drivers for residents wanting to upgrade their broadband were to access faster download/browsing speeds, to access a reliable uncontested line, followed by the desire to access faster upload speeds. Far smaller proportions (fewer than one in ten) of residents cited other motivations such as being persuaded by a supplier.

4.43 These findings were broadly comparable with the responses to the same question in the business survey except a higher proportion of businesses stated reliability and access to faster upload speeds as a motivation (66% and 55% respectively).

4.44 Statistically significant differences between different groups were as follows:

- A higher proportion of younger (under 65) and employed residents selected download speeds, faster upload speeds and to access a reliable, uncontested line as their motivation for applying for a voucher. In contrast, a slightly higher proportion of older and retired residents (10%) said there was 'no specific reason, but the benefits seemed worthwhile' and / or selected 'to access a dedicated customer service and technical support' (11%), compared to the rest of the sample.
- A higher proportion of residents with children (81%), and those with four or more people living within their household (82%) said that they used the voucher scheme to access faster download speeds compared to smaller households and those without children.

Figure 4.11 What were the main reasons why you applied for or accepted and approved the voucher? (multiple response) (n=4,928)



Source Winning Moves

4.45 The desire for faster speeds and greater reliability were the main reasons why all groups decided to apply for a residential voucher. However there were a number of statistically significant differences in the motivations of people with different characteristics related to age, employment, income and household type (see Table 4.4).

4.46 This shows working households, those in high skilled or high-income roles and those with children were more likely to cite faster speeds and reliability as a motivating factor compared to retired and lower income households. In contrast, retired households were more likely to give apathetic reasons for applying for a voucher, with 20% reporting that they did not have a specific motivation or they were persuaded by the broadband supplier compared to 12% of working households.

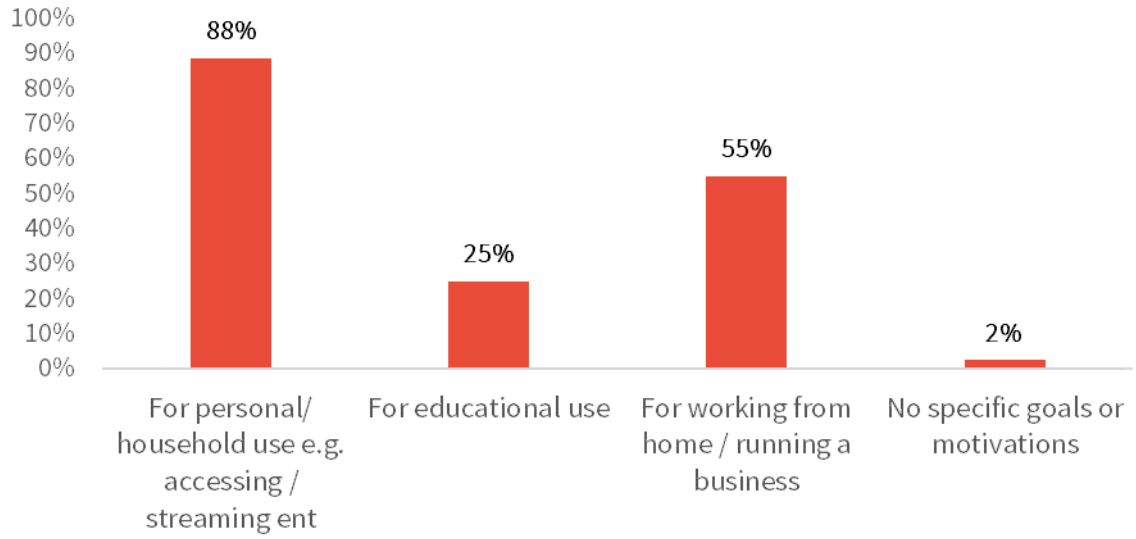
Table 4.4 Characteristics of respondents who were more or less likely to cite different motivations (percentages shown in brackets)

Motivation for seeking upgrade	More likely to cite motivation	Less likely to cite motivation
Faster download speeds	• Incomes over £80K (86%) • People in employment (83%) • People in high skill occupations (82%) • Households with children (81%) • People of working age (80%)	• Over 65s/retired (74%) • One person households (68%) • Incomes below £30K (61%)
Reliability	• People in high skill occupations (59%) • GBVS voucher recipients (57%) • People aged 40 to 64 (56%) • Employed or self-employed (57%/61%)	• RGC voucher recipients (52%) • Over 65s/retired (50%) • Incomes below £20K (41%)
To access dedicated customer service/tech support	• Over 65s (11%) • Retired (10%)	• Working age (6%) • Employed (5%)
No specific motivation but seemed worthwhile, or persuaded by a supplier	• Over 65s/retired (20%)	• 40 to 64 (10%) • Employed (9%)

Note: Sample sizes for each of these groups is provided in Appendix D

4.47 Respondents were asked what their wider goals and motivations were for seeking an upgraded internet connection, specifically whether this was driven by personal/household, education or professional reasons. A large majority (88%) indicated 'personal/household use' was a driver, while just over half cited 'working from home/running a business'. A smaller proportion cited educational use as being a motivating factor (25%).

Figure 4.12 What were your wider goals and motivations for seeking an upgraded internet connection? (Multiple response) (n=4,928)



Source Winning Moves

4.48 Personal/household use was the main motivation for all groups, but there were a number of significant differences between different types of households for other motivations. Table 4.5 shows households that were more likely to cite education and professional reasons as a motivation for seeking an upgrade have a number of shared characteristics, including age, tenure, family status and household income.

Table 4.5 Groups more likely to cite education or professional uses as a motivation for upgrading

Characteristics of households	More likely to cite education uses	More likely to cite professional uses
Between ages of 25 and 65	✓	✓
Own their own home with a mortgage	✓	✓
Households with children (including lone parents and couples)	✓	
Couples with children	✓	✓
Household income over £80,000	✓	
Household income over £60,000		✓
Households in commercial areas	✓	
Self-employed or people working full time		✓
People working in managerial, professional or technical occupations		✓

Source: Winning Moves

Reasons for not upgrading connection previously

4.49 82% of residential survey respondents stated the main reason why they had not upgraded their broadband previously was because it wasn't available where they live. This is much higher than the proportion of businesses who gave this answer in the business survey (62%). Only 6% of residential survey respondents said they had not upgraded their connection because it was too expensive, which was significantly lower than in the business survey (34%). Much smaller proportions of respondents selected the other options.

4.50 The differences in responses to the residents and business survey can be explained by the fact that a much higher share of residents received a voucher through the RGC scheme which was targeted on rural and non-commercial areas, while businesses were more likely to receive a voucher through GBVS. If we focus only on the responses from RGC beneficiaries in both surveys, a very similar proportion cite availability as the main reason why they had not upgraded (87%).

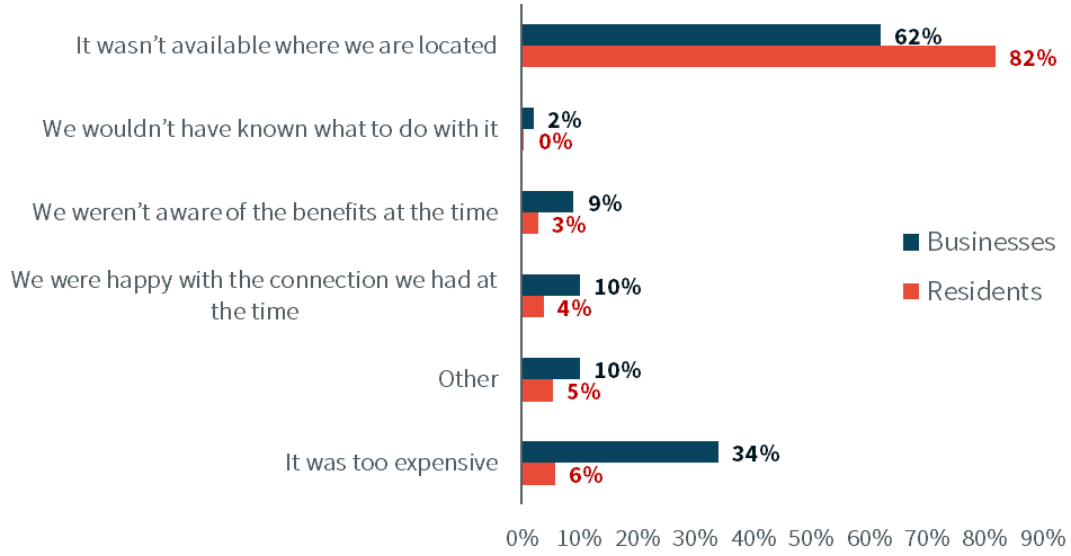
4.51 A small proportion (5%) of residents selected 'other' when asked why they had not upgraded their connection previously. Responses tended to fall into one of two main themes:

- The resident was moving house, waiting to move house or was changing living arrangements, so the timing of upgrading was not appropriate.
- An upgrade was not available beforehand, with some specifically commenting that they had been told by internet service providers that they weren't able to connect them / do the necessary cable work.

4.52 Significant differences between groups include:

- A higher proportion of residents in non-commercial areas (86%) said that they had not upgraded before because it wasn't available where they are located, compared to 80% in commercial areas.
- Affordability was a more important reason for lower income households. 13% of residents on the lowest incomes (less than £20,000) selected 'it was too expensive' compared to just 3% of residents with a household income of £80,000 or more. Similarly younger respondents below the age of 40 were also more likely to cite affordability as the main constraint (11%) than over 65s (4%).

Figure 4.13 Why had you not upgraded your broadband connection previously? (n=4,928 for residents survey, n=1,681 for business survey)



Source Winning Moves

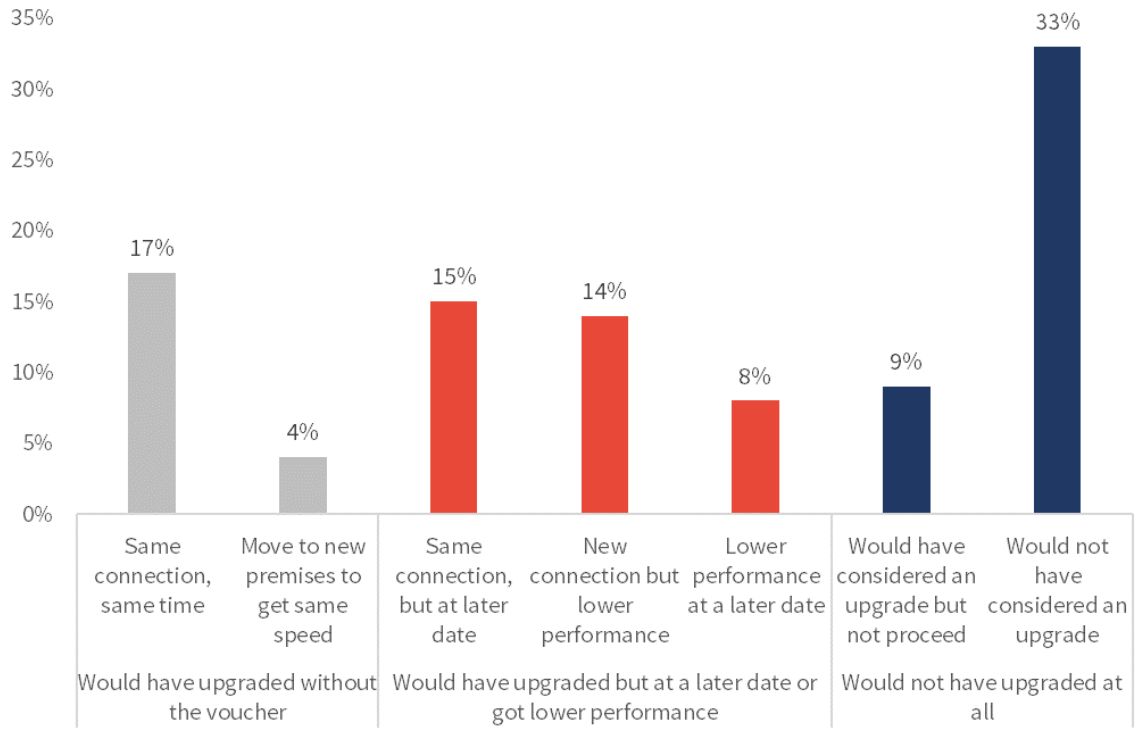
What would residents have done if the voucher had not been available?

4.53 When asked what they would have done had the voucher not been available, 17% of residential survey respondents stated that they would have got the same connection at the same time, and a further 4% would have achieved the same connection by moving house. This represents the pure deadweight of the intervention (21%); any benefits that flow from these connections would have happened anyway and therefore the vouchers would not have provided any additional benefits. However some caution is needed. The proportion that stated this is much higher than in the business survey (15%) despite a much higher proportion of residents claiming they had not upgraded because fibre broadband was not available in their area. Further analysis shows that 16% of those who said they would have got the same connection at the same time also said that it was not available in their area, and therefore provided conflicting information.

4.54 A further 37% of respondents said they would have upgraded, but in a way which is sub-optimal (the red bars). This includes 15% who would have got the same connection but at a later date, 14% who would have got a lower performance connection now, and 8% who would have got a lower performance connection at a later date. It can be assumed that these households would have been able to secure some of the benefits that the upgrade has provided in the absence of a voucher but not all of them.

4.55 Almost half of respondents (42%) said that they would not have upgraded their broadband at all without the voucher. This is also higher than the proportion of businesses who gave the same answer (38%). For these respondents, 100% of the benefits that flow from their upgrade can be attributed to the voucher (meaning deadweight is zero).

Figure 4.14 What would you have done about your broadband connection if the voucher had not been available? (n=4,928)



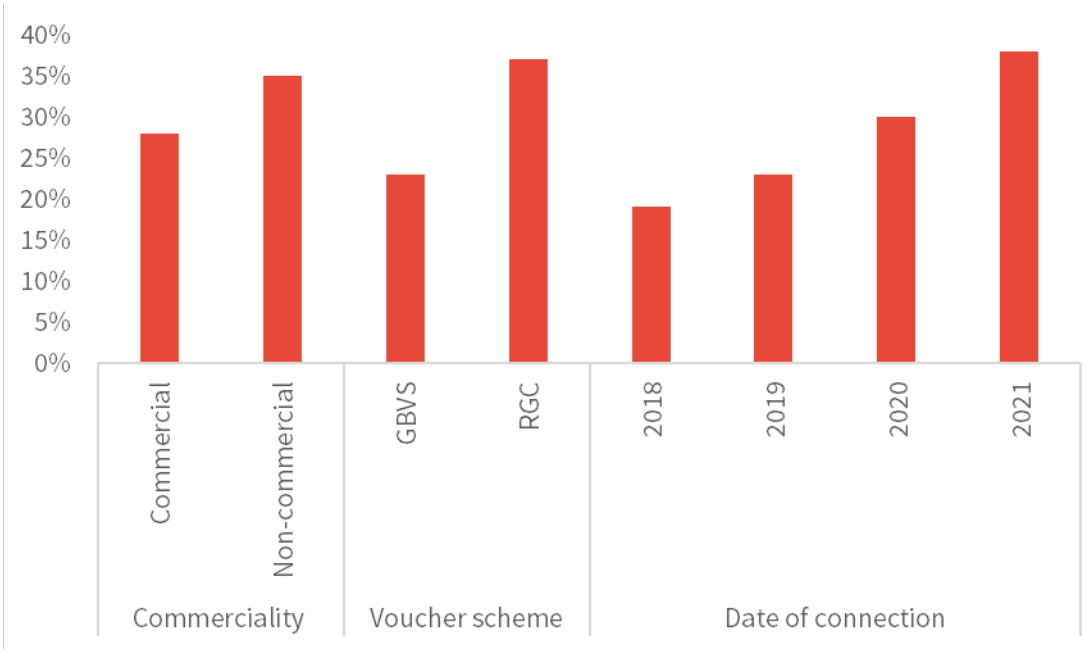
Source Winning Moves

4.56 The survey results suggest deadweight is lower in rural and non-commercial areas. A higher proportion of respondents in non-commercial areas (35%) and RGC voucher recipients (37%) said that they would not even have considered an upgrade to their connection without the voucher, compared to residents in commercial areas (28%) and GBVS voucher recipients (23%).

4.57 The proportion of residents who said they would not have considered a new connection without the voucher also increases by voucher application year. 19% of voucher applicants in 2018 said they would not have considered a new connection, compared to 23% of 2019 applicants, 30% of 2020 applicants and 38% of 2021 applicants. This may also reflect growing awareness and interest in adopting gigabit capable connectivity over time.

4.58 There is also a high degree of crossover between people who said they would not have considered an upgrade without the voucher and those that said they actively sought out the voucher (which is also increasing over time; see Figure 4.9 above); 75% of people who said they sought out the voucher said they would not have considered an upgrade if it had not been available. This suggests the voucher schemes have become more effective in their targeting over time. They are increasingly being used by people who are more motivated to get a voucher and who otherwise would not and could not have upgraded their connection.

Figure 4.15 Percentage of respondents who would not have considered an upgrade without the voucher (n=4,928)



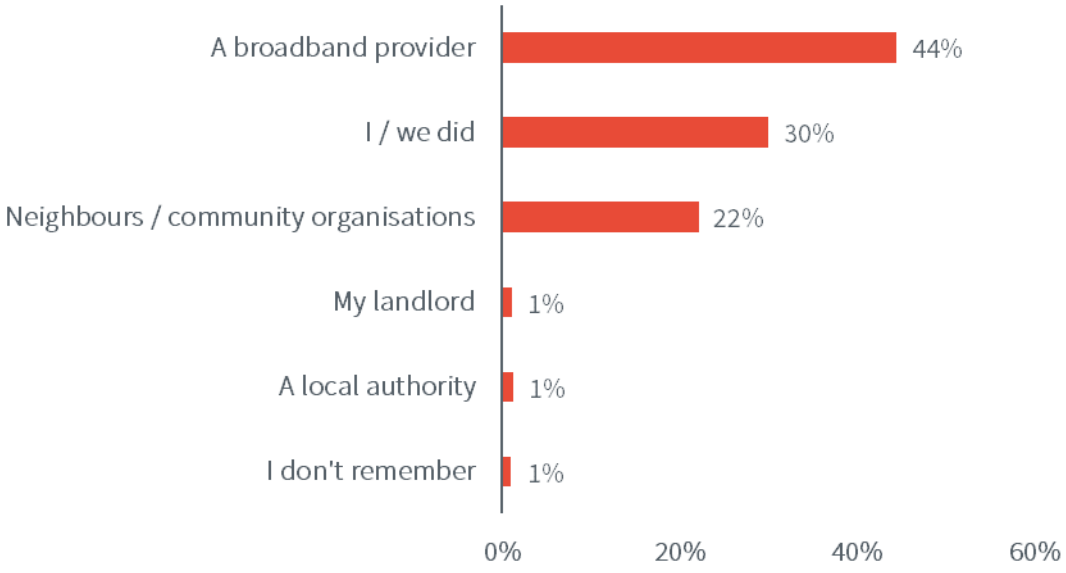
Source Winning Moves

The Application Process

4.59 Under a third of residents led the voucher application process themselves (30%). 44% of respondents reported the process was led by the broadband supplier and 22% said it was led by a community organisation or by neighbours as part of a shared initiative.

4.60 There were some significant differences between groups, most notably by age group. Young people below the age of 40 were more likely to have led the application process themselves (37%), while older people over the age of 65 were more likely to say it was led by a neighbour or a community organisation (27%).

Figure 4.16 Who led the application process for your voucher? (n=4,928)

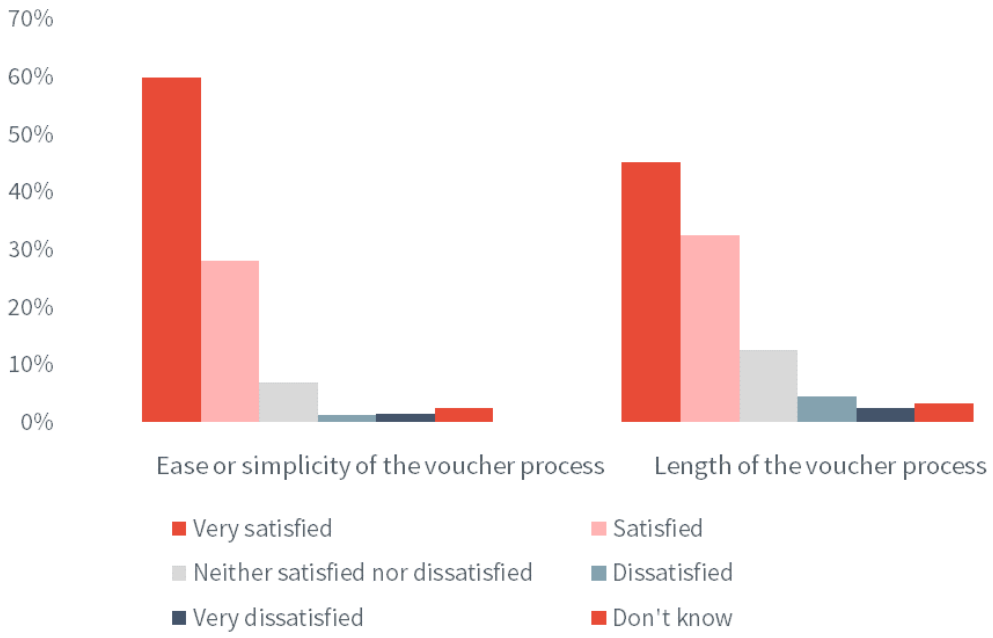


Source Winning Moves

4.61 Levels of satisfaction with the voucher process were high. 88% of residents said they were satisfied or very satisfied with the ease or simplicity of the voucher process and 87% said they are satisfied or very satisfied with the length of the process. There were also no statistically significant differences in satisfaction with the voucher process between any voucher types or types of household, or for households who led the application themselves compared to those where a broadband supplier led the application.

4.62 Satisfaction levels amongst residents were also broadly similar to the satisfaction levels of businesses for both ease and length of the voucher process.

Figure 4.17 Resident satisfaction with the voucher application process (n=4,928)



Source Winning Moves

4.63 A small proportion (2%) of residents said they were dissatisfied with the ease or simplicity of the voucher process. Analysis of comments made by these respondents suggest there were two main issues:

- Residents that applied for a voucher as part of a community meant that there were some delays waiting for a sufficient number of residents to sign up to the scheme
- Experiencing delays and / or communication issues with the service provider either in the application process or installation process.

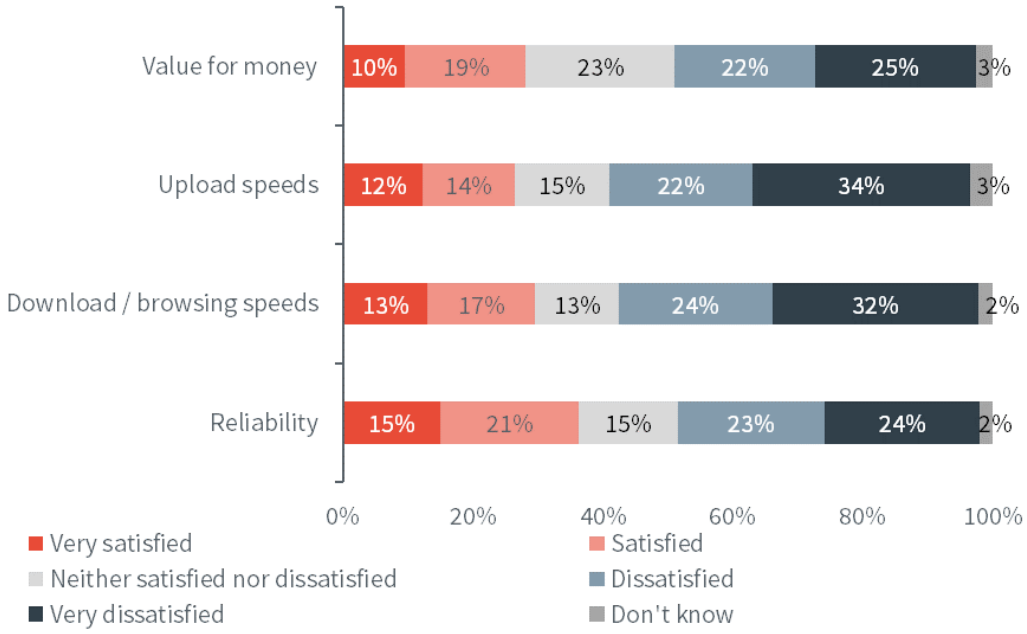
Satisfaction with the connection

4.64 Resident satisfaction with their broadband connection has increased significantly following their upgrade. Between one quarter and one third of respondents were satisfied with their broadband connection before the upgrade, depending on the specific measure (see Figure 4.18). Following the upgrade satisfaction levels increased to over 90% or more for most measures (upload speeds, download speeds and reliability) and to 75% for value for money (see Figure 4.19).

4.65 The increase in satisfaction was highest for residents living in non-commercial areas or who received a voucher through the RGC scheme. These households were more likely to report very low levels of satisfaction with their broadband connection before the upgrade for most measures.

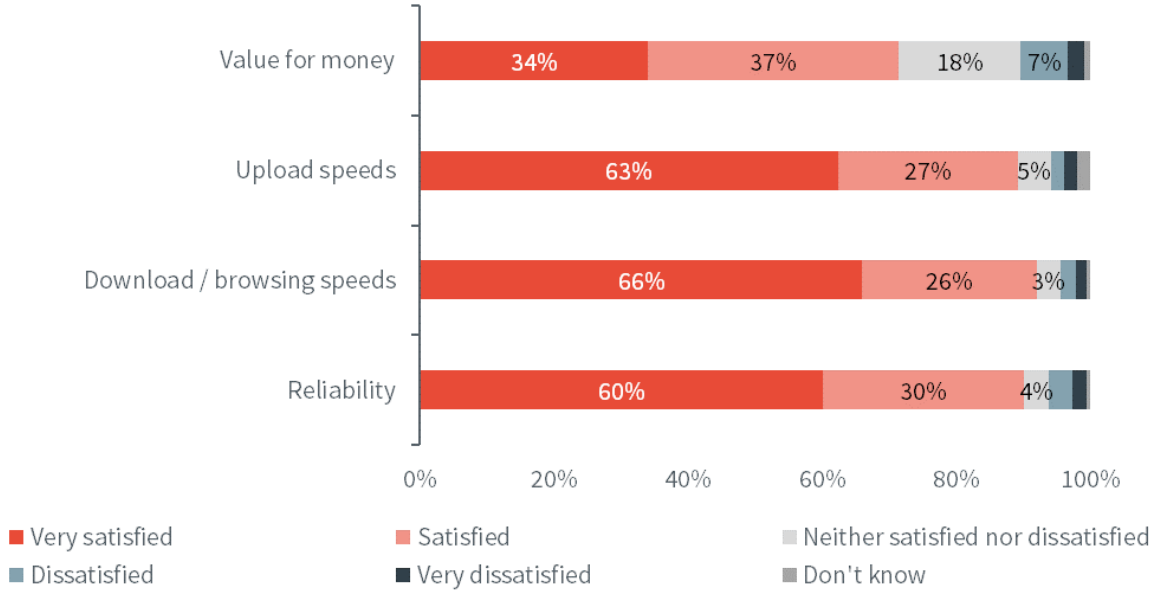
4.66 The pre and post upgrade satisfaction levels among residents were also broadly consistent with the responses to the business survey.

Figure 4.18 Satisfaction with broadband connection before the upgrade (n=4,928)



Source Winning Moves

Figure 4.19 Satisfaction with broadband connection after the upgrade (n=4,928)



Source Winning Moves

Use of the internet

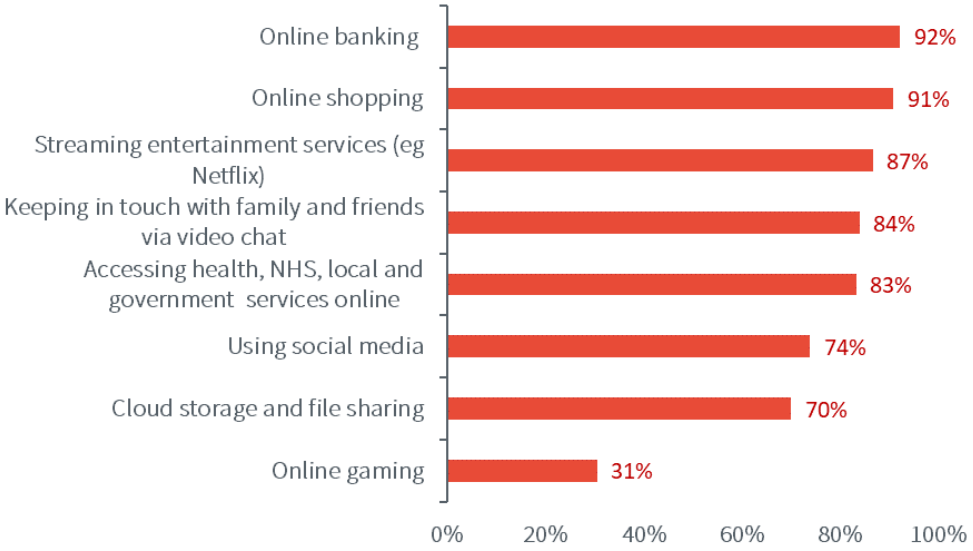
4.67 Residents were asked about how they are using the internet now that they have an upgraded connection. This distinguished between personal, education and work/business related uses. For each type of use, respondents were asked whether they

are using the internet for this purpose for the first time, more easily, more effectively or more often.

Personal uses

4.68 Figure 4.20 shows how voucher recipients are using the internet for personal reasons. The most popular uses include online banking, online shopping and streaming entertainment services. The only application which was not widely used by households was online gaming, where only 31% of households were using the internet for this purpose. This was significantly higher for younger households; 87% where the applicant was between the age of 18 and 24 and 62% for 25 to 39 year olds.

Figure 4.20 Percentage of households using the internet for different personal uses (n=4,928)



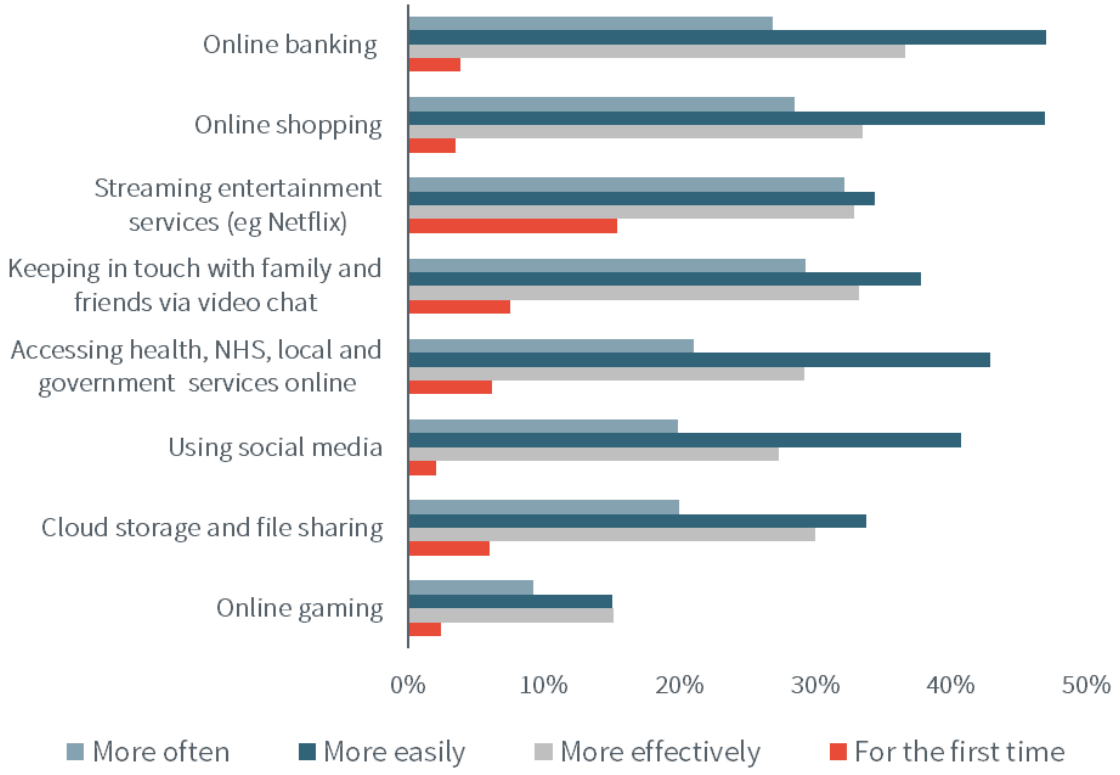
Source

4.69 Figure 4.21 looks specifically at how the upgraded connection has affected households' use of the internet for personal uses. The key points are as follows:

- Very few households are using most applications for the first time. The one exception to this is streaming entertainment services (such as Netflix) where 15% of respondents were doing this for the first time. For all other personal uses, less than 10% of households were doing this for the first time.
- The main benefit of the upgraded connection is that it has made it easier to use the internet for a range of personal uses. This was particularly the case for online banking, online shopping, accessing health and other public services and using social media, where more than 40% of households said the upgrade had made it easier. This could have resulted in a range of marginal but difficult to measure benefits for households.
- A smaller proportion of respondents said they were using applications more often. Nevertheless, more than a quarter said they are making more frequent use of

online banking online shopping, streaming entertainment services and keeping in touch with family and friends.

Figure 4.21 Residents personal uses of the internet (n=4,820) (multiple response)



Source Winning Moves

4.70 Table 4.6 identifies the characteristics of respondents where a significantly higher proportion of respondents said they were using the internet for certain personal uses than those with different characteristics (for example, households in commercial areas vs non-commercial areas, 16 to 24 year olds vs people in other age groups). The key points are as follows:

- Over 65s and retired households are more likely to be making use of a range of applications for the first time compared to younger working households. This was the case for all personal use applications except for online gaming.
- Households in non-commercial areas were also more likely to be using a range of applications for the first time. However this is explained by the fact that non-commercial areas have a much higher proportion of older, retired households who are using these applications for the first time. Once we control for this, by focusing only on working age households, there is no significant difference between commercial and non-commercial areas.
- Working households, particularly those in highly skilled or high-income roles, and households with children were less likely to be using applications for the first time, but more likely to be using them more effectively or more frequently. This was also the case for GBVS beneficiaries and households in commercial areas.

However, this is also explained by the demographic characteristics of households in these areas.

Table 4.6 Groups which are more likely to be using the internet for personal uses

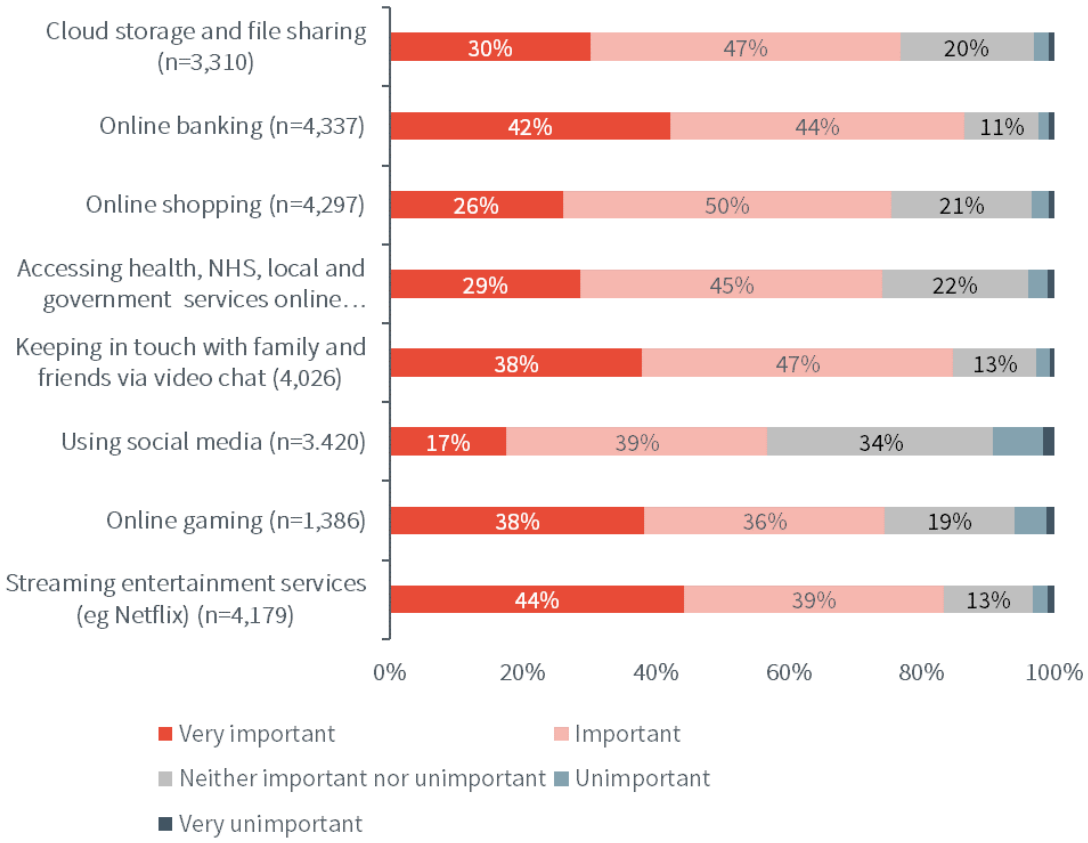
Use of the internet	More likely to be doing it for the first time (percentages shown in brackets)	More likely to be doing it more easily, more effectively or more often
Online banking/shopping	• Over 65s/retired (4%)	• 25 to 64 year olds • Employed people • Households with children
Streaming entertainment services	• Over 65s/retired (20%) • Households in non-commercial areas (18%)	• Households in commercial areas • GBVS beneficiaries • 18 to 64 year olds • Employed people • People on high incomes/in high skilled occupations • Households with children
Keeping in touch with family & friends through video chat	• Over 65s/retired (11%) • Households in non commercial areas (9%) • Light internet users (8%)	• 25 to 64 year olds • GBVS beneficiaries • Employed people • Households with children • People on high incomes/in high skilled occupations
Accessing health and other services online	• Over 65s/retired (9%) • Households in non-commercial areas (7%)	• Households in commercial areas • Households with children
Using social media	• Over 65s/retired (3%)	• 25 to 64 year olds • Households with children
Cloud storage and file sharing	• Over 65s (8%) • Households in non-commercial areas (7%)	• 25 to 64 year olds • Employed people • Households with children • People on high incomes/in high skilled occupations • Households in commercial areas
Online gaming		• 18 to 64 year olds • Households with children

Source: Winning Moves.

Note: sample sizes for all of the groups are provided in Appendix D

4.71 Those residents who reported making greater use of the internet for personal uses were asked how important the upgraded connection had been in enabling this. Figure 4.22 shows that over 70% of respondents said the upgrade was important or very important in enabling all but one of the uses. The one exception was use of social media where 56% said it was important. This suggests the voucher has been an important enabler for a wide range of uses.

Figure 4.22 Importance of the upgrade for greater personal use



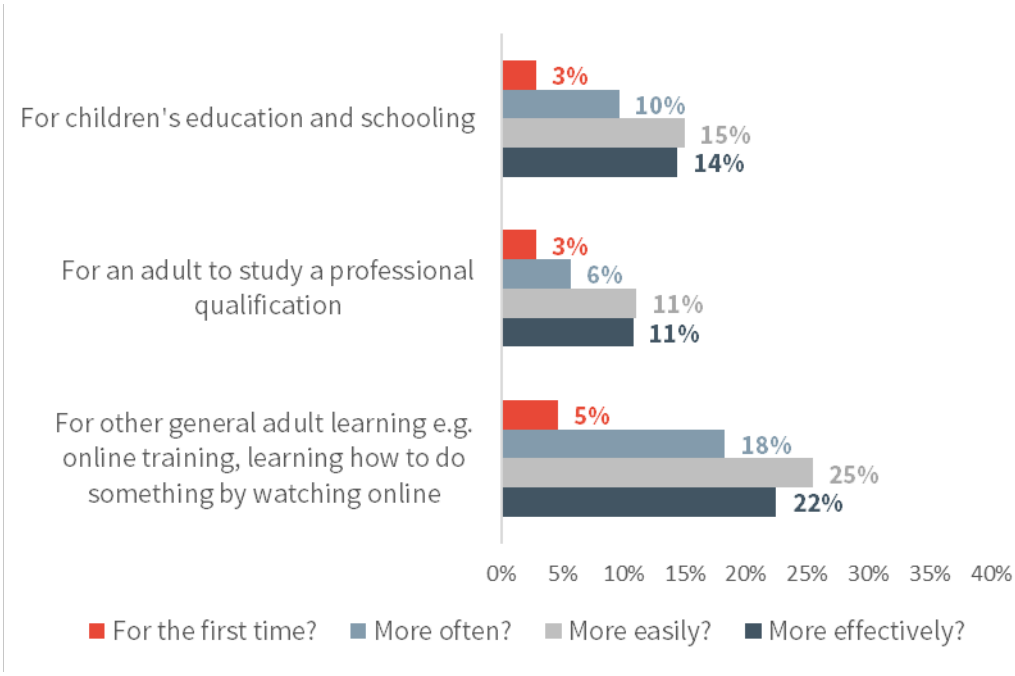
Source Winning Moves

Educational uses

4.72 Overall, two thirds of residents (62%) are making greater use of the internet for educational purposes, with most of this use being related to general adult learning as opposed to children's schooling or formal adult qualifications.

4.73 As shown in Figure 4.23 very few respondents are using the internet for educational purposes for the first time (less than 5% in each case). The main benefit for households has been the ability to use the internet more easily and more effectively.

Figure 4.23 Residents use of the internet for education (n=4,820)



Source Winning Moves

4.74 Table 4.7 shows that, in general, the groups that are most likely to be making greater use of the internet for educational purposes are working households, particularly higher skilled households and those with children.

4.75 The only group that was more likely to be using the internet for children's education for the first time was households with children (6%). This group was also more likely to be using it for this purpose more often (23%), more easily (33%) and more effectively (33%) (see Figure 4.24).

4.76 There are a range of groups who were more likely to be using the internet to study for an adult qualification. This included people in certain low skilled occupations and people who work part time which may indicate that the upgraded connection is helping some people to develop their career and earnings potential.

Table 4.7 Groups which are more likely to be using the internet for educational purposes

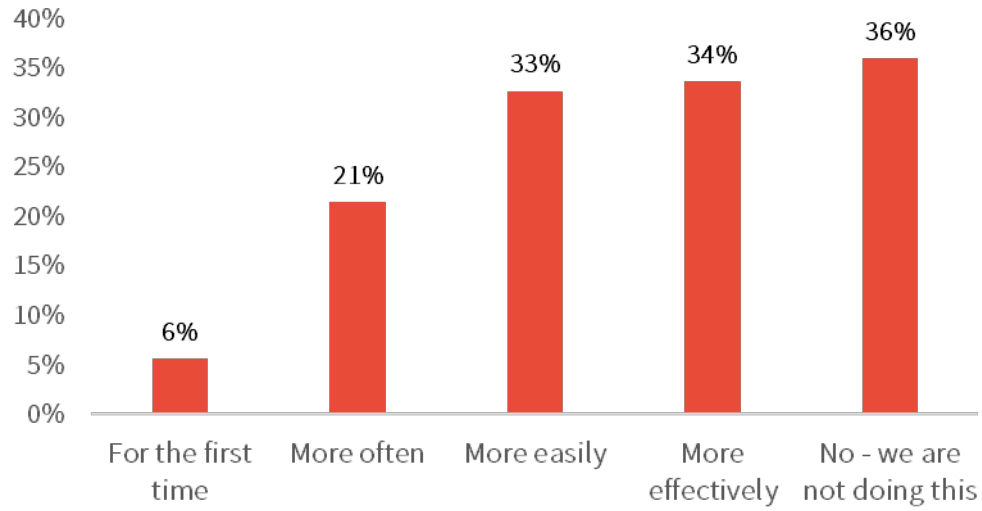
Use of the internet	More likely to be doing it for the first time (percentages shown in brackets)	More likely to be doing it more easily, more effectively or more often
Children's education and schooling	• Households with children (6%)	• Households with children • 25 to 64 year olds • Employed people • Frequent internet users • Households in commercial areas

Adult studying for a professional qualification	• Full time students (18%) • Some low skilled occupations (carers, manual workers): 9% / 11% • Employed part time (6%) • Households with children (5%) • Multi-family households (5%)	• Employed people • Full time students • 25 to 64 year olds • Households with children • Multi-family households • People in high skilled occupations
Other general adult learning		• 25 to 64 year olds • Employed people • Households with children • People in high skilled occupations • Frequent internet users

Winning Moves

Note: Sample sizes for all groups are provided in Appendix D

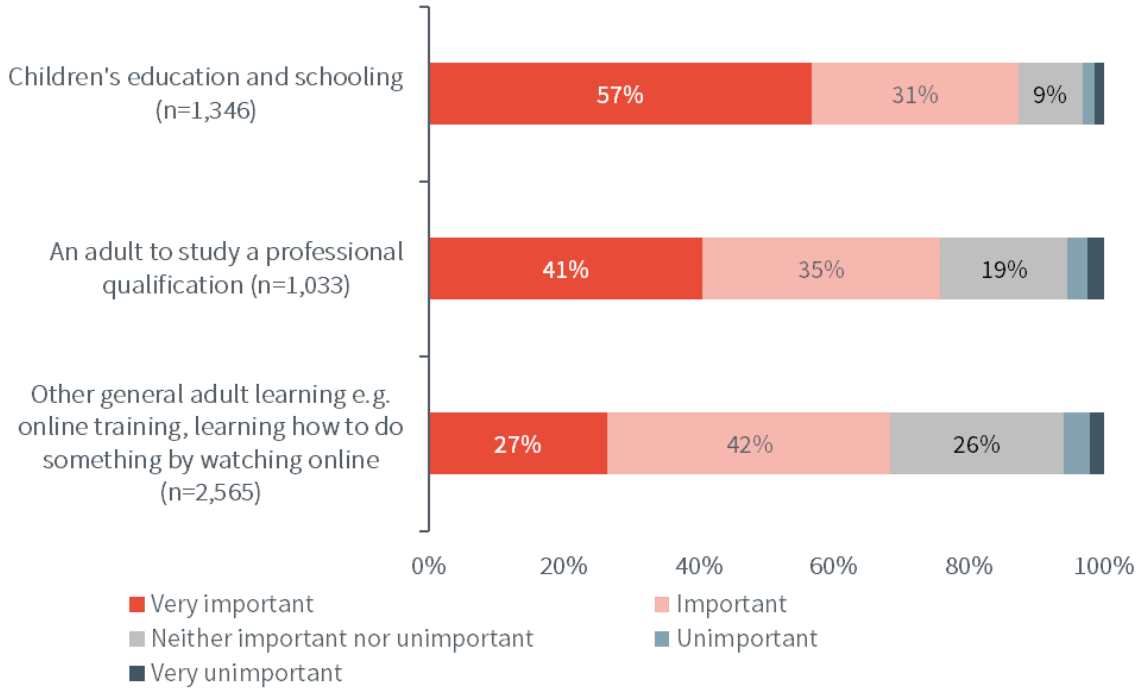
Figure 4.24 How households with children are using the internet for children's education since the voucher (n=1,334)



Source Winning Moves

4.77 For residents making greater use of the internet for their children's education, 88% said that their upgrade was important or very important in enabling them to do so. Three quarters of residents using their internet for an adult to study a qualification said their upgrade was important and two thirds (69%) of residents doing other general learning said their upgrade was important.

Figure 4.25 Importance of the upgrade for enabling greater educational use of the internet



Source Winning Moves

Work or business use

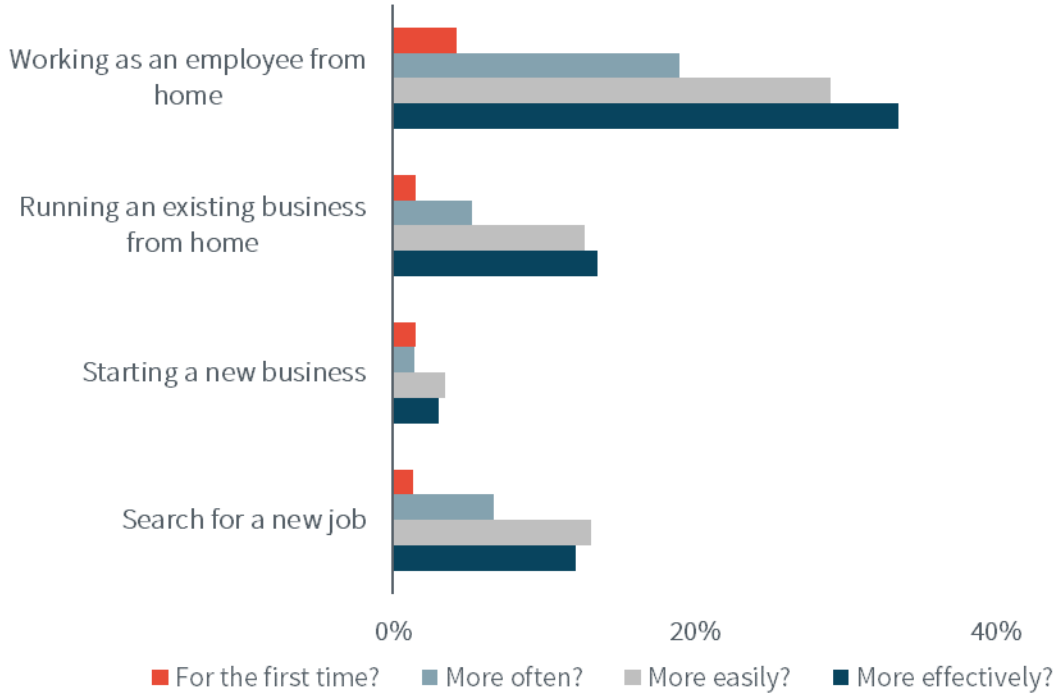
4.78 Overall, two thirds (62%) of residents are making greater use of their internet for work or business purposes[33]. This includes:

- 57% of residents who are using the internet to work from home as an employee
- 24% who are using the internet to run a business from home
- 7% who have used it to start a business, and
- 24% who have used it to search for a new job.

4.79 As shown in Figure 4.26, very few respondents are using the internet for these purposes for the first time (although this might be expected in most cases). In each case the main benefit is that the upgraded connection has enabled them to work more easily and more effectively, and, to a lesser extent, more often.

[33] It should be noted that some of the people who said they were using the internet for work or business purposes reported being economically inactive. For example, 30% of retired people said they had been using the internet for this purpose.

Figure 4.26 Residents internet use for work or business (n=4,699)



Source Winning Moves

4.80 Young people aged 18 to 24 stand out as being the main group that are using the internet for work or business for the first time. Although it might be expected that people in this age group would be doing these things for the first time, it is striking that nearly a quarter of young people claim to have used their internet connection to start a business, and 14% are using it to run a business from home for the first time. Although caution is needed given the low sample size for this group (18 respondents).

4.81 Again, the groups that are most likely to be making greater use of the internet for work or business are working households, particularly higher skilled and high-income households and those with children. Households in commercial areas are also more likely to be making greater use of the internet for work or business due to the demographic characteristics of people who live in these areas.

Table 4.8 Groups that were more likely to be using the internet for professional reasons

Use of the internet	More likely to be doing it for the first time (percentages shown in brackets)	More likely to be doing it more easily, more effectively or more often
Search for a new job	• 18 to 24 year olds (14%) • Unemployed (6%) • Lone parents (5%) • Self-employed (3%)	• 25 to 64 year olds • Employed • Households with children • High income households (over £80K) • High skilled occupations

		• Households in commercial areas
Starting a new business	• 18 to 24 year olds (24%) • Self-employed (4%)	• 25 to 64 year olds • Self-employed • Households with children • High skilled occupations • Households in commercial areas
Running an existing business from home	• 18 to 24 year olds (14%) • Self-employed (5%)	• 40 to 64 year olds • Self-employed • Households with children • High income households (over £80K) • High skilled occupations
Work as an employee from home	• 40 to 64 year olds (6%) • Employed people (6%) • Households with children (6%)	• Households in commercial areas • Employed people • Households with children • High income households (over £60K) • High skilled occupations • Frequent internet users

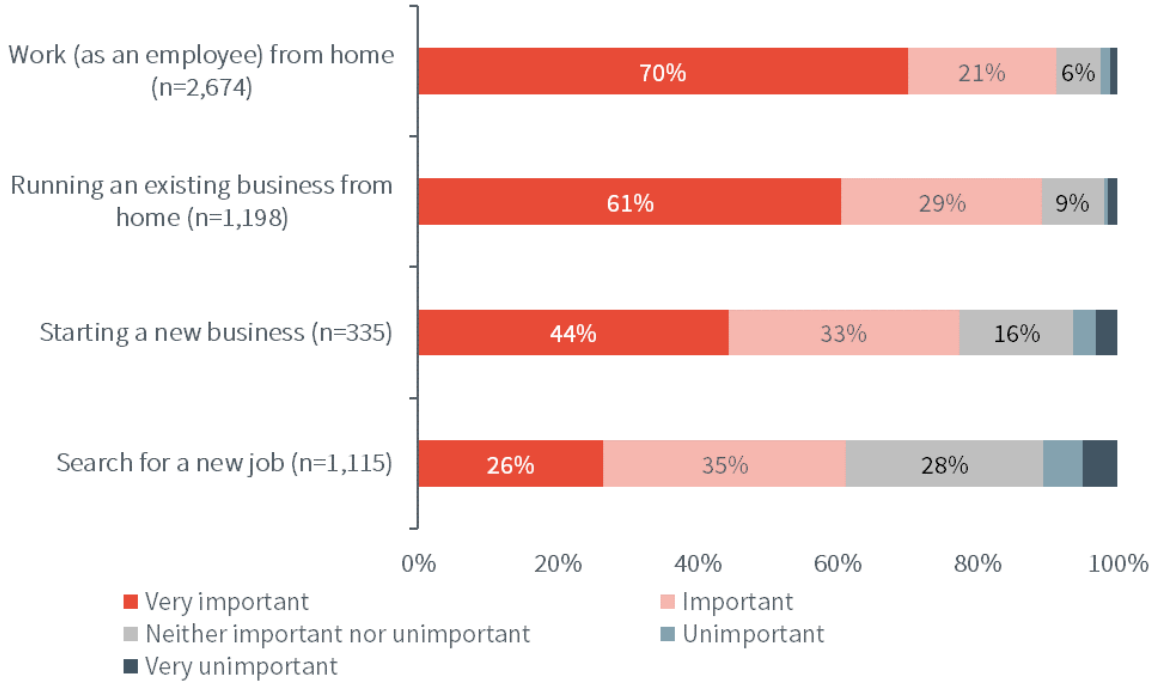
Source: Winning Moves

Note: Sample sizes for all groups are provided in Appendix D

4.82 Figure 4.27 shows that the upgraded connection has been a critical enabler for work or business uses. Almost all residents that are using their internet to work from home (91%) or to run a business from home (90%) said their upgrade was important or very important in enabling them to do so, with a large proportion saying it was very important.

4.83 Large proportions of residents who have used the internet to start a new business or search for a new job think their upgrade was important in helping them to do so (77% and 61% respectively).

Figure 4.27 Importance of the upgrade for enabling greater work/business use of the internet



Source Winning Moves

Support received

4.84 A small proportion (5%) of residents said that they received help, training or support to use or make the most of their enhanced connectivity. A slightly higher proportion of residents over the age of 65 and / or retired (7%) said they had received support.

4.85 The proportion of residents receiving support (5%) is slightly lower than the 13% of businesses that said they received support to make the most of their enhanced connectivity.

4.86 72% of residents who did receive support (n=245), said that the support was provided by their Internet Service Provider. A further 19% said they received support from a friend or from family. The remaining small proportion (9%) of residents said they received support from a consultant, a training provider or from their employer.

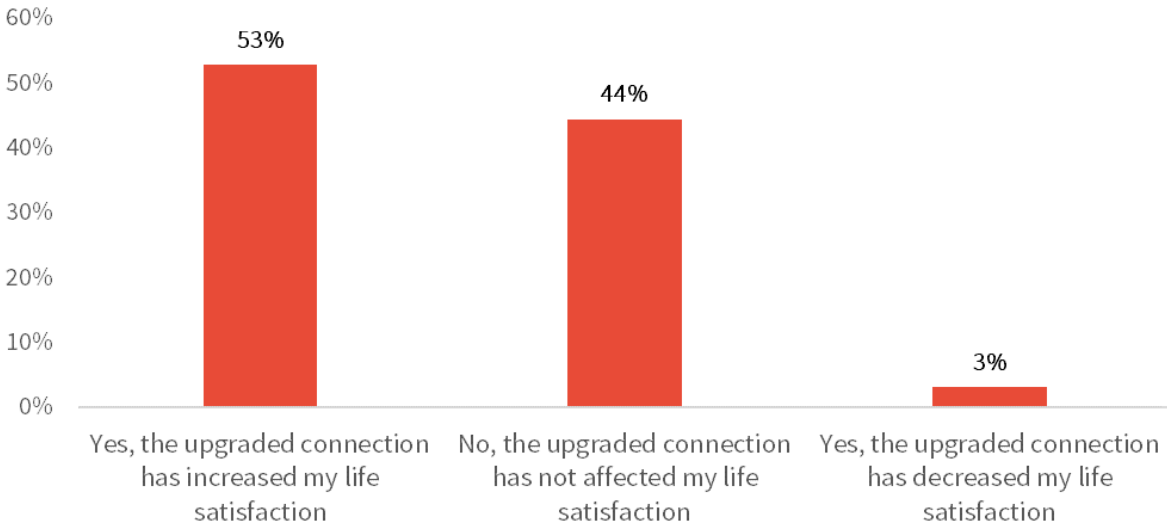
Impacts on the household

4.87 The survey sought residents views on the impact of the upgrade on various aspects of their lives including life satisfaction, feelings of loneliness, reduced travel, increased skills and incomes. The survey findings are summarised below. Chapter 5 shows how we have used these findings to quantify the impacts of vouchers on wellbeing and Chapter 6 presents the results for changes in carbon emissions.

Impacts on life satisfaction

4.88 The upgrade has affected the life satisfaction of just over half (56%) of residents, the majority of whom (53%) said the upgrade increased their life satisfaction, while a small proportion (3%) said their life satisfaction had decreased (see Figure 4.28).

Figure 4.28 Has the upgrade affected life satisfaction of residents? (n=4,928)



Source Winning Moves

4.89 Table 4.9 shows the groups that were more likely to report changes in life satisfaction. Working households were most likely to report life satisfaction has improved, particularly those in high skilled or high income roles and those with children. This is consistent with the analysis of usage above, which shows these households are using the internet for a wide range of uses, including personal, professional and educational uses.

Table 4.9 Impacts on life satisfaction – differences between groups

More likely to report life satisfaction has improved	More likely to report life satisfaction has not changed	More likely to report life satisfaction has decreased
• 25 to 64 year olds • Employed full-time • Households with children • High income households (over £80K) • People in high skilled occupations • Frequent internet users	• 65+ • Retired • Households with no children • Infrequent internet users (once a day)	• Low income households (<£10K) • Infrequent users (less than once a day) • Unemployed or economically inactive

4.90 A disproportionately high share of respondents that reported a decrease in life satisfaction were unemployed or in households with very low incomes (less than £10,000). This may suggest that the worsening in life satisfaction was due to factors other than the upgraded connection.

4.91 Older, retired households with no children were the most likely to report that their life satisfaction has not changed. Again, this is consistent with the analysis of usage above, which shows these households use the internet for a relatively narrow range of personal uses.

4.92 Respondents were asked to score their life satisfaction before and after the upgrade, on a scale of 0-10, with 0 being very low and 10 being very high. The average life satisfaction score of residents before the upgrade was 6.6, and this increased to an average of 8.7 after the upgrade[34].

- For residents that said their life satisfaction had increased, the average increase in points was 3 and the median increase was 2, although responses ranged widely from a 1 point increase to a 9 point increase.
- For residents that said their life satisfaction had decreased, the average decrease in points was 2.5, and the median decrease was 2, although again this varied widely from a 1 point to a 9 point decrease.

4.93 As we note in Chapter 5, these ratings should be treated with a high degree of caution. Data from the Annual Population Survey shows that average life satisfaction for the UK has been between 7.4 and 7.7 since 2011. The average life satisfaction scores given by survey respondents are therefore much lower than the national average for before the upgrade, and much higher than after the upgrade.

4.94 There is a high probability that many respondents were unable to accurately recall their life satisfaction before the voucher. Although this is not an issue for their current life satisfaction, there is a risk that respondents exaggerated the change because there was a specific reference to the upgrade in the question. A more robust approach would have been to ask voucher recipients to rate their life satisfaction before receiving the upgrade and again after the upgrade independent of any references to broadband upgrades. However this was not possible as the evaluation has taken place after beneficiaries have received support.

4.95 While this means the ratings cannot be used to quantify changes in wellbeing, the survey does provide further evidence that vouchers have improved life satisfaction overall, and that in some cases this has been a significant improvement.

Drivers of wellbeing improvements

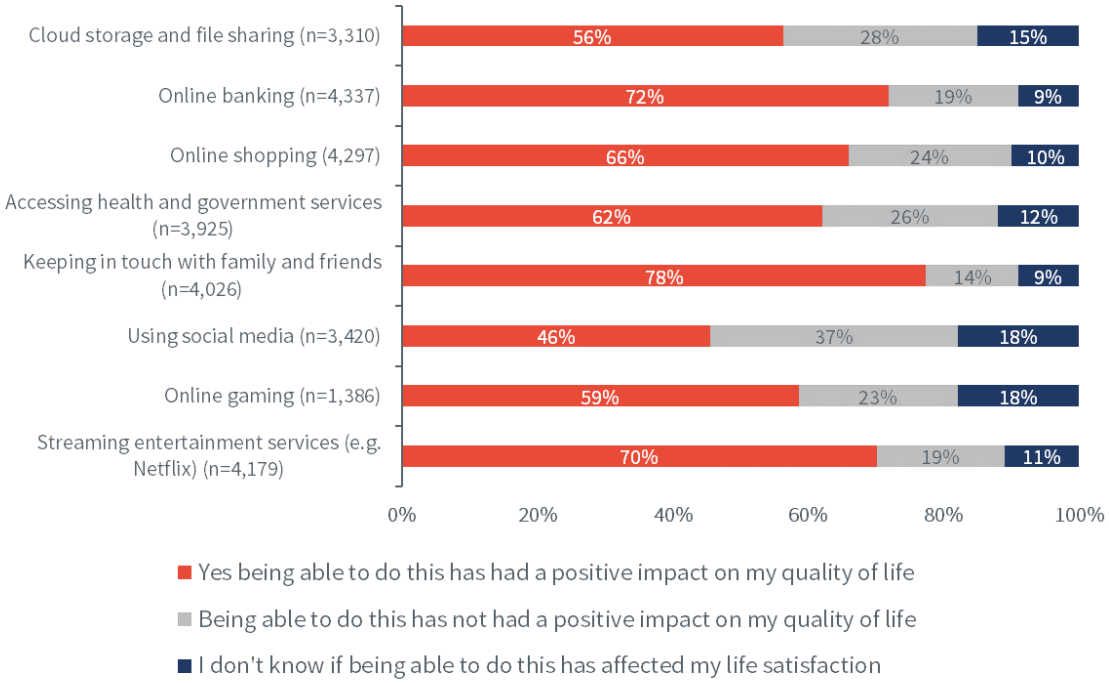
4.96 Respondents who said they were making greater use of the internet for personal uses were asked whether each of their usage types had affected their life satisfaction. Responses are shown in Figure 4.29. Key points to note are as follows:

- Keeping in touch with family and friends, streaming entertainment services and online banking have had the greatest impact on increasing the life satisfaction of residents. Over 70% of residents who use the internet for these purposes report that being able to do so has improved their quality of life.

[34] The median score before the upgrade was 6 and the median score after the upgrade was 9.

- Between 60 and 70 per cent of respondents who use their upgraded connection for online shopping, accessing health and government services and online gaming report that this has had a positive impact on their quality of life.
- Less than half of respondents who have used their upgraded connection for social media report that this has had a positive impact on their quality of life.

Figure 4.29 Effect of using the upgraded connection for personal uses on quality of life



Source Winning Moves

4.97 Beneficiaries who are using the internet for personal uses 'for the first time' or 'more often' are most likely to report that this has had a positive impact on their quality of life than people who are using these applications more easily or more effectively (see Table 4.10). The exceptions to this are online gaming and cloud storage/file sharing where being able to make more effective use was more likely to have a positive impact.

Table 4.10 Percentage of respondents who report personal uses have had a positive impact on quality of life by type of usage

Use of the internet	For the first time	More often	More easily	More effectively
Streaming entertainment services	77%	75%	70%	74%
Online gaming	55%	65%	57%	66%
Using social media	53%	56%	44%	50%

Keeping in touch with friends and family though video chat	82%	84%	77%	82%
Accessing health, NHS, local and government services online	73%	72%	60%	66%
Online shopping	78%	75%	64%	70%
Online banking	81%	80%	71%	75%
Cloud storage and file sharing	60%	67%	54%	61%

Note: for each application the highest percentage is shaded in red and the second highest percentage is shaded in pink

4.98 Working households, particularly those in high skilled or high income roles and those with children, are more likely to report streaming entertainment services and cloud storage have had a positive impact on quality of life (see Table 4.11). While over 65s and retired households were more likely to report use of online banking and shopping has improved their life. Young people were the most likely to report that online gaming has improved their quality of life.

Table 4.11 Groups more likely to report that personal uses of the internet have had a positive impact on quality of life

Use of the internet	Groups more likely to state that use has had a positive impact on quality of life (percentage shown in brackets)
Streaming entertainment services	• 25 to 64 year olds (75%) • Employed (73%) • Households with children (74%) • High income over £80K (76%) • Frequent internet users (72%)
Online gaming	• 18 to 39 year olds (74%) • Frequent internet users (60%) • Households in commercial areas (65%)
Using social media	• No statistically significant differences
Keeping in touch with friends and family though video chat	• No statistically significant differences
Accessing health, NHS, local and government services online	• No statistically significant differences
Online shopping	• Retired (68%)
Online banking	• Over 65s/retired (75%)
Cloud storage and file sharing	• 25 to 64 year olds (61%) • Employed (60%) • Households with children (60%) • Managers and professionals (62% and 61%)

Source: Winning Moves

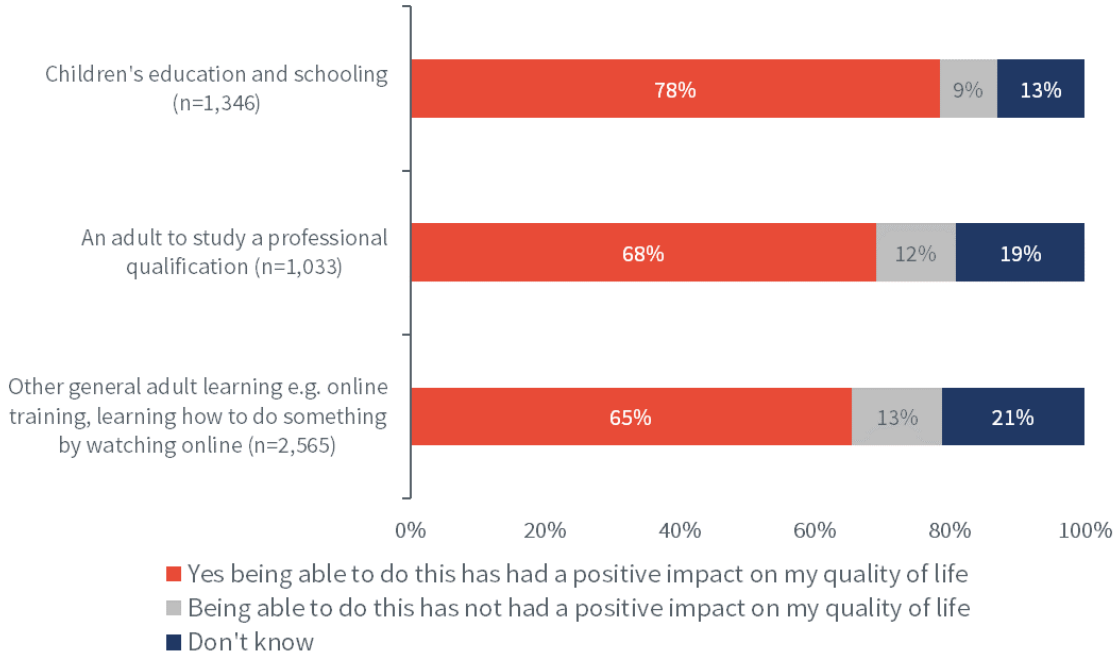
The following quotes from survey respondents illustrate the ways in which households are using the internet for personal and leisure uses and the benefits this has had for their quality of life

- *"We are very grateful for the voucher. It has made a huge positive difference. I have a brain injury and it has improved my quality of life as I can now stream YouTube songs and can pick my spirits up if I am starting to struggle, I can watch a wildlife documentary on demand and watch the world markets. None of these were possible before the upgrade. So thank you so much for improving my quality of life by making it easier."*
- *"I can keep up with my 6/12 year old grandsons in Australia, deal with emails, and can watch on line streaming entertainment without a film stopping every five minutes to up load the next 5 minutes"*
- *"I couldn't believe how fast and reliable this fttp broadband is. It is amazing for all our streaming - we watch far more over the internet now as there is no buffering…. It also means we have more online video chats with our family living overseas. We can have a proper chat without the picture being fuzzy or the speech being distorted."*
- *"it was honestly life changing. with having 3 children in the house, who wanted to stream and do online gaming, it made a massive difference to the quality of our lives here."*
- *"I am having cancer treatment and need to keep in touch with the hospitals that look after me. Our new connection is faster but, even more important, it is way more reliable than before"*

4.99 More than three quarters of residents that use their upgraded connection for children's education and schooling say that this has had a positive impact on their quality life. Two thirds of residents who use it for adult education (either a professional qualification or more general learning) say that doing this has had a positive impact on their quality of life.

4.100 Beneficiaries who are using the internet for educational uses for the first time, more often or more effectively are more likely to report that this has had a positive impact on their quality of life than people who are using these applications more easily.

Figure 4.30 Effect of using the upgraded connection for education purposes on the quality of life of residents



Source Winning Moves

4.101 Working households with children are more likely to report increased or improved use of the internet for children's schooling or other general adult learning have had a positive impact on quality of life.

Table 4.12 Groups more likely to report that educational uses have had a positive impact on quality of life

Use of the internet	Groups more likely to state that use has had a positive impact on quality of life (percentage shown in brackets)
Children's education and schooling	• 40 to 64 year olds (81%) • Employed (82%) • Households with children (83%) • Managers and professionals (86%/82%)
Adults studying for a professional qualification	• No statistically significant differences
Other general adult learning	• 18 to 64 year olds (68%) • Households with children (71%)

Source: Winning Moves.

Note: sample sizes for all groups are provided in Appendix D

4.102 Using the internet to work from home has had a positive impact on the large majority (84%) of residents who say that they use the upgraded connection for this purpose.

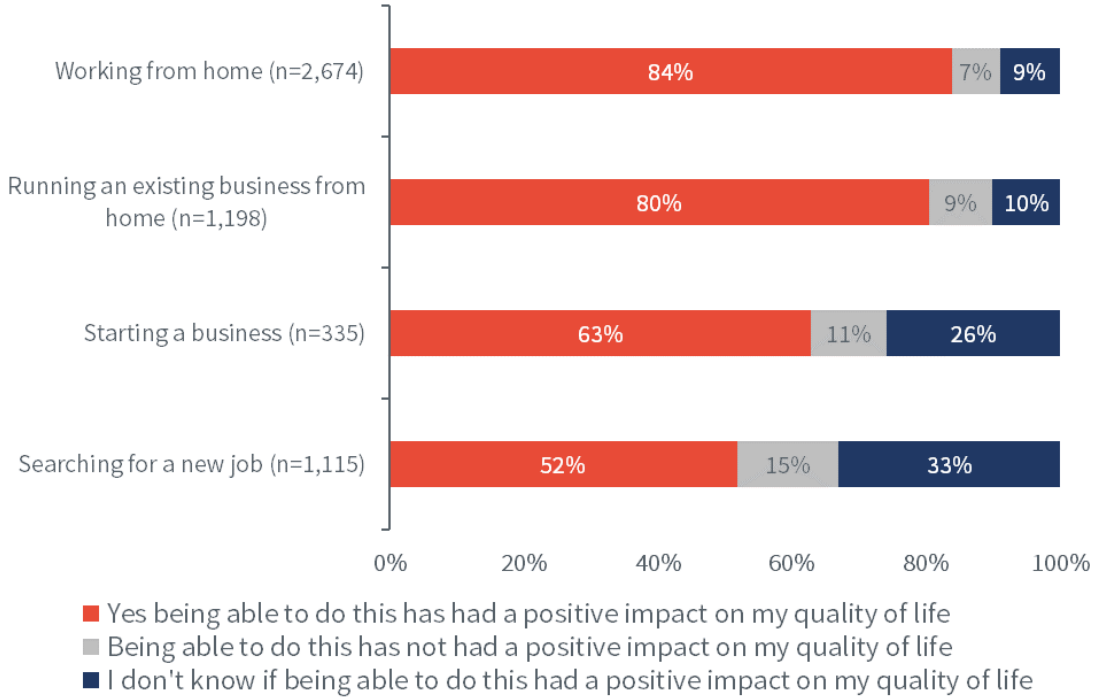
Equally, 80% of residents who use the upgraded connection to run a business from home, say that being able to do so has had a positive impact on their quality of life.

4.103 People who are doing these things for the first time are the most likely to report a positive impact on their quality of life. Over 90% of people who are working from home or running a business from home for the first time report a positive impact. Over 85% of respondents who are doing this more often or more effectively also report a positive impact.

The following quotes from survey respondents illustrate the ways in which households are using the internet for educational uses and the benefits this has had for their quality of life

- *"It completely transformed things for our children. They were able to do schoolwork at home - including live lessons during lockdown - and access google classroom, play video clips, etc. They felt included and were able to connect more with their friends."*
- *"Can't tell you how profoundly pleased I was at the upgrade. I really think it prevented likely additional disruption to my childrens' learning - for one of them that was exam classes. As a teacher myself I saw how problematic other students found it when there were several people conferencing online simultaneously in their homes."*
- *"The new connection is great… My husband has done a number of online courses which have given him new skills and helped in his job."*
- *"Through use of YouTube on the internet we have developed new skills (antiquarian bookbinding, woodturning, violin lessons, harp lessons, painting) that have opened up new hobbies and interests. Without this internet service we would have struggled through the pandemic and our lives in retirement would have been far less rewarding and satisfying."*

Figure 4.31 Effect of using the upgraded connection for business/professional purposes on the quality of life of residents



Source Winning Moves

4.104 Having the ability to run a business or work from home has had a positive effect on quality of life for a range of different types of residents. However it has been particularly positive for residents who are between the ages of 25 and 64, employed (particularly if in high skilled roles) and households with children.

Table 4.13 Groups more likely to report that work or business uses have had a positive impact on quality of life

Use of the internet	Groups more likely to state that use has had a positive impact on quality of life (percentage shown in brackets)
Working from home	• 25 to 64 year olds (86%) • Employed (87%) • Households with children (87%) • Managers and professionals (90%/86%)
Running an existing business from home	• Self-employed (87%) • Households with children (85%) • Managers/directors (86%) • Frequent internet users (81%)
Starting a business	• No statistically significant differences
Searching for a new job	• No statistically significant differences

Source: Winning Moves

Note: sample sizes for all groups are provided in Appendix D

The following quotes from survey respondents illustrate the ways in which households are using the internet for professional uses and the benefits this has had for their quality of life

- *"The upgrade has literally transformed our lives: my husband can work from home, I am getting ready to launch my own business, heavily reliant on the internet."*
- *"I work from home and it has turned a constant pain in the backside connection into a perfect solution…the difference has been night and day."*
- *"As a home based business, the upgrade has been invaluable… It has allowed us to connect with clients without leaving the house which has been a massive time and cost saver"*
- *"Total gamechanger - It meant I could stay in my present location and run my business instead of having to move to get a better/faster connection"*
- *"It is absolutely brilliant and can't imagine how I managed my business admin before we had this"*

Impacts on loneliness

4.105 Residents were asked whether their upgraded broadband connection had affected how lonely they feel. 10% of residents said it had, 77% said it had not and 13% said that they did not know (n=4,928).

4.106 Residents who said that their upgrade had affected how lonely they feel were then asked how often they felt lonely before and after their upgrade. Figure 4.32 shows that the proportion of respondents that feel lonely at least some of the time has fallen from 40% before the upgrade to 13% after the upgrade. This represents a significant fall in levels of loneliness, although we would note the following caveats:

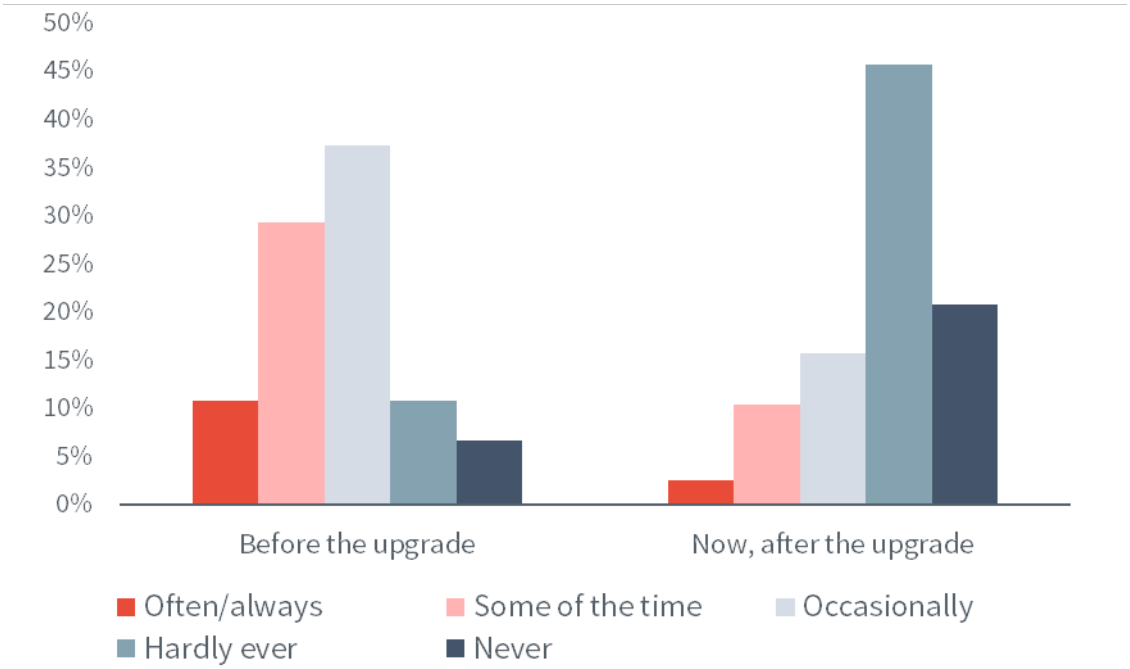
- This only applies to those who reported a change in loneliness as a result of the upgrade, which is 10% of all respondents.
- As was the case with life satisfaction, the answers given to this question may be subject to recall bias, where people cannot accurately recall how often they felt lonely before the upgrade and may exaggerate the benefit of the voucher.

4.107 Further analysis of responses shows that, of the residents that said their upgrade affected how lonely they feel, (n=515):

- the majority (71%) said that they feel lonely less often
- 16% feel lonely just as frequently as they did before; these residents did not change their response to 'how often did you feel lonely before and after the upgrade'. It is possible that whilst the frequency of feeling lonely for these residents has not changed, they may have experienced a change in the intensity of the loneliness that they felt as a result of the upgrade, although the survey did not ask residents about this specifically.
- 7% said they feel lonely more frequently (this appears to affect a similar proportion of residents of all types).

- 6% said that they did not know or preferred not to say.

Figure 4.32 How often residents feel lonely before and after their upgrade (only respondents who said their loneliness had been affected by the upgrade, n=515)



Source Winning Moves

4.108 Whilst the upgrade has affected the loneliness of all types of resident, it had a greater impact on residents who live on their own, with 18% of one person households saying their upgrade has affected how lonely they feel. Residents with a lower household income (£20,000 or under) and those living in in private rented or socially rented housing were also more likely to say it had affected their loneliness. All of these groups were far more likely to report that the upgrade had reduced feelings of loneliness than increased them.

4.109 A number of the quotes from respondents also illustrate how the upgrade has helped people facing particular challenges to feel better connected and less isolated.

- *"It's fantastic - I have a chronically ill & autistic son who relies on the internet for education and as a portal to the world at large. The difference is phenomenal. The difference it makes to the quality of life should not be underestimated."*
- *"As I am disabled it also means that I can stay connected - as my condition has got worse I might be able to work from home more as well in future."*
- *"I live on my own in a very rural area. The upgrade provided a lifeline during the pandemic as it meant the whole family could come together on Zoom every week and keep in touch. This made such a difference to my life during lockdown"*

4.110 Closer analysis of people who reported a change in loneliness shows that they are more likely to be doing a number of things for the first time or more often compared to other respondents:

- 29% are streaming entertainment services for the first time, which is significantly higher than the average for all respondents (18%). Of these, 87% report that it has had a positive impact on their quality of life compared to an average of 77%.
- 15% are using video chat to talk to friends and family for the first time, compared to 10% of all respondents. Of these, 89% report that it has had a positive impact on their quality of life compared to an average of 82%.
- 37% are using video chat to talk to friends and family more often which is also higher than average (31%). Of these, 95% report that it has had a positive impact on their quality of life compared to an average of 84%.
- 29% are using social media more often compared to 24% of all respondents. Of these 72% report that it has had a positive impact on their quality of life compared to an average of 56%.

Figure 4.33 Groups who are more likely to report a change in loneliness as a result of the broadband upgrade

Source Winning Moves

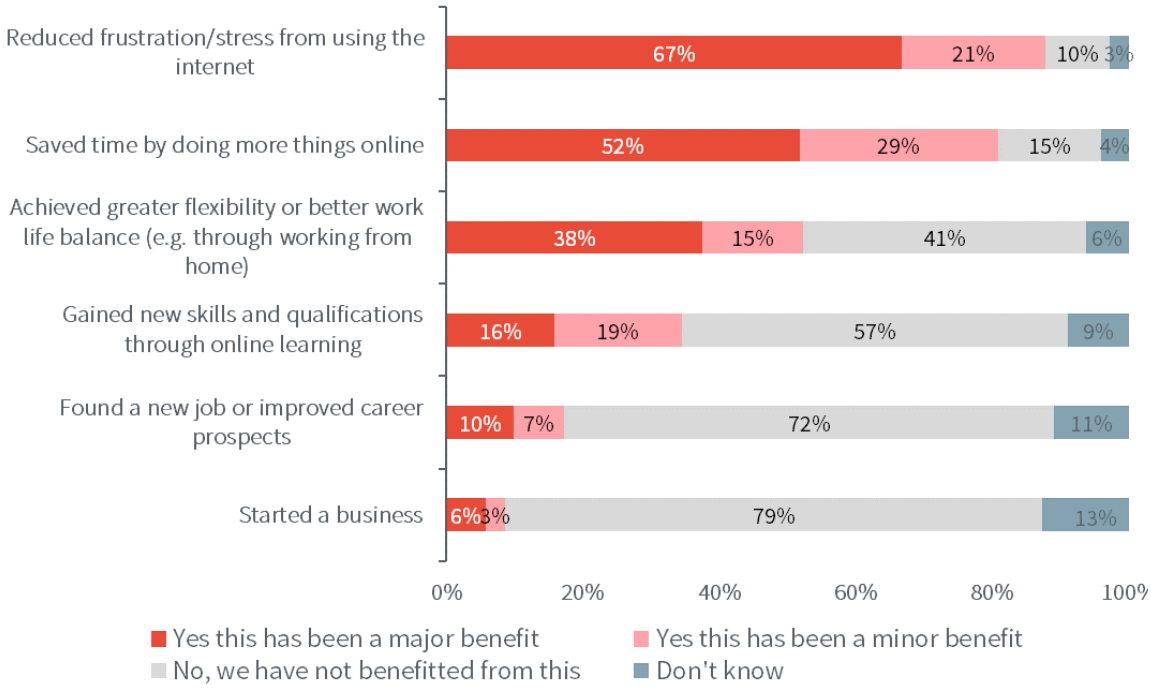
Benefits of the connection

4.111 Respondents reported that they have experienced a range of benefits as a result of their upgraded connection. Most notably, 88% of residents reported a reduction in frustration and stress from using the internet, 81% of residents said they save time by doing more things online and just over half (53%) say they have achieved greater flexibility or a better work life balance.

4.112 A much lower proportion of people report benefits relating to new skills, a new job or starting a new business. However, a much higher share of working age residents (under 65) report these benefits:

- 70% say they have benefitted from a better work/ life balance.
- 41% have benefitted from gaining a new skill or qualification
- 32% have found a new job or have improved their career prospects
- 18% say they have benefitted from starting a business

Figure 4.34 Benefits experienced by residents as a result of their upgrade (n=4,928)



Source Winning Moves

4.113 Table 4.14 shows the groups that are most likely to cite different benefits as a major benefit. Key points to note are as follows:

- Working households, those with children and those in high skilled occupations are more likely than other respondents to cite each of the benefits as a major benefit.
- Households in non-commercial areas are more likely to cite reduced frustration and time savings as major benefits.
- Lone parents are more likely to cite ‘gaining new skills or qualifications’ or ‘found a new job or improved career prospects’ as major benefits.

Table 4.14 Groups that are most likely to cite different benefits as major benefits (percentages shown in brackets)

Reduced frustration	Saving time by doing things online
• Households in non-commercial areas (69%) • 40 to 64 year olds (71%) • Employed (69%) • Households with children (71%) • Managers and professionals (74%/71%) • Frequent internet users (68%)	• Households in non-commercial areas (53%) • 40 to 64 year olds (59%) • Employed and self-employed (59%/62%) • Households with children (59%) • Managers (62%), professionals (59%) and associate professionals (62%)
Achieving greater flexibility or work life balance	**Gained new skills or qualifications**
• Households in commercial areas and GBVS voucher recipients (44%) • 25 to 64 year olds (52%) • Employed and self-employed (60%/52%) • Households with children (57%) • Managers (62%), professionals (58%) and associate professionals (63%)	• 25 to 64 year olds (22%) • Employed and self-employed (21%/23%) • Households with children (21%) • Lone parents (26%) • Associate professionals (27%), managers (21%), professionals (20%) and skilled trades (24%)
Found a new job or improved career prospects	**Started a business**
• Households in commercial areas and GBVS voucher recipients (12%) • 25 to 65 year olds (16%) • Employed and self-employed (15%) • Lone parents (20%) • Households with children (16%) • Managers, professionals and associate professionals (18%)	• 18 to 24 year olds (30%) • Self-employed (19%) • Households with children (9%) • Managers & professionals (9%/8%)

Note: all sample sizes for groups are provided in Appendix D

Benefits from reduced travel

4.114 44% of residents (n=4,928) said that they have reduced their weekly travel following their upgrade. Higher proportions of residents with the following characteristics have reduced their travel:

- Residents aged between 40-64 (51%)
- Residents employed full-time (52%)
- Households with children (53%)
- Residents in managerial (60%), professional (53%), and technical (59%) occupations.

4.115 There is also significant overlap between respondents who said they have been using the internet to work from home and those who have reduced their travel (63% for people who said they have been working from home and 57% for people running a business from home).

4.116 The survey findings have been used to estimate the total reduction in travel by grossing up the survey findings for all voucher beneficiaries. The results of this are shown in Table 4.15. If the total voucher population had a similar reduction in travel, it is estimated that this would result in over 500,000 fewer miles travelled each week, over 40,000 hours in saved travel time and total travel savings of nearly £300,000.

4.117 Not all of this can be attributed to vouchers since it does not take account of deadweight (what would have happened anyway). To assess this we have referred to Figure 4.14 which shows what respondents would have done if the voucher was not available. This showed:

- 21% would have upgraded to the same quality connection, even if they had not received a voucher (with some of these moving to new premises in order to do so). It can be assumed all of these beneficiaries would have achieved the same benefits from their broadband connection, with or without the voucher.
- A further 37% would have upgraded but at a later date or settled for a lower performance connection. It can be assumed that beneficiaries in this group would have achieved some of the benefits of an upgraded connection but not all of them. However it is very difficult to attach a quantitative value to this.

4.118 Based on the above, we have assumed 40% of respondents would have been able to secure a connection which would have enabled them to reduce their travel, although this is subject to uncertainty.

Table 4.15 Quantifying the benefits of reduced travel

Outcome indicator	Survey sample	All vouchers (gross)	All vouchers (net additional)
Number of fewer miles travelled in total each week	107,450*	544,642	326,785
Number of hours saved each week	8,548†	43,438	26,062
£ saved	£58,620‡	£297,132	£178,279

Source: Winning Moves

* This equates to 50 miles per household (median value) that reduced their travel, although responses ranged from 1 mile to 11,670 miles.

† This equates to 4 hours per household that reduced their mileage (median value). Responses ranged from 1 hour to 160 hours.

‡ This equates to £30 saved per week per household (median value) although responses ranged from £1 to £10,000

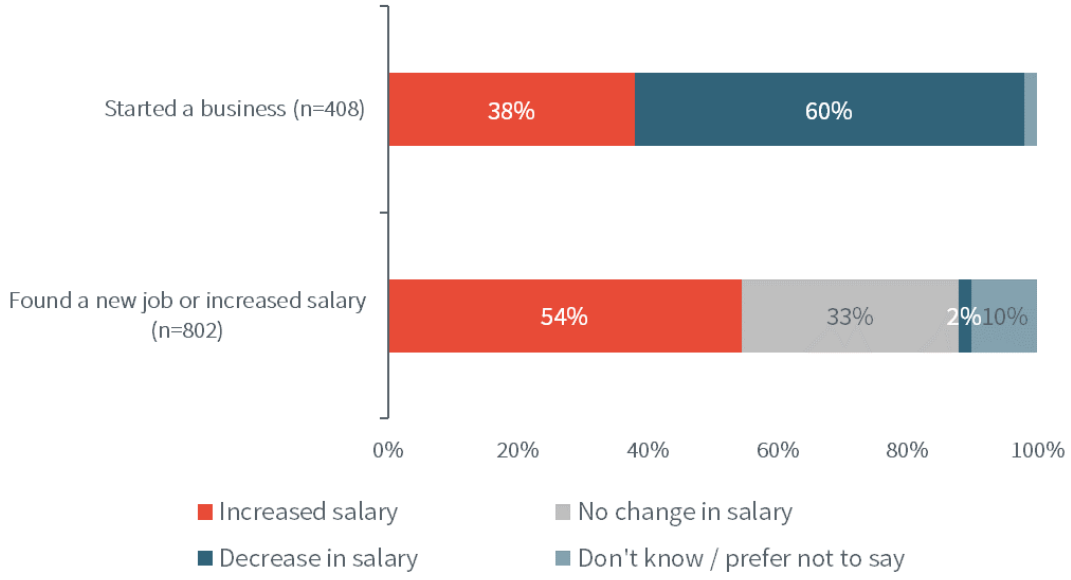
4.119 Table 4.15 shows this would mean vouchers have resulted in 327,000 fewer miles travelled, 26,000 hours saved and money savings of £179,000. It should be noted that these benefits are not additional to the estimates of subjective wellbeing (SWB) benefits in Chapter 5 which are based on changes in life-satisfaction. Any hours or money saved as a result of the broadband upgrade will have contributed towards this change in life satisfaction. Therefore, these benefits cannot be counted on top of the life satisfaction improvements or it would risk double-counting.

4.120 The reduction in travel will also reduce carbon emissions. These benefits can be assessed as additional to impacts on SWB because they are external benefits which benefit everyone, not just the individual. Any carbon savings as a result of reduced travel need to be weighed against the potential increase in emissions from people using heating and electricity whilst at home. The net effect of these changes is quantified in Chapter 6.

Skills and earnings benefits

4.121 Residents who said they had found a new job or started a business following their upgrade were asked if this had resulted in a change in their salary. Of those that had found a new job, half report an increase in their salary. For those starting a business, 38% reported an increase in salary while 60% reported a decrease in their earnings (see Figure 4.35).

Figure 4.35 Residents change in salary resulting from starting a business or finding a new job following their upgrade



Source Winning Moves

4.122 Where applicable, residents were asked to quantify their change in earnings. This was grossed up to calculate the total change in earnings for all voucher recipients (see Table 4.16). We estimate that the total gross change in earnings is in the region of £26.1m per annum.

4.123 As above, we assume that 40% of respondents would have been able to access a connection of sufficient quality to secure these benefits without the voucher. In addition, we have made a further adjustment to allow for the fact that some respondents would have started a business, found a new job or increased their salary even if they did not have access to a higher speed connection. To do this we have referred to the results in Figure 4.27 which showed that:

- 77% of those who had set up a business said the broadband upgrade was important or very important in enabling them to do so. This means it did not play a role for 23% of people.
- 61% of those who had got a new job said the upgrade was important or very important in enabling them to do so, meaning it was unimportant for 39% of people.

4.124 We have therefore assumed that the deadweight for people setting up their own business is 53.8% (40% + 23% of 60%) and 63.4% for people that got a new job or increased salary (40% + 39% of 60%). After taking account of this, the net additional change which can be attributed to vouchers is **£9.5m** (see Table 4.16). This increase in earnings will have contributed to respondents' change in life satisfaction. It is therefore assumed to be not additional to the increase in wellbeing calculated in Chapter 5.

Table 4.16 Quantifying change in earnings due to career changes or starting a business

Change in income	Respondent sample	All vouchers (gross)	All vouchers (net additional)
Increase in annual income	£5.5m*	£27.8m	£10.3m
Decrease in annual income	£0.34m†	£1.7m	£0.8m
Net change	£5.16m	£26.1m	£9.5m

Source: Winning Moves

*This is based on a median value of £10,000 for residents reporting an increased salary. This ranged from a £15 increase to a £350,000 increase.

† This is based on a median value of -£20,000 for residents reporting a decrease in salary. This ranged from £3,000 to £100,000.

4.125 Residents who have used the upgraded connection to gain new skills and qualifications might also be expected to experience an increase in their earnings (although this might not have materialised yet). These benefits can be modelled using research produced by the Department for Education and BIS, which have estimated the relationship between gaining qualifications at different levels and future changes in earnings[35].

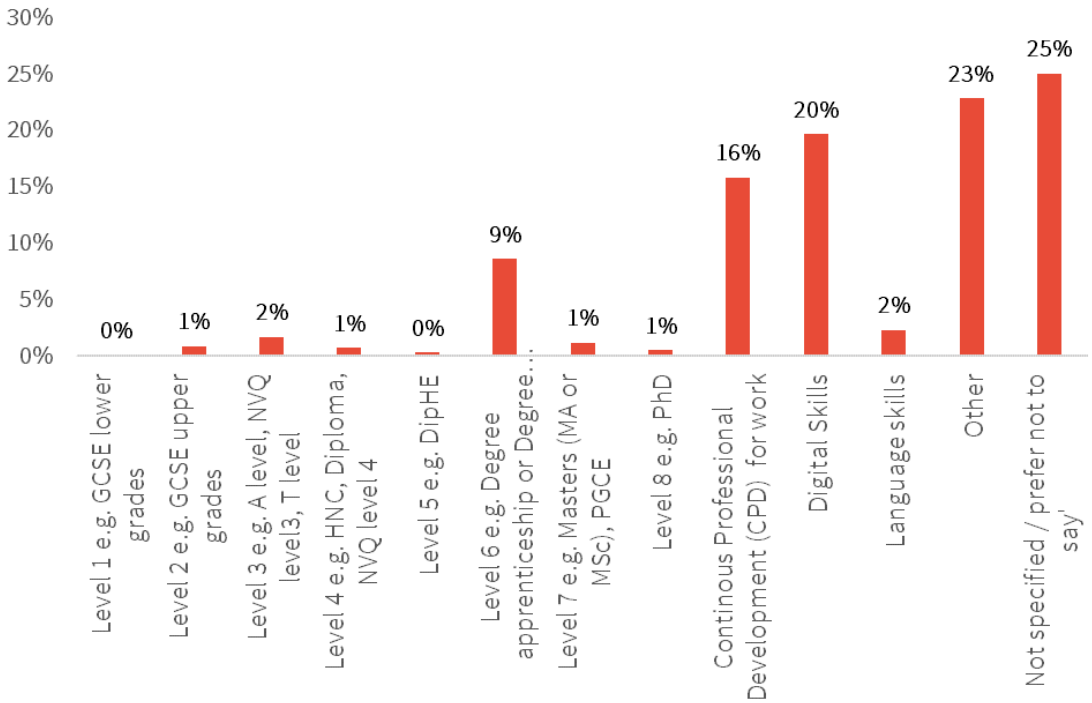
4.126 34% of respondents said they had gained new skills or qualifications through online learning. Of these, roughly half (48%) said they had used the internet to study for an adult professional qualification, with the remainder saying they had used it for general

[35] DfE (2014): The economic value of key intermediate qualifications and DfE/IFS (2020) Undergraduate degrees: lifetime labour market returns

adult learning. In both cases around 80% of respondents said that their upgraded connection was important or very important in enabling them to do so.

4.127 The survey asked respondents who have gained new skills or qualifications to specify the skills or qualifications gained. Figure 4.36 shows that around 15% of these specified qualifications could be coded to one of the levels in the National Qualifications Framework (ranging from level 1 to 8). The most common qualification level gained was Level 6 which is equivalent to a Bachelors degree. 60% of respondents provided a description of the skills gained but did not specify a particular qualification and the remaining 25% did not provide details or preferred not to say.

Figure 4.36 Types of skills/qualifications gained by residents



Source Winning Moves

4.128 Table 4.17 shows how we have used these responses to quantify the average increase in earnings per annum over the course of voucher recipients' working life. We estimate that the gross impact on earnings is around £660,000 per annum for the voucher sample, which translates to a total impact of around £3.3m for the voucher population as a whole.

4.129 As above, we assume that 40% of respondents would have been able to access a connection of sufficient quality to secure these benefits without the voucher. We make a further adjustment to account for the fact that the upgraded connection was not important for 20% of people who have used the internet to gain a professional qualification or for general adult learning. Therefore the total deadweight adjustment is 52% (40% + 20% of 60%).

4.130 This reduces the net additional impact of vouchers to **£1.6m per annum** (see Table 4.17). As above, the potential increase in earnings from new qualifications will have contributed to respondents' change in life satisfaction. It is therefore assumed to be not additional to the increase in wellbeing value shown in Chapter 5.

4.131 This is likely to be an underestimate of the total earnings benefits from the skills and qualifications enabled by vouchers. It does not include the long-term benefits for children's education or any of the potential earnings benefits from more informal adult education.

Table 4.17 Estimated increase in earnings per annum from gaining new qualifications

	No. in sample	Economic value per person per year (£)	Total for sample (£)	Voucher population gross (£)	Voucher population net (£)
Level 2	17	1,120	18,682	94,529	45,373
Level 3	33	1,174	39,165	198,173	95,123
Level 4+*	200	3,007	601,881	3,045,516	1,461,847
Total	250		659,727	3,338,218	1,602,344

Source: Hatch using DfE (2014): The economic value of key intermediate qualifications and DfE/IFS (2020) Undergraduate degrees: lifetime labour market returns

*the undergraduate degree study only provides a lifetime value for Level 4+ qualifications and provides separate estimates for males and females. We have taken the average of the 2 and assumed a working life of 40 years to estimate the annual average.

Summary of quantified benefits (not additional to the increase in SWB quantified in Chapter 5)

- **Reduced travel**: Vouchers have resulted in 327,000 fewer miles travelled, 26,000 hours saved and money savings of £179,000.
- **Changes in earnings**: the upgraded connection have enabled some people to secure an increase in earnings as a result of starting a business or finding a new job, which is an overall net-additional increase of £9.5m per annum.
- **Future changes in earnings**: the upgraded connection has also helped others to gain new skills and qualifications which could lead to an increase in future earnings. We estimate the net additional value of these benefits to be £1.6m per annum (although this is a minimum figure as it has not been possible to quantify earnings benefits for all people).

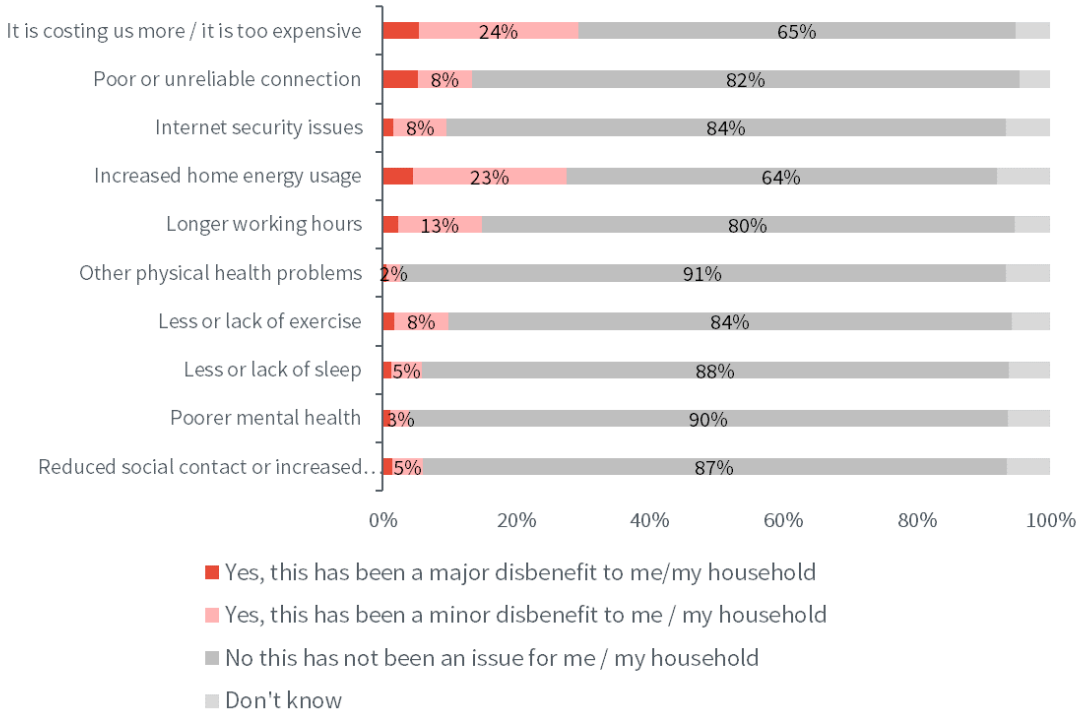
Challenges and Disbenefits

4.132 Approximately half of residents (56%) said that they had experienced a 'disbenefit' from their upgrade. The disbenefits affecting the highest proportions of residents are the cost of their upgrade (29%) and an increase in home energy usage (28%). 15% of residents also said that they are working longer hours.

4.133 The cost of the upgrade was reported to be a disbenefit for a similar proportion of residents (29%) as businesses (27%).

4.134 Approximately one in ten residents have experienced major or minor issues with their connection, either relating to the reliability of their connection or internet security issues. These proportions are similar to the proportion of businesses who said they had experienced reliability or internet security issues.

Figure 4.37 Disbenefits experienced by residents (n=4,928)



Source Winning Moves

4.135 The following groups were more likely to report disbenefits:

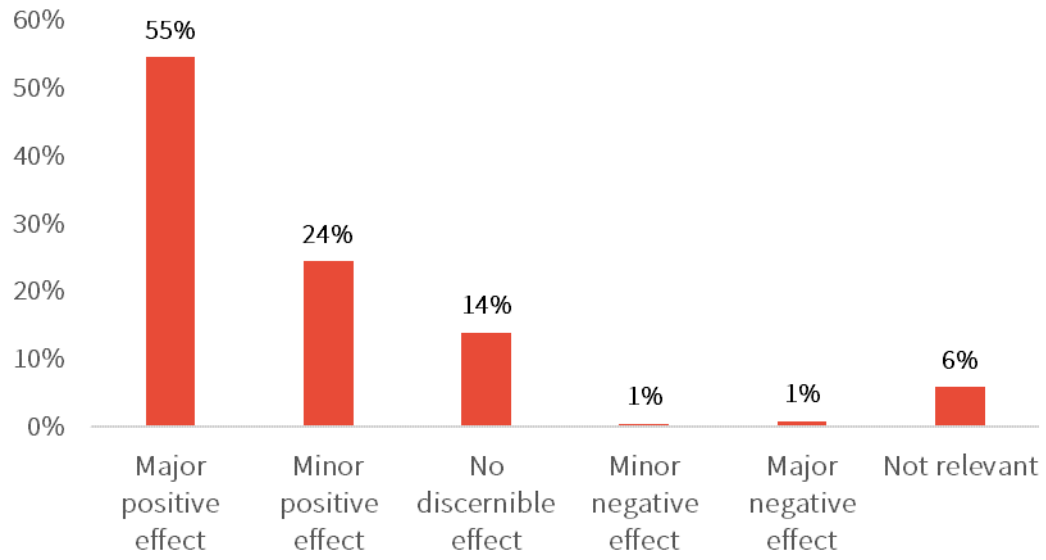
- A higher proportion of 18-24 year olds have experienced poorer mental health (22%), a lack of sleep (22%) and / or other physical health problems, compared to other residents.
- A higher proportion of residents working full time (26%) and residents with children (24%) have experienced longer working hours.
- A higher proportion of residents in commercial areas (35%) have experienced increased energy use, compared to 24% of residents in non-commercial areas. Increased energy usage is also associated with residents that work full time (38%), suggesting that residents that are benefitting from working from home have also seen an increase in energy usage, as described by one resident; *"I work longer hours from home as I don't have to spend hours travelling - which is a good thing…. I use more heat and electricity working from home."*

4.136 The carbon impacts of increased home energy usage are assessed and quantified in Chapter 6.

Covid Pandemic

4.137 More than three quarters of respondents (79%) said that their upgrade has had a major or minor positive effect on their household's ability to adapt. This is even higher than the 70% of businesses who said their upgrade had had a positive effect on their ability to adapt during the pandemic.

Figure 4.38 Effect of upgrade on respondents' ability to adapt during the Covid 19 pandemic (n=4,928)



Source Winning Moves

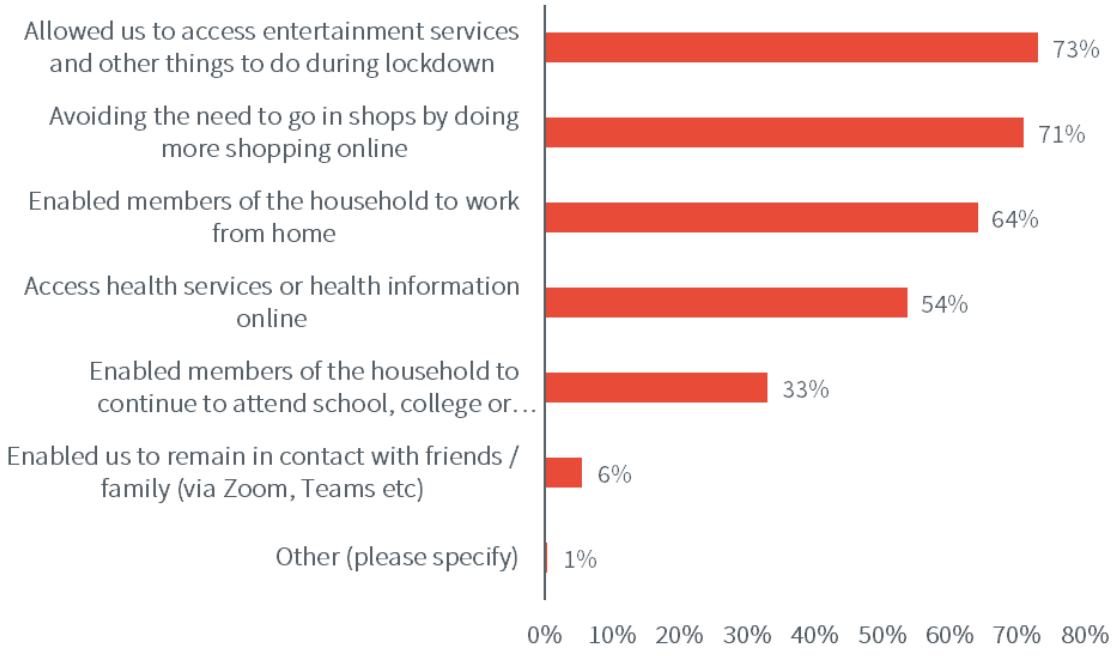
4.138 A higher proportion of residents in the following groups reported that their upgrade had a positive effect on their ability to adapt during the pandemic:

- 83% of employed people compared to 53% of unemployed and 76% of retired people
- Residents in manager, director or senior official occupations (86%) and professional occupations (84%) reported a positive effect compared to 75% of residents in other occupations.
- 84% of residents with children reported a positive effect compared to 72% of residents without children.
- 85% of GBVS recipients reported a positive effect compared to 77% of RGC recipients. This can be explained by the demographic characteristics of these respondents (e.g. age, employment status). When we control for these factors there is no difference.

4.139 Residents who said their upgrade had had a positive effect on their ability to adapt during the pandemic were then asked what were the main ways in which the upgrade had helped. Being able to access entertainment services and avoiding shops by shopping online were the most frequently selected options, selected by 73% and 71% of residents

respectively. Being able to work from home and accessing health services and information have also been important to large proportions of residents.

Figure 4.39 Main ways in which the upgrade helped residents to adapt during the pandemic (n=3,892)



Source Winning Moves

4.140 The following statistically significant differences between resident groups are observable in the data:

- A higher proportion of residents over the age of 65 said that the upgrade helped them to avoid shops (76%) compared to 59% of residents under the age of 65.
- A higher proportion of residents in managerial and professional occupations (89%) reported being able to work from home as a benefit of adapting to the pandemic compared to 66% of residents in other occupations.
- A higher proportion of residents over the age of 65 (61%) found the ability to access health services and information beneficial compared to 52% of younger residents.
- As would be expected, a higher proportion of residents with children (66%) said that being able to access school, college or university was beneficial to adapting compared to 14% of residents without children.
- A higher proportion of residents over the age of 65 (8%) said that being able to remain in contact with friends and family via Zoom and Teams was helpful in adapting to the pandemic, compared to 3% of younger residents.
- A higher proportion of residents in commercial areas said that being able to work from home was beneficial to adapting (75%), compared to 61% of residents in

non-commercial areas. Again, this is explained by the demographic characteristics of these areas.

The following quotes from survey respondents illustrate the range of ways that the upgrade helped households to adapt during the pandemic, and the transformative impact it had on many people's lives:

- *"it has made a life changing difference… we can work from home, do schoolwork, attend virtual lessons during Covid and also use the online entertainment such as iplayer and Netflix. We can also video chat with family and friends"*
- *"it has been a lifeline during the pandemic – for work, pleasure and general day to day living. I do a lot of charity work and it meant we were able to operate during COVID times distributing nearly 3 million pounds to people who desperately need financial support."*
- *"It has been a God-send during Covid"*
- *"It has totally transformed our daily life....able to stream music, download films in seconds rather than days , enabled me as a key worker to work with large computer systems of NHS and social care with ease from home throughout Covid"*
- *"I am a teacher and we had to deliver lessons from home on a daily basis with no equipment provided. It wouldn't have been possible to do this without the upgraded connection"*
- *"The upgrade was hugely valuable during Covid lockdowns with three children remote schooling. It would not have been possible without the upgrade"*
- *"The upgrade made life immeasurably better during the lockdowns of the pandemic. Our family live more than 200 miles away but we have been able to stay in touch using WhatsApp and Zoom. I have also been able to fulfil my role as a `trustee of a charity and my wife has been able to continue as a Community First Responder. We have also been able to keep in contact with friends and attend virtual meetings of local societies to keep our minds active and engaged. The broadband service has enabled us to research issues of interest (wildlife, archaeology and local history, art) as well as access news (we are unable to get a daily newspaper as we live in a remote location - but we now read newspapers online and access media newscasts through iPlayer and the like)."*
- *"I am very grateful that a rural area had this opportunity. I work in a local NHS hospital and have a low income. The upgrade enabled me to occasionally work from home which was beneficial during the pandemic especially as I am clinically vulnerable to Covid-19. I am very grateful that such schemes run and create a more level playing field both in terms of rural areas having access to superfast broadband and availability for people on low incomes"*

Conclusions

Voucher beneficiaries are older, wealthier and higher skilled than the UK population

4.141 Although there is some uncertainty over the degree to which the survey sample is representative of voucher beneficiaries, the analysis suggests a high proportion of beneficiaries are older, wealthier and higher skilled than the UK average. Voucher beneficiaries are also less likely to live alone and less likely to have children than the UK average, but more likely to own their own home outright.

4.142 The most likely explanation for this is that residential vouchers have been used mainly in rural areas which have an older population (although it is difficult to confirm this with the data available). The high proportion of high-income households is explained by the supplier-led nature of the programme, and the fact that suppliers seem to have targeted wealthier locations where take-up is likely to be higher.

4.143 The analysis also shows that the population is even older in non-commercial areas, which are the current focus of BDUK's investments through Project Gigabit. This has implications for the scale and range of wellbeing benefits that future rounds of investment could generate. Although the broadband upgrade provides some benefits for older people (e.g. doing a range of things for the first time), younger groups are far more likely to report a change in life satisfaction (the main measure for assessing wellbeing), and these are more likely to live in commercial areas.

Vouchers have been increasingly well-targeted on people who need it most

4.144 The proportion of people who say they would not have upgraded their broadband connection without the voucher has increased significantly, from 27% in 2018 to 48% in 2021 meaning the additionality of benefits from vouchers has grown over time. This supports BDUK's strategy to focus on non-commercial areas, where a similar proportion state that they would not have considered an upgrade if it was not for the voucher (45%).

4.145 There has also been strong growth in the number of people that have actively sought a voucher, from 16% in 2018 to 36% in 2021, indicating vouchers are increasingly being issued to highly motivated households in greatest need.

There are high levels of satisfaction with the application process and the upgraded connection

4.146 Resident satisfaction with the voucher application process is high, with 88% of residents satisfied or very satisfied with the ease of the voucher process and 87% satisfied or very satisfied with the length of the process.

4.147 Residents' satisfaction with their internet connection has increased following the upgrade. Whilst before the upgrade, between one quarter and one third of residents were satisfied with their connection, more than 90% of residents are now satisfied with the upgraded connection's reliability, download and upload speeds. The increase in satisfaction was

particularly high in non-commercial areas which also supports BDUK's strategy to focus on these areas.

The upgraded connection has enabled older households and those in non-commercial areas to do a range of things for the first time

4.148 One in five older households (over 65) have streamed entertainment services for the first time since receiving the upgrade, significantly more than other age group. The proportion of older households using applications for the first time was also higher for video chat with friends and family (11%), accessing health and other services online (9%) and cloud storage and file sharing (8%). For a number of these uses, a high proportion of these older people said their broadband upgrade had been important in enabling them to do this (93% for streaming entertainment services, 91% for video chat with friends and family and 80% for accessing services online).

4.149 A high proportion were also likely to say it had had a positive impact on their quality of life; 70% for streaming entertainment services, 83% for keeping in touch with friends and family and 73% for accessing services online).

4.150 The proportion of households doing things for the first time was also higher in non-commercial areas, although this mainly reflects the fact that these areas have a much higher share of older residents.

The greatest range of benefits have been for working households, particularly those in high skilled and high-income jobs and those with children.

4.151 Relatively few working age households and households with children are using internet applications for the first time. However, they are using the internet for a much wider range of uses than older groups, including personal, educational and professional applications. They are also more likely to report using the internet for these reasons more frequently and more effectively.

4.152 As a result, these households were more likely to report a much wider range of benefits from their upgraded connection, including a better work-life balance, educational benefits, reduced stress and the ability to start a new business. This range of benefits explains why these groups were more likely to report an increase in life satisfaction than older households, households without children and unemployed people.

There is also evidence of distinctive benefits for certain groups

4.153 In addition to the above, we would highlight the following benefits for certain groups:

- 24% of young respondents (18 to 24) report that the broadband upgrade has helped them to start a business, while 14% say it has helped them to run an existing business.

- 26% of lone parents have gained new skills or qualifications and 20% have found a new job or improved their career prospects.
- 10% of people in lower skilled occupations (carers and manual workers) say they have used the internet to study for a professional qualification.

4.154 The analysis also shows that the broadband upgrade facilitated by vouchers have helped 19% of people to feel less lonely. This is particularly the case for some at risk and vulnerable groups (e.g. those living on their own, households with low income). The survey shows that streaming entertainment services and using video chat applications have been particularly valuable for improving the wellbeing of these groups.

The upgrade helped many households to adapt during the Covid pandemic

4.155 More than three quarters of respondents (79%) said that their upgrade has had a major or minor positive effect on their household's ability to adapt. This is even higher than the 70% of businesses who said their upgrade had had a positive effect on their ability to adapt during the pandemic.

4.156 The main benefits for households was their ability to stream entertainment services during lockdown, avoiding the need to go in shops (particularly important for older age groups) and working from home (particularly important for working age households).

5. Wellbeing impacts of vouchers

Summary of key findings

- Wellbeing improvements have been estimated and monetised in line with Green Book Guidance using a Subjective Wellbeing (SWB) method. This requires beneficiaries to rate their life satisfaction before and after an intervention. The change can then be converted into a monetary value (a WELLBY).
- Although the residents survey provides valuable information on whether vouchers have improved residents' wellbeing, the scale of the improvement in life satisfaction reported by respondents is likely to be subject to bias and significantly overstated.
- We therefore draw upon the findings of an earlier evaluation of the SWB impacts of BDUKs Superfast Broadband Programme. The benchmarks for improvements in life satisfaction for different age groups from this study are applied to the voucher population, with minor adjustments to ensure these are consistent with the findings of the residents survey. The results are presented as a range to reflect the uncertainty with this approach.
- We estimate the total gross effect of vouchers on wellbeing is between £53.5m and £90.0m (in 2022 prices). After accounting for deadweight, the net additional impacts are estimated to be between £32.2m and £54.1m. This is equivalent to between £1,262 and £2,168 per household per annum.
- It is assumed that, for a large number of households these wellbeing benefits will persist for a number of years. The persistence period depends on the number of years it would have taken for households to gain access to high speed broadband through the market rollout. This has been estimated using DSIT's Fscore model, which assigns scores to individual premises based on how commercial feasibility. After accounting for persistence the total impact of vouchers on wellbeing is estimated to be between £114m and £195m.
- The residents survey shows there was no statistically significant difference in the proportion of residents reporting a change in life satisfaction between households that received a voucher through the GBVS or RGC scheme. Similarly there was no difference for households that received project or standard vouchers. Therefore, the gross change per household is likely to be the same for both voucher schemes and types. However deadweight is lower in RGC and project areas, meaning the net additional impact per household is larger.
- When we compare survey responses for the same age group, households that received vouchers through the RGC scheme are more likely to report an improvement in life satisfaction than those that received vouchers through the GBVS scheme. However these differences are cancelled out by the fact that RGC households are older on average, and older groups were less likely to report an improvement in life satisfaction than younger groups.

Purpose of Chapter

5.1 In order to estimate the value for money of BDUK's vouchers schemes, it is necessary to estimate and, wherever possible, monetise the full range of impacts that vouchers have generated. This includes economic, social and environmental impacts.

5.2 As evidenced by the findings of the residential survey, improving access to high-speed broadband can generate a range of social benefits including increased leisure time, improved access to information, entertainment and public services, reduced loneliness and educational benefits from online learning. Conversely, it may lead to social disbenefits associated with excessive internet use such as internet addiction, insufficient exercise or sleep.

5.3 All of these effects will contribute to voucher recipients' overall wellbeing. Some changes in wellbeing will be reflected in the prices paid by households for their monthly broadband subscription and any additional subscriptions for related services (such as the cost of entertainment services). However, this may not capture all of the value that households derive from their upgraded connection (the consumer surplus).

5.4 This section explains the approach taken by the study to quantifying wellbeing improvements and presents results for the net additional effects on wellbeing that can be attributed to vouchers. These results are presented as a range due to the higher level of uncertainty associated with estimating impacts on wellbeing.

Context for valuing wellbeing effects of broadband

Green Book guidance on valuing wellbeing improvements

5.5 HM Treasury has published Supplementary Green Book Guidance[36] on how to monetise a policy or programme's effects on wellbeing as part of Social Cost Benefit Analysis. This includes several different methods such as stated preference and revealed preference methods and subjective wellbeing (SWB) approaches. Of these, SWB approaches were considered to be the most practical approach to quantifying wellbeing effects from vouchers. While other studies have used hedonic pricing to model wellbeing effects of broadband[37], this approach is still being developed and tested by BDUK. There are also issues with the cost and availability of data required for this approach, and a risk of the sample size being too small to produce robust results (since only a small proportion of the

[36] Wellbeing guidance for appraisal - supplementary Green Book guidance.pdf (publishing.service.gov.uk)

[37] This is a specific type of revealed preference method which identifies the internal and external factors which affect the price of a particular asset or service, and uses this to place a value on certain characteristics. The most common example is in the housing market, where a hedonic pricing model can be used to estimate quantitative values for environmental or ecosystem services that directly affect market prices for homes. An ongoing BDUK evaluation is using this method to estimate the wellbeing value of a property having access to superfast broadband (SFBB)

homes which have received a voucher are likely to have been sold in the intervening period[38]).

5.6 SWB approaches use surveys to ask large numbers of respondents to rate their subjective wellbeing (or life satisfaction) before and after an intervention, then control for the range of other factors which influence wellbeing to detect the change which can be attributed to the intervention. This change in wellbeing can then be monetised by translating the change into an equivalent change in income.

5.7 A discussion paper published alongside the Supplementary Green Book Guidance[39] reviewed a number of studies which have taken different approaches to valuing and monetising wellbeing to arrive at a consistent set of assumptions that can be applied to a range of different interventions. This recommended an approach whereby life satisfaction is rated on a scale of 0 to 10, and a change in life satisfaction can be converted to a monetary value by multiplying by £13,000. This is the recommended standard value of one wellbeing adjusted life year – a 'WELLBY' in 2019 prices and values. The value of a WELLBY derived in this way can then be applied linearly to any change in life satisfaction. For example, increasing life satisfaction by 0.4 for 1 year would have a value of 0.4 x £13,000 = £5,200.

Findings of the residents survey

5.8 The evaluation of gigabit vouchers was commissioned after residents had received their voucher and benefitted from their upgraded broadband connection. BDUK did not undertake a baseline survey of life satisfaction before the upgrade, meaning it was not possible to undertake a 'before and after' survey of the life satisfaction of voucher beneficiaries.

5.9 Instead the survey asked respondents whether their life satisfaction had changed as a result of the upgrade and, if so, to retrospectively assess their life satisfaction on a scale of 0 to 10 before the intervention and to rate their current life satisfaction on the same scale. 56% of respondents said their life satisfaction had changed, with most of these saying their life satisfaction had improved (53%). A small minority said it had decreased (3%). As shown in Chapter 6, households with certain characteristics were more likely to report that life satisfaction had improved (particularly working households, those with children and those in highly skilled or high income occupations).

5.10 For those respondents that did report a change in life satisfaction, the average life satisfaction score of residents before the upgrade was 6.6, and this increased to an average of 8.7 after the upgrade:

[38] To illustrate, ONS data shows around 2.4% of residential properties in England and Wales were sold in the year ending June 2022. If that also applied to the sample of residential vouchers it would return a maximum sample size of 580. The turnover rate tends to be lower in rural areas so in practice the sample is likely to be smaller than this.

[39] Wellbeing_guidance_for_appraisal_-_background_paper_reviewing_methods_and_approaches.pdf (publishing.service.gov.uk)

- for residents that said their life satisfaction had increased, the average increase in points was 3 and the median increase was 2, although responses ranged widely from a 1 point increase to a 9 point increase
- for residents that said their life satisfaction had decreased, the average decrease was 2.5, and the median decrease was 2, although again this varied widely from a 1 point to a 9 point decrease.

5.11 If we assumed the scale of these effects was accurate and representative of the voucher population as a whole, this would translate to an annual wellbeing value of nearly £350m, or £14,000 per household. In practice, the self-reported changes in life satisfaction are likely to significantly overstate the wellbeing improvement compared to if we had asked respondents a general question about their life satisfaction before and after the intervention. This is due to:

- recall bias, which occurs when participants do not remember previous events or experiences accurately. A number of studies have demonstrated the existence of recall bias in relation to past life satisfaction or wellbeing[40].
- the fact that vouchers were referred to in the survey question which is likely to exaggerate their effect. It was difficult to avoid reference to this given that the survey was focused on vouchers and we needed to refer to the period before the voucher when asking them to rate their life satisfaction.

5.12 On this basis, we do not believe the self-reported figures are a robust measure of the scale of change in wellbeing attributable to the upgraded broadband connection. We have therefore reviewed other studies which have measured the subjective wellbeing of digital connectivity in a more robust way and considered how the findings of these studies can be used to inform reasonable assumptions about the wellbeing effects of vouchers.

Findings of other studies

5.13 We have identified two other relevant studies which have measured the impact of digital connectivity on life satisfaction. We provide a summary of the method used by the authors, the key findings and discuss how these could inform assumptions about the effects of vouchers.

Subjective wellbeing analysis of the Superfast Broadband programme (Simetrica, 2018)[41].

5.14 This was one of the technical papers which fed into the Evaluation of the Economic Impact and Public Value of the Superfast Broadband Programme (Ipsos Mori, 2018). The study assessed the impact of the BDUK Superfast Broadband Programme on the

[40] For example, see Easterlin, R. A. (2001): Income and happiness: Towards a unified theory, The economic journal 111(473): 465–484 and Prati, A. and Senik, C. (2020): Feeling good or feeling better? (hal.science)

[41] BDUK Superfast Broadband Evaluation Annex C- Subjective Wellbeing Analysis Technical Report

subjective wellbeing (SWB) of households with access to subsidised superfast broadband and aimed to value this in monetary terms.

5.15 The study used data for the period 2011 to 2016 from two national surveys which both asked questions about life satisfaction (the Annual Population Survey and the Understanding Society survey). By matching the geographical location of respondents to the roll-out of Superfast Broadband, the study was able to assess the difference in life satisfaction for people living in a postcode already upgraded by SFBB with those which have not yet received an upgrade. The study used econometric methods to control for a range of other factors which affect life satisfaction such as age, earnings, educational status and so on.

5.16 Differences in life satisfaction were then converted into monetary values using a method developed by one of the study authors to calculate the income equivalent of a shift in subjective wellbeing due to another cause[42].

5.17 The results based on responses to the APS responses are shown below[43]. The study found that, for the sample as a whole, living at a postcode serviced by an upgraded cabinet was associated with a *lower* life satisfaction score of -0.005 units on the 0-10 scale. However, this finding was not statistically significant at the 10% level. The study also provided the results split by age group which did find statistically significant results. This found a positive correlation between life satisfaction and living in an upgraded postcode for people in the youngest age group (35 and below), but this was counterbalanced by a negative correlation for people aged between 36 and 64, resulting in an insignificant effect for the sample as a whole.

Table 5.1 Model coefficients for life satisfaction for people living in postcodes upgraded with SFBB

Age group	Upgraded
Full model (all ages)	-0.005
Aged 18 to 35	+0.078*
Aged 36 to 64	-0.033*
Aged 65+	+0.001

*statistically significant at 10% level

5.18 These results were then monetised and the results were aggregated for the population as a whole by applying the age specific coefficients to the age breakdown of the population in areas upgraded with SFBB. This resulted in an **average wellbeing value per person of £93.78 per year** and an **average of £222.25 per year per household with access to SFB[44]**.

[42] This preceded the Green Book guidance on WELLBYs

[43] The study concluded that the responses given to the APS survey were likely to be more robust than the Understanding Society survey as it was possible to match responses at postcode level using APS but only at Lower Super Output Area level for Understanding Society.

[44] These results are positive because the age profile of the intervention area was skewed more towards age groups with positive coefficients (35 and below and 65+) than the sample from APS.

5.19 After adjusting for the estimated take-up rate in upgraded postcodes at the time (40%), the wellbeing value of the upgrade was estimated to be **£46 per month per premise which adopts SFBB**. This was over and above the price that households pay for the internet and the extent to which households pay for SFBB access through housing.

5.20 The coefficients above are significantly lower than the changes in life-satisfaction reported by voucher beneficiaries in the residents survey. As a result, the impact on wellbeing estimated in the SFBB study is far lower (£225 per household compared to £14,000 per household based on the responses to the voucher survey). This suggests the change in life satisfaction reported by vouchers beneficiaries was subject to bias and therefore overestimates the scale of the benefits.

5.21 It should be noted that the SFBB programme is not directly comparable with the voucher scheme, and there are a number of reasons why we might expect the increase in wellbeing to be higher for vouchers. Firstly, the vouchers programme has delivered a far greater improvement in connectivity than the SFBB programme. The SFBB evaluation found that the average download speed for postcodes receiving investment through the SFBB programme was around 10 Mbps before the upgrade, increasing to 27 Mbps three years after the upgrade[45]. For residential vouchers, mean average download speeds increased from 14 Mbps before to 345 Mbps after the upgrade (based on BDUK monitoring data).

5.22 This has occurred alongside a significant increase in households' use of the internet and need for higher bandwidth, which is likely to increase the wellbeing benefits of vouchers relative to the effects of SFBB investment. There is evidence for this in the SFBB evaluation which found that wellbeing effects were higher for frequent internet users, leading the authors to conclude that "the wellbeing effects of the programme may grow over time, if take-up and internet use increases". There is clear evidence that this is the case; Ofcom estimates that adults who use the internet spent around 4 hours a day using the internet in 2021, up from 2 hours 40 mins per day in 2015. This only includes time spent on computers, tablets and mobile devices and excludes streaming services through smart televisions, the take-up of which has grown strongly since the mid 2010s[46]. Furthermore, unlike the SFBB programme, the voucher schemes were demand-led, meaning beneficiaries are more likely to make greater use of the internet. The survey analysis in Chapter 3 shows that 98% of respondents say they use the internet at least once a day, compared to 89% of the UK population according to ONS's most recent survey[47].

5.23 The Covid-19 pandemic has also had major implications for the way we use the internet, leading to changes in the way we live and work which have persisted as restrictions have

[45] See Figure 2.6 of Ipsos Mori (2018): Superfast Broadband Programme Evaluation; Annex A: Reducing the Digital Divide

[46] The total number of Netflix subscribers in the UK increased from 2.8m in 2014 to 17.3m in 2021

[47] Internet access - households and individuals - Office for National Statistics (ons.gov.uk). It should be noted that the ONS survey data is for 2020 while the vouchers survey was undertaken in 2022. The ONS survey shows that the proportion of people who are daily internet users increases year on year. Therefore we would expect the proportion in 2022 to be higher than this data suggests.

eased; Labour Force Survey data shows over 30% of employed people were working from home in the first quarter of 2022, more than double the proportion for 2019 (14%). A further 14% are working from home at least one day a week. Faster and more reliable broadband has been a critical enabler of this; the residents survey showed 70% of households who were working from home said the upgraded connection was 'very important' in enabling them to do so. Similarly, the proportion of retail sales conducted online is still well above the pre-pandemic average (30.2% in November 2022 compared to 21.6% in November 2019). It is therefore reasonable to assume that access to a fast and reliable internet connection is a more important contributor to life satisfaction now than it was in the mid 2000s.

5.24 It can also be argued that these changes in working and living patterns has led to changes in the age profile of people who derive benefits from faster and reliable broadband compared to the mid-2010s. The residential survey shows that the group who derived the greatest benefits from their upgraded connection were working households, particularly those employed in highly skilled occupations and those with children. As well as greater entertainment options these households were more likely to report educational benefits, time savings and improved work-life balance as a result of working from home. For instance:

- 82% of respondents aged 25 to 64 said saved time had been a benefit of their upgraded connection, with 56% saying it was a major benefit (compared to 43% of households aged over 65)
- 68% of those aged 25 to 64 said an improved work life balance was a benefit, with 52% saying it was a major benefit (compared to 15% of those over 65).

5.25 As a result, working age households were significantly more likely to report an improvement in life satisfaction as a result of the upgraded connection than those over 65 (56% vs 49%).

5.26 We therefore believe there are strong grounds to conclude:

a) that the increase in wellbeing per household subscribing to SFBB in the mid 2010s should only be used as a minimum estimate of the increase in wellbeing from households upgrading their connection through a gigabit voucher, and

b) that, on average, older working age households (aged 36 to 64) have also experienced an increase in life satisfaction as a result of their upgraded connection, as well as younger age groups.

5.27 These conclusions inform the assumptions we have used for modelling the wellbeing impacts from vouchers (described below).

Digitalization and subjective wellbeing in Europe (Elmassah and Hassanein, 2022)

5.28 This study aimed to analyse the effect of digitalisation on 28 European countries' subjective wellbeing by using macro (aggregate level) indicators. The research used the Digital Economy and Society Index (DESI). This index summarises indicators on Europe's digital performance and tracks the progress of EU countries across a number of different domains:

- Human capital and digital skills
- Connectivity, based on the supply and demand of fixed and mobile broadband
- Use of the internet
- Integration of digital technology, and
- Digital public services

5.29 The authors investigate the relationship between each of these domains and life satisfaction at a macro level, controlling for a number of variables such as unemployment, GDP per head, life expectancy etc.

5.30 Table 5.2 shows the results from this study. Specifically, it shows the effect of a 1% increase in each of the domains on life satisfaction. This found statistically significant results for each of the domains. For connectivity, the study found a 1% increase in connectivity leads to an increase in life satisfaction of 0.84%.

Table 5.2 Elasticities of DESI variables in predicting subjective wellbeing

Dependent variables	Co-efficients (%)
Connectivity	0.843
Human Capital	-3.726
Use of the Internet	4.573
Integration of Digital Technology	0.153
Digital Public Service	-0.708

Source: Elmassah and Hassanein, 2022

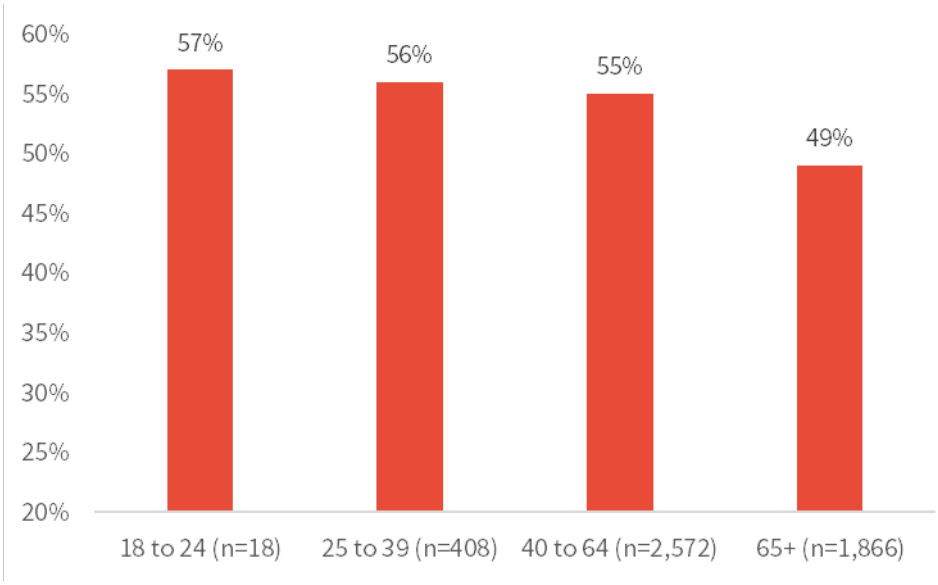
5.31 While this study provides further evidence of a positive correlation between enhanced digital connectivity and life satisfaction, the macro nature of the study means the findings are of limited value for informing the assumptions about changes at a micro level (for an individual or a household). Therefore we have not used the findings of this study in the modelling of SWB effects from vouchers.

Method for assessing impacts

5.32 The evaluation has used the findings of the SFBB evaluation to derive a modelled estimate of the impact of vouchers on SWB. This allows us to eliminate the risk of bias and provide a more realistic estimate of the impact on wellbeing.

5.33 We assume that the age-specific wellbeing coefficients for voucher beneficiaries are the same as those from the SFBB evaluation (presented in Table 5.1). The only age group where we have made changes to the coefficients is for 36 to 64 year olds. This is on the grounds that the residents survey showed 36 to 64 year olds were among the groups that derived the widest range of benefits from the upgraded connection, were more likely to report an increase in life satisfaction than people over the age of 64 and were just as likely to report an improvement as people aged 25 to 39. There is therefore a clear, evidence-based logic for assuming positive wellbeing coefficients for this age group instead of the negative coefficient from the SWB evaluation.

Figure 5.1 Percentage of respondents reporting an improvement in life satisfaction by age



Source Winning Moves

5.34 The estimates of wellbeing are presented as a range, with the modelling making the following assumptions, set out in Table 5.3:

- Lower estimate: the change in life satisfaction for people aged 36 to 64 is +0.039 which is equivalent to half the increase for people aged 18 to 35 in the SFBB study (+0.078)
- Upper estimate: the increase in life satisfaction for people aged 36 to 64 is equal to the increase for people aged 18 to 35 from the SFBB study (+0.078).

Table 5.3 Modelling assumptions for age based coefficients for wellbeing effects of vouchers

Age group	SWB Evaluation	Assumptions for vouchers	
		Lower estimate	Upper estimate
Aged 18 to 35	+0.078	+0.078	+0.078
Aged 36 to 64	-0.033	+0.039	+0.078
Aged 65+	+0.001	+0.001	+0.001

Hatch using findings from Simetrica (2018)

5.35 The modelling has involved the following steps and assumptions:

- The total population of households receiving vouchers has been estimated using the average household size of 2.6 from the residential survey. Based on 24,979 residential vouchers[48] (1,125 through the GBVS scheme and 3,803 through RGC) this gives a total population of 65,072.

[48] These are all residential vouchers that were connected up to the end of December 2021. This was based on the most up to date vouchers data available at the time.

- The adult population was estimated using the responses to the survey question which asked how many children in full time education there were in the household. We made further adjustments to take account of children below school age (0 to 4) and those between the age of 16 and 18 who are not in full time education using Census data. This gave a total adult population of 52,502.
- We assumed the age profile of these adults was in line with the age profile of the voucher applicant who responded to the survey. This may not be fully accurate, but is the most robust way of estimating the age profile for other adults living in the household.
- There is a slight mismatch between the age categories in the residential survey and the categories in the SFBB evaluation. We therefore applied changes in life satisfaction to the closest matching age group. For example, for 18 to 39 year olds we applied the change in life satisfaction for 18 to 34 year olds.
- The upper and lower estimates used the same assumptions about changes in life satisfaction for 18 to 39 year olds and people aged 65+ (based on the coefficients given in Table 5.1). The only age group where we have made adjustments is for 40 to 64 year olds. This means we have taken a conservative approach for the other age groups given that dependence on the internet has increased since the mid 2010s.
- The SFBB evaluation monetised changes in life satisfaction using a method developed by one of the study authors. The exact values are not given and this preceded the publication of the WELLBY guidance in the Green Book. We have therefore used WELLBY values to monetise changes in life satisfaction, where a one point change on the 0 to 10 scale has a value of £13,000 (in 2019 prices).
- The estimates of wellbeing in the SFBB evaluation were for all people who had gained access to SFB, but who had not necessarily subscribed to SFBB. Given that all of the households with vouchers have subscribed to faster broadband packages, it was necessary to adjust for this. We have therefore multiplied the figures by 2.5. This is the inverse of 40%, which was the estimated take-up rate for SFBB at the time of the evaluation. This is consistent with the approach taken in the SFBB evaluation.

Results

5.36 The results are shown in Table 5.4. Using this method, we estimate that the gross impact of vouchers on wellbeing is between £49.6m and £85.2m per annum in 2019 prices (the year WELLBY values are based on). This is equivalent to between £1,984 and £3,410 per household per annum. This is over and above the price that households pay for their broadband subscription.

Table 5.4 Gross effect of vouchers on wellbeing per annum (£m, 2019 prices)

Age group	Adult population	WELLBY value per person (£)		Total value of WELLBYs (£m)	
		Lower	Upper	Lower	Upper
18 to 39	5,267	1,014	1,014	5.3	5.3
40 to 64	28,084	507	1,014	14.2	28.5
65+	19,152	13	13	0.2	0.2
Total	52,502			19.8	34.1
Total WELLBY value per annum adjusted for take-up (1/40%) - £m				**49.6**	**85.2**
WELLBY value per annum per household (based on 24,978 households) - £				**1,984**	**3,410**

Calculations by Hatch using Simetrica (2018): Subjective wellbeing analysis of the Superfast Broadband programme and Green Book guidance.

5.37 To arrive at an estimate of the total net impact of vouchers, we also need to consider deadweight (what would have occurred anyway in the absence of vouchers) and persistence (how long the effects of wellbeing last for).

Deadweight

5.38 Assessing deadweight in this case is complex as it depends on:

- whether households would have received access to gigabit capable broadband in the absence of the voucher, and
- whether households would have upgraded their connection in the absence of vouchers (potentially to a lower quality connection), and the extent to which that upgrade would have improved life satisfaction.

5.39 We currently have mixed evidence to inform these assumptions. 82% of respondents to the residents survey reported that they had not upgraded because it was not available where they are located, which suggests deadweight is low. The counterfactual analysis has shown a clear link between vouchers and change in download speeds (although the additional effect is only c. 3 Mbps for vouchers connected in 2019 and 2020) but provides inconclusive results on the relationship between vouchers and availability of UFBB and gigabit capable broadband (due mainly to inconsistencies in Connected Nations data). Although it should be noted that the analysis was undertaken at output area level which is likely to understate additionality for individual premises or postcodes.

5.40 The residents survey[49] also showed that:

- 21% would have upgraded to the same quality connection, even if they had not received a voucher (with some of these moving to new premises in order to do so). It can be assumed all of these beneficiaries would have achieved the same increase in life satisfaction. This is a conservative assumption as 16% of these people also said they had not upgraded previously because it was not available in

[49] See Figure 4.14 in Chapter 4 which provides a more detailed breakdown of responses to this question

their area. If this is true it is not clear how they could have upgraded to the same quality connection. Furthermore, respondents who said this may not have been aware of the full cost implications of achieving the same connection or might not have been aware that it was not available.

- A further 37% would have upgraded but at a later date or settled for a lower performance connection. It can be assumed that beneficiaries in this group would have achieved some of the improvement in life satisfaction but not all of it. However it is very difficult to attach a quantitative value to this.

5.41 Based on the above, we have assumed deadweight of 40% (21% + half of 37%), although we would note again that this is subject to uncertainty.

5.42 On this basis, the net additional value of WELLBYs due to vouchers is estimated to be between £30m and £51m per annum in 2019 prices, with the range based on the assumptions applied for 36 to 64 year olds in Table 5.3. This is equivalent to between £1,191 and £2,045 per household (based on 24,979 households). It should be noted that the maximum value for residential premises vouchers was £500 for GBVS and £1,500 for RGC. Therefore the benefit gain is higher than the value of vouchers themselves.

5.43 Adjusting for inflation, this is equivalent to between £32m and £54m in 2022 prices, or between £1,262 and £2,168 per household.

Table 5.5 Net additional effects of vouchers on wellbeing (2019 prices)

Estimate	Gross value of WELLBYs (£m)	Net additional value of WELLBYs (*0.6) (£m)	Net additional value per household (£)
Lower estimate	49.6	29.7	1,191
Upper estimate	85.2	51.1	2,045

Calculations by Hatch

Persistence

5.44 There is little evidence on how long effects on wellbeing from an upgraded broadband connection will persist for. The SFBB evaluation stated that the annual estimates could be "*used as an estimate of future impact up until the technology becomes redundant*". Given that gigabit capable broadband is a future-proofed technology, this is not likely to occur for some time. It is also likely that dependence on internet connections will continue to grow as the number of applications proliferates, leading to further changes in the way we live and work. This suggests the evaluation should assume a long persistence period in line with other infrastructure investments[50]. It should also be noted that respondents to the residential survey who received their upgrade in 2018/19 were just as likely to report an improvement in life satisfaction as respondents who received

[50] For example, 2014 HCA Additionality Guide recommends a persistence period of 10 years for a number of infrastructure investments including bringing land back in to use, public realm improvements and educational infrastructure

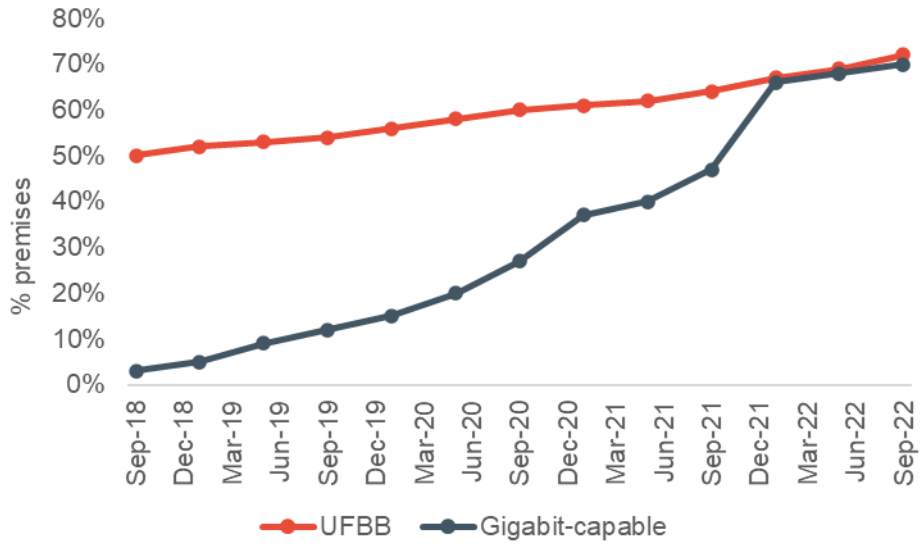
their upgrade in 2021 which also suggests that benefits persist for a number of years (see Figure 5.3 below)

5.45 However, in this case, we also need to account for the fact that some households are likely to have gained access to a higher speed connection at some point after they took up the voucher due to the continued market rollout of gigabit-capable broadband.

5.46 To account for this, we have used DSIT's Fscore model which assigns a 'commerciality' score to individual premises based on the estimated cost to provide that premise with access to gigabit capable broadband. If the cost to build is greater than £615, the premise is considered to be non-commercial. Premises with a build cost of £615 have an F score of 0.83 meaning, under normal market conditions, 83% of premises in the UK would be expected to receive gigabit-capable broadband via the market at some point, according to BDUK's F score model.

5.47 Figure 5.2 shows that only 4% of premises in the UK could access gigabit capable broadband in 2018 (the early stages of the voucher schemes). This increased to 12% by the end of 2019. It may therefore be reasonable to assume that, for premises that received a voucher in 2018, any premises with an F score above 0.12 would not have received access via the market in 2019 and therefore the benefits persist for at least two years. However the chart also shows that availability of UFBB (offering download speeds of at least 300 Mbps) was much higher, at 50%. According to BDUK monitoring data, the median download speed taken by residential voucher beneficiaries was just over 300 Mbps (330 Mbps). This means that, for around half of households, access to UFBB would have been sufficient to deliver the same improvement in life satisfaction. Therefore, a large proportion of households with a F score below 0.5 may still have been able to access the speeds they need at some point if they could not already.

Figure 5.2 Proportion of premises in the UK with access to ultrafast and gigabit-capable broadband



Source Connected Nations

5.48 This has informed the assumptions in Table 5.6. Wellbeing impacts for premises with an F score below 0.5 are assumed to persist for one year, on the basis that it is likely they could have found an alternative solution quickly. Assumptions for vouchers in other years have been informed by the date at which it is reasonable to assume they would have got access to UFBB or gigabit capable broadband. For households with an F score over 0.82 it is assumed the persistence period is five years. This can be considered to be a conservative assumption since it may have taken even longer than five years for these households to secure access via the market rollout.

Table 5.6 Wellbeing persistence period assumptions by F score and year of connection

F score	2018	2019	2020	2021
0 to 0.5	1	1	1	1
0.5 to 0.6	2	1	1	1
0.6 to 0.7	3	2	1	1
0.7 to 0.82	4	3	2	2
Over 0.82	5	5	5	5

Source: Hatch

5.49 **Error! Reference source not found.** shows the total number of residential vouchers connected in each year, broken down by F score. These have then been multiplied by the estimate of net additional wellbeing per household and the relevant persistence period to estimate the total increase in wellbeing attributable to vouchers. This ranges from **£114m to £195m**.

Table 5.7 Total net additional impacts on wellbeing including persistence, 2022 prices

Indicator	F score	2018	2019	2020	2021	Total
Number of households	0 to 0.5	22	487	1,315	1,807	3,632
	0.5 to 0.6	34	340	794	748	1,916
	0.6 to 0.7	1	74	1,071	935	2,081
	0.7 to 0.82	22	49	934	536	1,540
	Over 0.82	230	1,437	6,082	8,060	15,809
	Total	309	2,387	10,195	12,086	24,978
Low estimate of wellbeing (£000)	0 to 0.5	28	615	1,660	2,280	4,583
	0.5 to 0.6	85	429	1,002	944	2,461
	0.6 to 0.7	6	186	1,351	1,180	2,723
	0.7 to 0.82	112	184	2,357	1,353	4,005
	Over 0.82	1,450	9,070	38,378	50,858	99,756
	Total	1,680	10,484	44,747	56,616	**113,527**
High estimate of wellbeing (£000)	0 to 0.5	48	1,057	2,851	3,918	7,873
	0.5 to 0.6	147	738	1,721	1,622	4,227
	0.6 to 0.7	10	319	2,321	2,027	4,677
	0.7 to 0.82	192	316	4,048	2,324	6,880
	Over 0.82	2,490	15,581	65,930	87,370	171,371

	Total	2,886	18,010	76,872	97,261	**195,029**

Source: Hatch/BDUK. Note: the F score for individual premises was not known for 32% of residential voucher recipients. Where this was not known we took the average F score for the relevant output area

Differences in wellbeing between groups

5.50 The evaluation has also investigated whether the wellbeing value per household is likely to differ for households that fall into different groups, including whether a household:

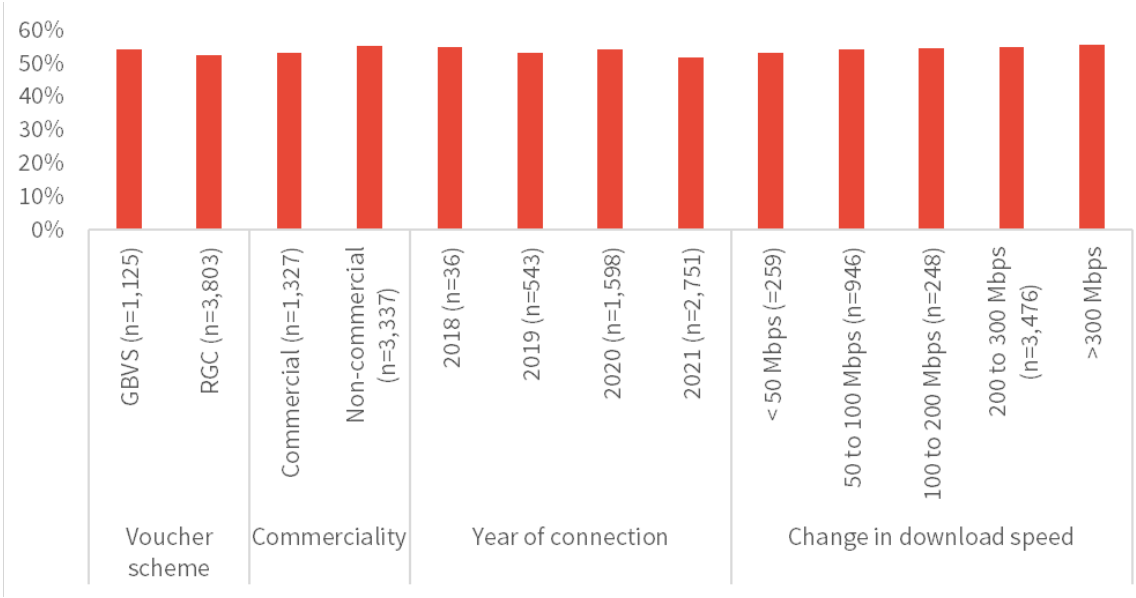
- received a voucher through the GBVS or RGC scheme
- lives in an area which has been deemed commercial or non-commercial according to BDUK modelling
- received a voucher at different times, or
- received different uplifts in speed.

5.51 The SWB evaluation did undertake some analysis of how changes in life satisfaction varied for households in urban vs rural areas. This found that average satisfaction increases were higher for urban respondents than rural respondents but the difference was not significant at the 10% level. Differences were statistically significant if rural/urban households were further broken down by age group, with younger households (18 to 35) in urban areas more likely to have a positive effect and middle-aged households (36 to 64) in rural areas more likely to have a negative effect. Again, this suggests it is demographic differences driving improvements in life satisfaction from broadband improvements rather than location, although these are magnified in urban/rural areas.

5.52 The residents survey also shows very few differences in changes in life satisfaction when we focus on the variables above. As shown in Figure 5.3, the proportion of households reporting a change in life satisfaction was very similar for all groups, with none of the differences being statistically significant at the 10% level.

5.53 Demographic characteristics, including age, employment status, occupation, and whether the household contains children are all far better predictors of whether a household is likely to report a change in life satisfaction than any of the variables above (see Chapter 6). This suggests average wellbeing per household is likely to be broadly similar regardless of scheme, commerciality, year of connection or uplift in speed.

Figure 5.3 Percentage of respondents reporting an improvement in life satisfaction by voucher characteristics



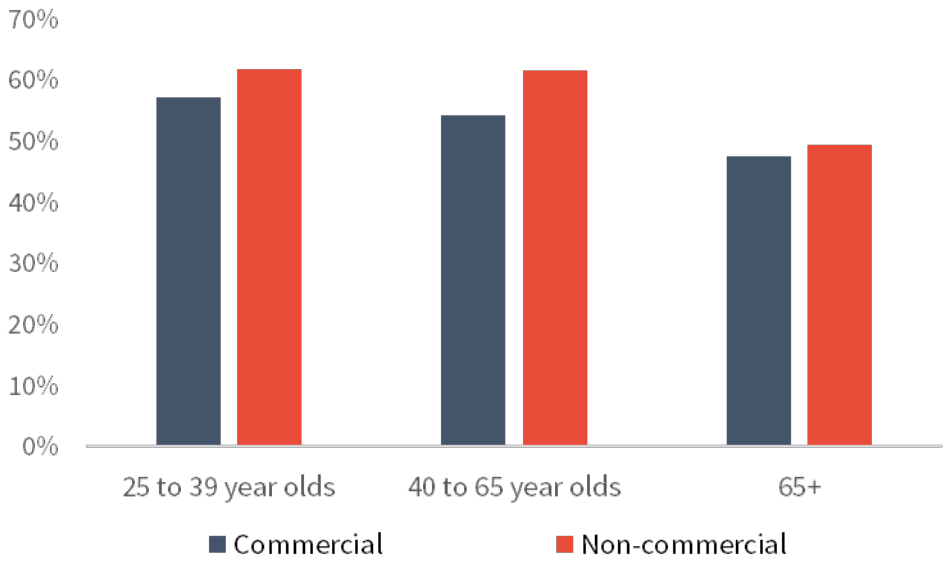
Source Winning Moves

5.54 There may be a case for taking account of the differences in the age profile of households that fall into these different groups. This would involve applying the age specific coefficients in Table 5.3 to an estimate of the age profile of households that have received vouchers through different schemes or in different years. However, this would fail to take account of the non-demographic or place specific factors which the survey suggests have also affected life satisfaction.

5.55 To take households in non-commercial areas as an example, these areas have a much older age profile than those in commercial areas (see Chapter 6). We would therefore expect a higher proportion of respondents in commercial areas to report an improvement in life satisfaction. However this is not the case; Figure 5.3 shows that respondents in non-commercial areas were slightly *more* likely to report an improvement in life satisfaction than those in commercial areas (although this difference is not statistically significant). Further analysis shows that the proportion of respondents reporting an increase in life satisfaction is higher in non-commercial areas than commercial areas in each age group, and this is statistically significant for 25 to 64 year olds (see Figure 5.4).

5.56 The older age profile of non-commercial areas, and the fact 65+ households are less likely to report an improvement in satisfaction than younger age groups, mostly cancels these differences within age-groups out to the point where the difference in life satisfaction between commercial and non-commercial areas is statistically insignificant. The same finding applies to households who have secured a voucher through different schemes or in different years, although the differences within age groups are not as large as they are for commercial vs non-commercial households.

Figure 5.4 Proportion of respondents reporting an improvement in life satisfaction by age (commercial vs non-commercial areas)



Source Winning Moves

5.57 This means that applying the age specific coefficients in Table 5.3 would underestimate the wellbeing effects for households in non-commercial areas, RGC households and those who received their voucher in 2020/21, since it would fail to take account of the differences that exist within age groups.

5.58 There are therefore two options for estimating gross wellbeing effects of vouchers in these different groups:

1) Assume the average wellbeing value per household is the same for all groups, and apply this to the total voucher population.

2) Make further adjustments to the age-specific coefficients for households in all of the different categories (scheme, commerciality, year of support) and apply these to estimates of the age profile for the total voucher population.

5.59 The latter option would require us to make a number of assumptions about:

a) the age profile of the population in these groups. As described in paragraph 5.35, the age profile of voucher beneficiaries needs to be estimated based on responses to the web-survey combined with Census data. These estimates would be subject to a larger margin of error in this case because of the smaller sample sizes from the survey.

b) the differences in age-specific coefficients, with different assumptions made for each age group for each voucher scheme, commerciality category and year of voucher. These could be informed by the findings of the residents survey, which are also subject to larger margins of error at this level of granularity, but would also rely on an element of professional judgement.

5.60 Given the above, and the fact that differences in change in life satisfaction within age groups are largely cancelled out by demographic differences, we have used the first approach. This is much simpler, consistent with the findings of the residents survey, reliant on fewer assumptions, and would arrive at a broadly similar answer which is within the margin of error of the more complex second approach.

5.61 Table 5.8 shows the total gross effects on wellbeing when we apply the lower and upper estimate of wellbeing per household per annum (£1,984 to £3,410) to the voucher population as a whole. Again, the range is based on the different assumptions applied for the 35 to 64 year old age group show in Table 5.3.

Table 5.8 Estimates of total gross wellbeing effects for different categories of voucher

Category	Description of voucher	Number of households	Gross increase in wellbeing (£m)	
			Lower	Upper
Scheme	GBVS	6,621	13.1	22.6
	Rural	18,357	36.4	62.6
Commerciality	Commercial	7,493	14.9	25.5
	Non-commercial	15,494	30.7	52.8
	Unknown	1,991	4.0	6.8
Year of voucher delivery	2018	534	1.1	1.8
	2019	2,766	5.5	9.4
	2020	9,801	19.4	33.4
	2021	11,875	23.6	40.5

Source: Calculations by Hatch

5.62 Although the gross average increase in wellbeing per household is expected to be the same for all groups, the net additional increase is likely to be higher for some groups than others due to higher levels of deadweight

5.63 As above, we have estimated deadweight using the responses to the question in the survey which asked what households would have done in the absence of the voucher. Table 5.9 shows that early voucher recipients (2018-19) and GBVS voucher recipients were more likely to say that they would have upgraded without the voucher. Therefore we assume a higher level of deadweight. As a result, the net-additional increase in wellbeing per household is lower for these households.

Table 5.9 Net additional increase in wellbeing for different categories of voucher, 2019 prices

Category	Description of voucher	What would household have done about their broadband if voucher had not been available?		Deadweight assumption based on responses to survey	Total net-additional increase in wellbeing (£m)		Net increase in wellbeing per household per annum (£)	
		Would have upgraded to same speed	Would have upgraded to lower speed or at later date		Lower	Upper	Lower	Upper
Scheme	GBVS	28%	41%	49%	6.7	11.6	1,016	1,746
	Rural	19%	35%	36%	23.2	39.8	1,263	2,170
Commerciality	Commercial	22%	39%	41%	8.7	15.0	1,167	2,004
	Non-commercial	21%	35%	39%	18.9	32.4	1,217	2,092
	Unknown	23%	41%	44%	2.2	3.8	1,121	1,925
Year of delivery	2018	41%	31%	57%	0.5	0.8	856	1,471
	2019	34%	38%	53%	2.6	4.5	939	1,613
	2020	21%	40%	41%	11.5	19.7	1,170	2,009
	2021	18%	34%	35%	15.3	26.3	1,291	2,218

Source: Hatch

Persistence

5.64 In order to provide a total estimate of wellbeing impacts for the GBVS and RGC schemes, it is also necessary to take account of persistence. This has used the same assumptions as Table 5.6, using the F scores for vouchers connected through each of the schemes. Since GBVS vouchers have lower F scores, the average persistence period for a GBVS voucher is shorter than for GBVS. The results for the GBVS scheme are shown in Table 5.10. This ranges from £23m to £39m in 2022 prices.

Table 5.10 Total net additional impacts on wellbeing including persistence for GBVS vouchers, 2022 prices

Indicator	F score	2018	2019	2020	2021	Total
Number of households	0 to 0.5	26	558	622	133	1,338
	0.5 to 0.6	40	394	439	28	900
	0.6 to 0.7	2	81	485	24	592
	0.7 to 0.82	26	54	200	38	318
	Over 0.82	269	1259	1666	278	3,473
	Total	363	2,345	3,412	501	6,621
Low estimate of wellbeing (£000)	0 to 0.5	28	597	665	142	1,432
	0.5 to 0.6	85	421	469	30	1,005
	0.6 to 0.7	6	174	519	26	725
	0.7 to 0.82	111	172	429	81	793
	Over 0.82	1,442	6,737	8,918	1,488	18,584
	Total	1,671	8,101	11,001	1,767	**22,540**
High estimate of wellbeing (£000)	0 to 0.5	48	1,026	1,143	245	2,462
	0.5 to 0.6	146	724	807	51	1,728
	0.6 to 0.7	10	299	893	44	1,245
	0.7 to 0.82	191	295	737	140	1,363
	Over 0.82	2,478	11,578	15,326	2,557	31,938
	Total	2,871	13,922	18,905	3,037	**38,735**

Source: Hatch

5.65 The results for the RGC scheme are shown in Table 5.11. This results in a range of between £91m and £156m.

Table 5.11 Total net additional impacts on wellbeing including persistence for RGC vouchers, 2022 prices

Indicator	F score	2019	2020	2021	Total
Number of households	0 to 0.5	11	745	1608	2,365
	0.5 to 0.6	4	399	688	1,091
	0.6 to 0.7	4	624	868	1,496
	0.7 to 0.82	3	724	478	1,205
	Over 0.82	345	4426	7429	12,200
	Total	368	6,918	11,072	18,358
Low estimate of wellbeing (£000)	0 to 0.5	15	992	2,140	3,146
	0.5 to 0.6	6	530	915	1,451
	0.6 to 0.7	11	830	1,155	1,996
	0.7 to 0.82	11	1,928	1,273	3,211
	Over 0.82	2,298	29,445	49,419	81,162
	Total	2,341	33,724	54,902	**90,968**
High estimate of wellbeing (£000)	0 to 0.5	26	1,704	3,676	5,406
	0.5 to 0.6	10	911	1,573	2,494
	0.6 to 0.7	19	1,426	1,985	3,430
	0.7 to 0.82	19	3,312	2,187	5,518
	Over 0.82	3,948	50,590	84,909	139,447
	Total	4,022	57,943	94,330	**156,294**

Source: Hatch

6. Environmental impacts of vouchers

Summary of key findings

- The evaluation has quantified the change in carbon emissions due to vouchers from three sources: reductions in travel, increased domestic energy usage and avoided office energy consumption. The main driver of these changes have been voucher recipients working from home more. 28% of survey respondents said they are working from home more or for the first time since the broadband upgrade, although in many cases this is likely to have been influenced by the Covid pandemic as well as the upgrade.
- The findings from the residents survey are used to quantify the change in carbon emissions from reduced travel, but cannot be used to quantify the change in energy usage at home or in the workplace. Therefore we draw upon the findings of research by the Carbon Trust which have quantified these effects for the average teleworker (someone who works from home).
- We estimate that, since the upgrade, households have reduced their travel by over 500,000 miles per week, resulting in a gross carbon saving of over 116 tonnes of CO_2e each week, or 6,000 tonnes per annum.
- We estimate that increased domestic energy usage while people work from home resulted in increased carbon emissions of 4,300 tonnes of CO_2e per annum for the voucher population as a whole.
- We estimate that avoided energy consumption in offices resulted in carbon savings of 2,500 tonnes of CO_2e per annum for the voucher population as a whole.
- The cumulative gross effect of these changes was estimated to be a reduction in carbon emissions of 4,300 tonnes CO_2e per annum. After accounting for deadweight, the net reduction in carbon emissions is 2,500 tonnes CO_2e per annum.
- It is assumed these effects persist for three years. Over three years the total carbon saving due to vouchers is estimated to be 7,600 tonnes of CO_2e.
- For the purpose of the cost-benefit analysis, these carbon savings have been converted in to monetary values using carbon values from supplementary guidance to the Green Book , with future savings discounted. The total value of carbon savings is estimated to be £1.85m in 2022 prices.

Purpose of chapter

6.1 In order to estimate the value for money of BDUK's vouchers schemes, it is necessary to estimate and, wherever possible, monetise the full range of impacts that vouchers have generated. This includes economic, social and environmental impacts. The focus of this chapter is on the environmental impacts of vouchers.

6.2 As evidenced by the findings of the residential survey, improving access to high-speed broadband can generate environmental benefits by reducing travel and therefore reducing carbon emissions. Conversely, the survey also showed that households may

use more energy while at home, for example, due to increased levels of homeworking. This chapter therefore seeks to measure the net effect of these outcomes on carbon emissions.

6.3 There are a number of caveats and limitations to the analysis of environmental impacts of vouchers which should be borne in mind:

- The impacts assessed here represent the initial impacts of vouchers, and only measure the carbon savings resulting from the change in travel patterns by voucher recipients themselves. There are likely to have been further carbon savings due to indirect beneficiaries (households who have gained access to upgraded broadband without receiving a voucher) also reducing their travel. There may also be future benefits which it is not possible to measure, as connections and take-up linked to vouchers increases.
- It is not possible to quantify the environmental effects of vouchers using robust counterfactual methods. The estimates have therefore been modelled using a number of assumptions and information sources. The results are therefore subject to significant uncertainty and have been presented as a range.
- The analysis does not include the potential increase in carbon emissions due to increased data being transmitted across the fibre network. The evaluation could find no way of estimating this, but this will be revisited as part of the final evaluation.

Context for valuing environmental effects

Findings of the residents survey

6.4 44% of residents that responded to the survey (n=4,928) said that they had reduced their weekly travel following the upgrade. 75% of these were people who said they were now making greater use of the internet to work or run a business from home. Higher proportions of residents with the following characteristics reported that they had reduced their travel:

- Residents aged between 40-64 (51%)
- Residents employed full-time (52%)
- Households with children (53%)
- Residents in managerial (60%), professional (53%), and technical (59%) occupations.

6.5 The survey also asked respondents who said they had reduced their travel to estimate the reduction in miles travelled per week and to specify the mode of transport that they would have used. This provides detailed information on which to base a modelled estimate of the carbon savings due to reduced travel (although it did not ask them to state how this might change in the future).

6.6 The survey also showed that 28% of respondents reported increased home energy usage as a disbenefit of their upgraded connection (see Figure 4.37). However it did not ask

respondents to quantify the change in energy usage. Therefore we have had to draw upon the findings of other studies to estimate this.

Findings of other studies

Homeworking report, Carbon Trust (June 2021)[51]

6.7 This report assesses the impact of teleworking (working from home) on carbon emissions in six European countries, including the UK. Specifically, it assesses the carbon savings for an average teleworker working at home for a year compared to going into the office in a number of different Covid related scenarios (pre-Covid, during Covid, post Covid 2021 and post Covid 2022+). This was calculated by analysing three different impact areas:

- Avoided commuting emissions from reduced travel
- Avoided office-related emissions (associated with heating the office and electricity usage of office equipment)
- Additional domestic energy consumption when working from home

6.8 The domestic energy calculation considered energy use from home office equipment , heating energy consumption and cooling energy consumption, and were based on data on the characteristics of each country's housing stock and energy consumption. The key parameters were as follows:

- Frequency of teleworking days per week, by Covid scenario
- Average home size (sq m) by country
- Energy consumption from homes, by emission source
- Electricity grid emission factors, by source

6.9 The avoided office-related energy consumption and associated carbon emissions savings were calculated by analysing average national buildings and office energy consumption data, statistics and literature. Additionally, the analysis accounted for the space utilisation of office workers, in order to allocate the additional avoided office-related energy consumption on a per office worker basis. In our view, a weakness of this study is that it assumes a linear relationship between office utilisation and energy usage. This may be true for certain types of energy usage (e.g. electricity for workstations) but not for others (e.g. heating). For instance, the carbon emissions associated with heating an open plan office to an ambient temperature are likely to be broadly the same regardless of how many people are in the office (as long as there is at least one person who turns the heating on). For this reason these results for 'avoided office energy consumption' should be treated with caution.

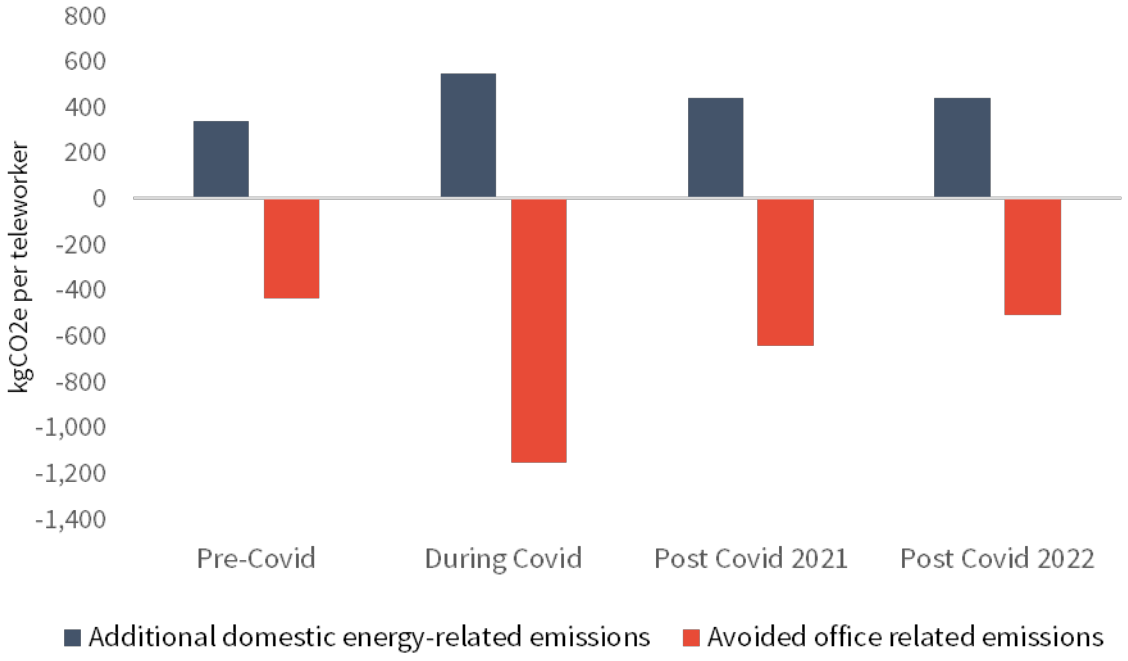
6.10 Figure 6.1 shows the estimated annual change in carbon emissions per teleworker as a result of these two effects in each of the scenarios[52]. The main difference in the

[51] The carbon savings potential of homeworking in Europe | The Carbon Trust

[52] The study also quantified avoided emissions associated with reduced commuting. These are not shown as the survey provided us with actual data on how voucher recipients have changed their travel as a result of the upgrade so it is not necessary to use the findings of other studies.

scenarios relates to the assumed number of days that each teleworker works from home and the office utilisation. It shows that, on average, each teleworker can be expected to generate additional domestic energy related emissions of 441 $kgCO_2e$ over the course of the year in the post Covid scenarios, but avoid between 510 and 642 $kgCO_2e$ in office related emissions. As above, we would question the robustness of the estimates for office related emissions.

Figure 6.1 Average potential carbon impacts ($kgCO_2e$) per teleworker per annum in the UK from office and domestic related emissions



Source Caron Trust (2021): Homeworking Report

Modelled estimates of carbon impacts

Avoided commuting emissions

6.11 The survey findings have been used to estimate the total reduction in travel for voucher beneficiaries. Cumulatively, survey respondents reported they were travelling 107,540 fewer miles each week following the upgrade[53]. The median household reduced their travel by 50 miles per week, although there was a large variation in the sample (one mile

[53] We have removed outliers where the respondent identified very large reductions in travel which did not correspond with other answers given. For example, one respondent said they were travelling 11,000 fewer miles per week but only saving £60 in transport costs each week.

to 260 after removing outliers). Grossing up for the voucher beneficiary population as a whole, this would equate to 544,642 fewer miles travelled each week[54]

6.12 Residents were asked to specify the main mode of travel that they would have used for the journeys which they would have taken in the absence of the upgrade. Table 6.1 shows the total number of miles saved for each mode of transport, with cars being the main mode affected.

Table 6.1 Reduction in mileage per mode of travel

Mode of transport	Number of miles reduced	Proportion of residents selecting this mode of transport (n=2,365)
Car-petrol	35,233	36%
Car - hybrid	642	1%
Car – electric	2,566	4%
Car – diesel	48,930	44%
Motorcycle	779	0.4%
Train / metro	16,922	10%
Tram	66	0.2%
Cycling / walking	391	3%
Bus	594	2%
Van	81	0.1%
Aeroplane	1,059	0.4%
Unspecified	187	0.1%
Total	107,450	

Source: Winning Moves

6.13 The findings above have been combined with UK Government emission conversion factors[55] for the relevant modes of transport to estimate the total weekly carbon savings from the reduction in travel (see Table 6.2).

6.14 We estimate that reduced travel among households that responded to the survey have resulted in carbon savings of just under 23,000 kg CO_2e per week or 1.2m kg CO_2e per annum. Applying this to the voucher population as a whole would translate to gross carbon savings of over 116 metric tonnes of CO_2e each week, and over 6,000 tonnes over the course of a year.

6.15 This is equivalent to a weekly reduction of 10.6 kgCO_2e per household who reported a reduction in travel since the upgrade, or 552 kgCO_2e per year. This is roughly twice as high as the estimated carbon savings per teleworker in the Carbon Trust report (228 kgCO_2e per year in the post Covid scenario). However the two are not directly comparable as the residents survey asked for the reduction in travel for the household as

[54] This has been grossed up by dividing the total miles travelled for the sample by 19.7% (the response rate for the survey). It assumes that the sample is representative of the voucher population as a whole

[55] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022

a whole and related to all travel (not just commuting). It may also be the case that the average commute for voucher beneficiaries was longer than the national average as a high proportion of beneficiaries live in rural areas and are therefore not as close to major employment centres.

Table 6.2 Estimated CO2 savings per week

Mode of transport	Number of miles reduced	Carbon factor	CO2 savings per mode of transport (kg CO_2e)
Car (petrol / diesel)	84,163	0.262137	22,062
Train / metro	16,922	0.038773	656
Motorcycle	779	0.172988	135
Bus	594	0.125114	74
Van	81	0.350895	28
Total for sample	107,450		22,956
Total for voucher population			116,262

Source: Winning Moves and Hatch

Additional domestic energy related emissions

6.16 In the absence of any detailed data on the energy consumption of voucher beneficiaries or the sizes of their homes, we have used the average domestic energy carbon emissions per teleworker from the Carbon Trust report for the post Covid scenarios (441 kgCO_2e per teleworker). We use this scenario because the survey was undertaken in 2022, so the responses relating to changes in travel are from a post Covid time period[56]. Therefore, for consistency, we use the same time period when assessing domestic energy related emissions.

6.17 We have applied this average figure to all survey respondents who said they are using the internet to work from home more often or for the first time (n=1,389 or 28% of all survey respondents). We have not applied the figure to all people who use the internet to work from home (including those who said they are only using it more easily or more effectively) since it is assumed that there is no change in the frequency of homeworking for these people.

6.18 Where these respondents were in a household with another adult, we assume that 39% of these other adults were also working from home. This is the proportion of survey respondents who are employed or self-employed who are working from home for the first time or more often since the upgrade (this assumes that the other adults in a household have the same employment status as the person that responded to the survey). We estimate there are an additional 1,387 adults living with people who are homeworking more. Therefore, this adds an additional 540 homeworkers (1,387 x 0.39), giving a total of 1,929 adults who are working at home for the first time or more often.

[56] The survey did not ask survey respondents to quantify the reduction in travel during the Covid pandemic

6.19 Assuming each of these people generates an additional 441 kgCO_2e through domestic energy consumption per annum, this equates to total carbon emissions of 850,689 kgCO_2e for the survey sample, and 4.3m kgCO_2e for the voucher population as a whole. This does not include any increased domestic energy usage which is due to reasons other than working from home (such as online shopping instead of visiting a supermarket). Any increase in emissions from these other sources would be difficult to estimate and would be expected to be very small in comparison to the emissions due to home-working.

Avoided office energy consumption

6.20 Avoided office energy consumption has also been modelled using the assumptions from the Carbon Trust report on the carbon savings per teleworker for the post Covid 2022 scenario. However, we have reduced the estimated saving per worker to take account of the fact that certain costs such as heating and lighting are more fixed, and will not vary with the number of people in the office (which is assumed in the Carbon Trust model).

6.21 The UK Green Building Council estimate that heating accounts for 36% of the energy used in UK offices, with lighting accounting for a further 26%[57]. We have therefore reduced the carbon savings per worker by 50%, on the basis that there may be some heating or lighting savings associated with fewer people being in the office[58]. This reduces the carbon savings from 510 kgCO_2e per worker to 255 kgCO_2e per worker. However there is some uncertainty about this assumption.

6.22 This has been applied to the estimate of the number of people in voucher households from the survey sample who are working from home more often or for the first time (1,929 people in total). This results in a total carbon saving of 491,895 kgCO_2e per annum for the sample, and 2.5m kgCO_2e for the voucher population as a whole.

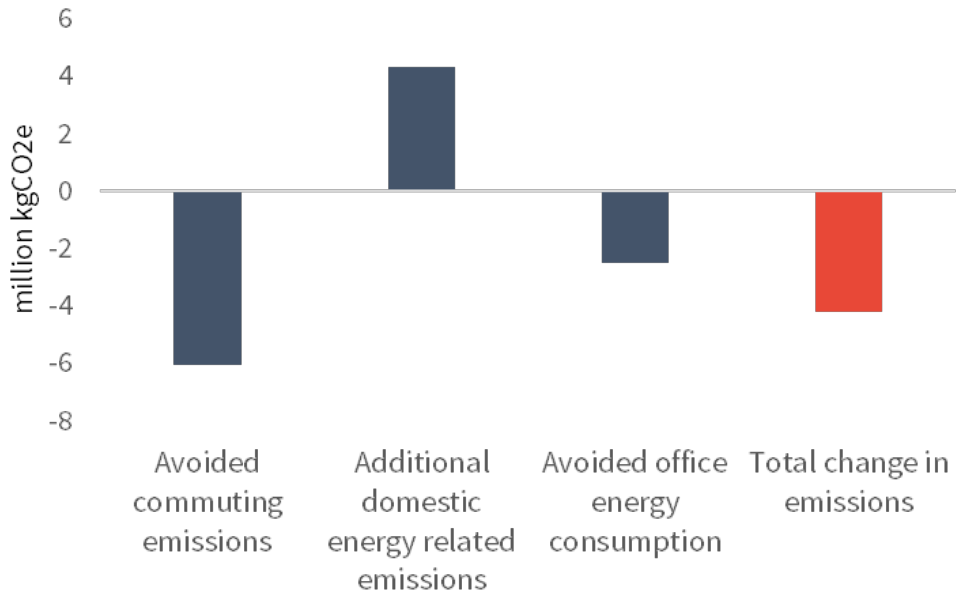
Summary results

6.23 Figure 6.2 shows the net result of these changes in carbon emissions due to increased levels of home-working. Overall, we estimate that this has led to gross carbon savings of 4.3m kgCO_2e per annum. However, given the uncertainty inherent in modelled estimates, this should be treated as a central estimate. The actual gross carbon savings are likely to fall within the range 3.9m to 4.7m kgCO_2e per annum (based on a +/-10% margin of error).

[57] UK Green Building Council (2019): Better Places for People: Office Energy Use

[58] For example in non open-plan offices which have multiple rooms, all of which would not need to be heated or lit if there are few people in the office.

Figure 6.2 Gross change in carbon emissions following the broadband upgrade



Source Hatch

Net additional effect of vouchers

6.24 The estimate above is based on gross change in carbon emissions. However it is also necessary to take account of deadweight (the carbon savings that would have happened in the absence of the voucher.

6.25 Assessing deadweight in this case depends on:

- whether households would have received access to gigabit capable broadband in the absence of the voucher, and
- whether households would have upgraded their connection in the absence of vouchers (potentially to a lower quality connection), and the extent to which that upgrade would have enabled them to work from home for the first time or more frequently.

6.26 We have used the same deadweight assumption that was used in Chapter 7 of 40% (21% + half of 37%) on the basis that 21% of respondents would have got the same connection at the same time and 37% would have upgraded but to a lower connection or at a later date. It can be assumed that some of these respondents would have been able to work from home without the voucher. We would note, however, that 70% of respondents who are using the internet to work from home said the upgrade was very important in enabling them to do so, and a further 21% said it was important. Deadweight may therefore be lower than 40% in practice.

6.27 This would mean that only 60% of the carbon savings are attributable to vouchers, meaning the net impact on carbon savings is **2.5m kgCO_2e per annum**. As noted above, this is a central estimate. Given the uncertainty, the true figure is likely to fall within the range 2.3m to 2.8m kgCO_2e per annum.

Persistence

6.28 The persistence period for effects on carbon emissions will depend on two factors:

- Whether the change in working patterns which has occurred since the Covid pandemic persists and, if so, for how long. It is likely that there will be some reduction in the number of people who work from home over time. For example, Remit Consulting's weekly office occupancy survey shows that average office occupancy increased from around 20% in January 2022 to 34% in January 2023[59]. However this is still well below the pre-pandemic estimate of 60 to 80%, and it is unlikely that working patterns will fully return to the pre-Covid average given that a significant number of employees appreciate the flexibility that it offers, and that many employers are adopting a more flexible model.
- The length of time it would take for the market to provide households with access to a broadband connection that allows them to work from home effectively and efficiently. As with the analysis of impacts on life satisfaction, this will depend on where households live and how commercially attractive they are to broadband suppliers.

6.29 How these two factors combine is subject to uncertainty and difficult to model. Therefore, we have made a conservative assumption that effects of vouchers persist for three years, meaning the total carbon saving attributable to vouchers ranges from 6.9m to 8.4m $kgCO_2e$, with a central estimate of **7.6m $kgCO_2e$.**

Monetising the value of carbon savings

6.30 In order to assess the value for money of the vouchers schemes it is necessary to convert all benefits in to monetary values, wherever possible. To do this, we have used carbon values from supplementary guidance to the Green Book[60] and discounted any future environmental benefits using a discount rate of 3.5% (again, in line with the Green Book). The central estimate of the total value of carbon savings is estimated to be £1.85m, but ranging from £1.68m to £2.04m. This has informed the cost benefit analysis in Chapter 9.

Table 6.3 Monetary value of carbon savings

	2022	2023	2024
Price of carbon (£/tCO_2e)	248	252	256
Total emissions saving (t/CO_2e	2537	2537	2537
Value of GHG savings (undiscounted) (£)	630,007	639,601	649,341
Value of GHG savings (discounted) (£)	1,854,145		

[59] News Release: Latest data shows UK office occupancy reaching new pandemic highs. (remitconsulting.com)

[60] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal - GOV.UK (www.gov.uk)

7. Cost-Benefit Analysis

Summary of key findings

- The report provides an initial cost-benefit analysis of vouchers based on the impacts which can be measured to date. This is an early assessment which is likely to significantly understate the benefits of the voucher schemes for a number of reasons, including time-lags in economic datasets and the inability of the evaluation to estimate indirect benefits for premises which benefitted from an upgrade without receiving a voucher. It is also too early for some businesses and households to have realised the full benefits of the upgrade. In contrast, the full public sector costs of the voucher schemes are already known and have been incurred.
- The total cost of delivering the BDUK voucher schemes is estimated to be £125m up to the end of 2021. This includes the cost of the subsidies paid out for connected vouchers and an estimate of the costs of administering the two voucher schemes.
- The total value of benefits delivered by the end of 2021 are estimated to be between £153m and £235m, with the range reflecting the uncertainty around the estimates of wellbeing values.
- Therefore, overall it is estimated that the voucher schemes have so far delivered a benefit-cost ratio (BCR) of between £1.22 and £1.88 per £1 of gross public sector spending. This is just based on what it has been possible to measure to date and mainly reflects the impacts of earlier vouchers delivered through GBVS. We also expect this to grow in future as take-up by other businesses and households in areas that have received vouchers rises and more data intensive applications become more widespread.
- It has not been possible to separately estimate the BCR for GBVS and RGC due to time lags in economic datasets. There is strong evidence that additionality of vouchers on download speeds was higher for the RGC than GBVS, which may suggest additionality of effects on businesses was also higher. This will be assessed in the follow-up evaluation. This will be done in the third and final evaluation in 2026.

Purpose of chapter

7.1 This section sets out the findings of an indicative cost-benefit analysis of the BDUK voucher schemes, providing an assessment of the value-for-money it has delivered to date. The cost-benefit analysis has been completed in line with the principles of the HM Treasury Green Book, and covers both the value of the economic impacts associated with the programme as well as environmental and wellbeing impacts described in previous chapters.

Context for the VfM assessment

7.2 As noted elsewhere in this report, it is still too early to assess the full impacts and value for money of vouchers. It will take time for the full range of economic and social benefits to emerge as take-up of high- speed broadband increases, new applications emerge, and

businesses and households adapt their behaviour to fully exploit their upgraded connection. The evaluation has been further hampered by the fact that it has only been able to assess the economic impacts on businesses for the 2020/21 financial year, when the RGC scheme was in its early stages and businesses had had limited time to derive benefits. This evaluation has found clear evidence that additionality on speeds has been higher in RGC areas than GBVS areas, reflecting RGC's focus on the more rural and hard to reach areas. Therefore we would also expect additionality of economic impacts to be higher. However it is still too early to assess this.

7.3 There have also been specific impacts which it is not possible to quantify in this report including:

- **Impacts on indirect beneficiaries**: voucher schemes were designed to ensure that other businesses and households benefit from improved access to broadband, even if they do not receive a voucher. We have not been able to estimate these impacts due to issues with the availability data on coverage which means we cannot estimate how many additional premises have benefited.
- **Impacts on cost savings**: the findings of the business survey suggested that cost savings have been a major benefit for businesses that received vouchers. This is an improvement in productivity which is not captured by changes in turnover per employee, the measure used in this report.

7.4 As a result, the findings here only represent a partial and incomplete assessment of the value for money to date. These will be assessed in full in the third and final evaluation, scheduled for 2026. This will:

- analyse change over a longer period. By 2026, the analysis should be able to access data for the 2023/24 financial year, giving us three additional years of data. This will allow more time for businesses to change their processes and activities in response to their upgrade and to have derived a greater range of benefits.
- distinguish between the impacts of GBVS and RGC. By this stage, it will be possible to include all of the business vouchers from the later scheme, which has been far more targeted on areas that are unlikely to receive access. This will allow us to construct separate counterfactuals for each scheme, reflecting the differences in areas targeted.
- estimate indirect benefits. Assuming issues with the consistency of Connected Nations data can be addressed, we will be able to provide more conclusive evidence of the number of premises who have gained access to high-speed broadband without receiving a voucher. If these issues cannot be overcome, we will work with BDUK to understand how their monitoring data can be better used to estimate these indirect benefits. For example, using data available for projects which show how many additional premises have gained access.

Overview of approach

7.5 A cost benefit analysis requires an assessment of the costs of delivery against the value of the associated consumer welfare impacts. This involves a number of challenges:

- **Displacement of employment benefits**: while businesses that received vouchers have expanded their employment as a result of the broadband upgrade, this will have come at the expense of other firms in the UK, leading to offsetting impacts in other locations. As such only impacts in terms of raising productivity can be considered to qualify as an economic benefit at the national level.
- **Valuing improvements in wellbeing**: the scale of the improvement in life satisfaction reported by voucher beneficiaries is likely to be exaggerated and subject to bias. The evaluation has therefore used the findings of previous studies assessing the relationship between broadband improvements and quality of life, and used HM Treasury Green Book guidance to convert these in to monetary values.
- **Valuing environmental improvements**: while the residential survey provided us with detailed data to quantify the reduction in travel enabled by vouchers, it has been necessary to draw upon other sources to quantify other environmental effects due to home-working.
- **Future costs and benefits**: a relatively short time has passed since the vouchers were connected, and it is unlikely that the benefits of the programme will have been fully realised by 2021. In particular, the assessment of economic impacts is subject to a time lag in the available datasets, which means it will not be possible to distinguish between the impacts of the GBVS and RGC schemes until a later date. This will be focus of a follow-up evaluation to be conducted in 2026.

Costs

7.6 The present value of the net cost to the public sector associated with the delivery of the voucher schemes up to the end of 2021 was £125m (in 2022 prices). This is made up of the following:

- £111.4m through the cost of connecting vouchers between 2018 and 2021
- £9.8 m in management and staff costs for the GBVS voucher scheme, taken from the LFFN voucher scheme business case (adjusted for inflation).
- £3.8m in forecast management and staff costs for the RGC voucher scheme. This is taken from the RGC business case. We have assumed only 30% of the total staff and management costs (£12.8m) apply to the vouchers scheme. This is on the basis that vouchers only account for 30% of the capital expenditure in the business case, with the rest relating to Hubs.

Table 7.1 Estimated costs for the voucher schemes

Type of cost	GBVS	RGC	Total
Cost of vouchers	62.8	48.6	111.4
Management costs	9.8	3.8	13.6
Total	72.6	52.4	125.0

Source; BDUK

7.7 All of these costs have been incurred, unlike some of the benefits of voucher schemes which will take time to emerge and to be measured.

Benefits

Productivity gains

7.8 The results of this initial evaluation suggest that vouchers have already led to positive impacts at firm level, resulting in additional employment growth over and above comparators. As indicated, it is likely that these impacts will be largely neutral at the national level. In line with the HM Treasury Green Book, only the effects of the programme in terms of raising productivity are considered to qualify as an economic benefit at the national level.

7.9 The evaluation has shown that the jobs created by businesses receiving vouchers have been in higher productivity roles, evidenced by the fact that workers moving into these roles have enjoyed a wage premium. In line with HM Treasury Green Book, these can be counted as an additional economic impact at the national level.

7.10 The evaluation estimates that these wage premia have a total value of **£37.5m** in 2022 prices (see paragraphs 3.51 to 3.53 for how this has been calculated).

7.11 The evaluation has not been able to find conclusive and measurable evidence of other effects on productivity to date (such as increased turnover per employee). Therefore these have not been included in the cost-benefit analysis. However we would note that the analysis is based mainly on the impacts of GBVS vouchers (where additionality was likely to be lower), and we have not been able to measure other types of productivity benefits such as cost reductions.

Wellbeing benefits

7.12 The results of the analysis in Chapter 7 indicate that vouchers have led to net-additional wellbeing improvements of between **£114m and £195m** in 2022 prices. This represents the value over and above the cost of paying for the broadband subscription. The values are presented as a range to reflect the uncertainty surrounding these wellbeing benefits.

7.13 It does not include the indirect benefits for households who also gain access to high speed broadband without receiving a voucher. We would also expect these benefits to grow over time as more households take up the service.

Environmental

7.14 The results of the analysis in Chapter 8 indicate that vouchers have led to a net-reduction of around 2.54 million kg CO_2e (2,537 tonnes CO_2e) per annum so far, based on the central estimate. This is assumed to persist for three years, resulting in a total carbon saving of 7.61 million kg CO_2e (7,611 tonnes CO_2e). These have been monetised and discounted in line with Green Book guidance to give a total value in 2022 prices of **£1.85m** so far. Given the uncertainty inherent in modelling benefits, the true value is likely to fall within a range of +/-10% of this figure (£1.68m to £2.04m).

Value for Money

7.15 Combining the costs and estimated benefits described above gives the following estimates of value for money:

- Overall it is estimated that the voucher schemes have so far delivered a benefit to cost ratio of between £1.22 and £1.88 per £1 of gross public sector spending by December 2021.
- At this stage it is not possible to separately estimate the BCR for the two voucher schemes or voucher types due to time-lags in economic datasets. This will be a focus of the follow-up evaluation.
- These are early estimates of the impact of the programme and will understate the net benefits of the voucher schemes as they do not include the full economic effects of the RGC scheme where additionality is likely to be higher. There is evidence to suggest that additionality of vouchers on download speeds was much higher for vouchers connected in 2021 than earlier years (mostly delivered through RGC project vouchers). Therefore we may expect the additionality of benefits for these businesses to also be higher.
- The benefits of the voucher schemes may also grow over time as take-up by other businesses and households in areas that have received vouchers rises and more data intensive applications become more widespread.

Table 7.2 Cost-benefit analysis for BDUK voucher schemes

	Low	High
Productivity effects	37.51	37.51
Wellbeing improvements	113.5	195.03
Carbon savings	1.68	2.04
Total value of benefits	**152.69**	**234.58**
Total value of costs	**125**	**125**
Value of benefits for every £1 invested	**1.22**	**1.88**

Source: Hatch

8. Conclusions

8.1 This section sets out the main conclusions from the evaluation.

Key findings from the evaluation

Impacts of vouchers

Voucher effects on download speeds and availability

8.2 **Vouchers have had a significant additional effect on average download speeds used by households and businesses** in the output areas where they have been used. The scale of this additional effect has increased over time, with vouchers connected in 2021 delivering a much greater increase in download speeds (27.89 Mbps) than earlier years (3.28 and 3.85 Mbps). This can mostly be explained by increasing demand for high speed broadband and the fact that areas supported in 2021 received a larger number of vouchers.

8.3 Similarly, areas that received project vouchers or were supported through the RGC scheme experienced a larger additional increase in download speeds than areas receiving standard or GBVS vouchers. An key reason for this is that these areas have tended to receive more vouchers on average. However, even when we control for this and the number of premises in treated areas, the results still show that RGC and project vouchers have had a greater effect on download speeds than GBVS and standard vouchers. This is likely to be due to the fact that projects have provided gigabit capable infrastructure to multiple other premises as part of the overall project build. Therefore further connection upgrades are likely to have been taken up outside of just the vouchers themselves, further increasing the average speeds. The only exception is for vouchers connected in 2019 where each standard voucher, on average, resulted in a higher increase in speeds than project vouchers. This could be explained by the fact that most project vouchers in 2019 were delivered through the GBVS scheme which tended to be used in more urban and commercial areas.

8.4 The analysis of the effects of vouchers on availability of UFBB and gigabit capable broadband is inconclusive at this early stage. Areas receiving vouchers in 2020 did experience a higher increase in availability of UFBB and gigabit-capable broadband than control areas (2.1 and 4.5 percentage points respectively), but in other years the difference was either negative or statistically insignificant. However, these results should be treated with a high degree of caution. There are a number of inconsistencies in different years of Ofcom Connected Nations data, which make it very difficult to analyse change in availability over time at a very local level. This skews the analysis and makes it difficult to draw conclusions about the effects of vouchers. These issues are unlikely to reoccur in future years as the data becomes increasingly accurate in terms of UPRN coverage, comprehensive in terms of supplier coverage and therefore consistent from one period to the next.

Impacts on business performance

8.5 Businesses that have received vouchers grew their employment at a significantly faster rate than the preferred control group, based on similar businesses who had a voucher application cancelled, in the year after support (four percentage points higher). This suggests vouchers had **an additional effect on employment growth in businesses that received a voucher** in the short term, although the difference is not statistically significant after two years. The firm level analysis did find that businesses with vouchers has increased their turnover, but this was in line with the preferred control group. Similarly the growth in turnover per employee (a measure of productivity) was lower than the preferred control group. This means we cannot conclude at this stage that vouchers had an additional effect on turnover or turnover per employee.

8.6 It is notable, however, that businesses that received vouchers have grown their turnover and employment at a much faster rate than the wider business population and at a faster rate than businesses with similar characteristics. It is only when we compare them to similar businesses with cancelled voucher applications or with similar businesses from the same exchange area that most of the difference disappears.

8.7 One possible explanation for this is that the results mainly reflect the impacts of the GBVS voucher scheme where vouchers were more likely to be connected in urban and commercial areas. Therefore, any businesses who wanted an upgraded connection (such as those who had a voucher application cancelled) were more likely to be able to secure an upgrade through alternative means. At this stage it has not been possible to assess differences between the GBVS and RGC schemes, however this will be a focus of the follow-up evaluation in 2024.

8.8 The firm-level analysis has shown that the additional jobs created in businesses that received a voucher have been of a higher quality and attract a wage premium for people moving in to these roles. This is an indicator that **the jobs created through vouchers has resulted in movement from less to more productive jobs**. We estimate the scale of these benefits to be £37.5m in 2022 prices.

Impacts on area level performance

8.9 The area level analysis is subject to much greater uncertainty than the firm level analysis due to issues with turnover data for small areas and the fact that fewer than 2% of businesses in supported output areas have received a voucher. That means the scale of intervention is very modest which makes it difficult to robustly detect the effects of vouchers, given the wide range of other factors which affect area level performance.

8.10 With these caveats in mind, the results show that areas that received vouchers experienced a fall in employment over time. However the fall in employment was lower than in control areas, indicating that the fall would have been even greater were it not for the voucher.

8.11 When interpreted alongside the firm level analysis, which showed businesses with vouchers had experienced strong growth in employment over and above comparator areas, this may suggest that receiving a voucher has helped businesses to navigate some of the challenges facing other businesses in the local area and, as a result, avoid further job losses.

Wellbeing and other benefits for households

8.12 The evaluation has shown that vouchers have delivered significant benefits for households. Over half of residents (53%) report that the upgrade has improved their life satisfaction and 7% report that they feel less lonely after the upgrade. Being able to keep in touch with friends and family, stream entertainment services and use online banking are the main internet uses that have improved life satisfaction.

8.13 Working households and those with children have derived a much wider range of benefits from the broadband upgrade than older retired households and those living alone. This includes a better work-life balance, educational benefits, reduced stress and the ability to start a new business. This range of benefits explains why these groups were more likely to report an increase in life satisfaction.

8.14 Nevertheless, the upgrade has **enabled a significant proportion of older households to do things for the first time**, including streaming entertainment services (20%), video chat with friends and family (11%) and accessing health and other services (9%) which have delivered benefits for these households.

8.15 **Vouchers also helped a large proportion of households to adapt during the Covid pandemic**, with 79% of households saying it had a major or minor positive effect on their household's ability to adapt

8.16 There is also evidence of distinctive benefits for certain groups

- 24% of young respondents (18 to 24) report that the broadband upgrade has helped them to start a business, while 14% say it has helped them to run an existing business.
- 26% of lone parents have gained new skills or qualifications and 20% have found a new job or improved their career prospects.
- 19% of people who live alone say they feel less lonely than before the upgrade,
- 10% of people in lower skilled occupations (carers and manual workers) say they have used the internet to study for a professional qualification.

8.17 Overall we estimate the vouchers have so far resulted in a net additional wellbeing improvement of between **£32m and £54m** (in 2022 prices), or between **£1,262 and £2,168 per household**. However this does not include indirect benefits from households from the wider rollout of high speed broadband in areas with vouchers. These benefits might also grow if households benefit from prolonged use or find new ways in which to use their high speed connection.

8.18 Other specific benefits (which are not additional to the overall wellbeing improvement include:

- **Time and money saved through reduced travel**: Vouchers have resulted in 327,000 fewer miles travelled, 26,000 hours saved and money savings of £179,000.
- **Changes in earnings**: the upgraded connection have enabled some people to secure an increase in earnings as a result of starting a business or finding a new job, with an overall net-additional increase of £9.5m per annum.

- **Future changes in earnings**: the upgraded connection has also helped others to gain new skills and qualifications which could lead to an increase in future earnings. We estimate the net additional value of these benefits to be £1.6m per annum (although this is a minimum figure as it has not been possible to quantify earnings benefits for all people).

Environmental benefits

8.19 It is estimated that the broadband upgrades have resulted **in over 500,000 fewer miles travelled each week** by households receiving vouchers. This has resulted in **a net-reduction of around 2.54 million kg CO_2e (2,537 tonnes CO_2e) per annum**. This is a net additional effect which also takes into account increased domestic energy usage at home and reduced energy usage in offices.

Benefit Cost Ratio

8.20 Overall it is estimated that so far the voucher schemes have delivered a benefit-cost ratio (BCR) of between £1.22 and £1.88 per £1 of gross public sector spending meaning the benefits have outweighed the costs. However this is based just on the benefits that could be measured to date and includes the full cost of the voucher schemes. There are a number of impacts which it has not been possible to measure due to timing or issues with data. The benefits of the voucher schemes may also grow over time as take-up by other businesses and households in areas that have received vouchers rises and more data intensive applications become more widespread. As a result this can only be considered to be an initial and partial assessment of VfM.

8.21 It should also be noted that this will understate the net benefits of the programme, particularly economic effects as it does not include the effects of most RGC vouchers connected in 2021. There is evidence that additionality of vouchers on download speeds was higher for vouchers connected in 2021 than earlier years, which may suggest additionality of effects on businesses was also higher. This will be assessed in the follow-up evaluation.

Other findings

8.22 The evaluation has also provided additional insights about the characteristics of people that use broadband and their motivations for applying. We would particularly highlight the following:

- **Voucher beneficiaries are more likely to be older, wealthier and higher skilled than the UK population**. This is explained by the fact residential vouchers have tended to be delivered in rural areas which have an older population, but also the supplier-led nature of the scheme which has prioritised wealthier areas where take-up is likely to be higher.
- **Residential vouchers have been increasingly targeted on people who need it most**. The proportion of people who say they would not have considered an upgrade if it was not for a voucher has risen over time, from 27% in 2018 to 48% in 2021. At the same time there has been strong growth in the proportion of

people who actively sought out the voucher (from 16% to 36%). This suggests additionality of residential vouchers has grown over time and that vouchers are reaching people who are highly motivated to get an upgrade and will realise immediate benefits

Learning for future policy design and implementation

8.23 The evaluation has shown that the later RGC scheme has been more effective at increasing download speeds than the earlier GBVS scheme, and that project vouchers were more effective than standard vouchers in later years 2020 and 2021. This suggests the targeting of vouchers has improved over time.

8.24 Similarly, the findings of the residential survey suggest that additionality of vouchers was higher for vouchers connected in 2021. Vouchers are more likely to be accessed by people who say they had not upgraded their broadband because it was not available, would not have upgraded without the voucher and who have actively sought out the voucher.

8.25 These results are likely to reflect the fact that voucher schemes have become increasingly focused on rural and non-commercial areas over time meaning they have targeted the households and businesses that need it most. We have also found that households in rural and non-commercial areas are more likely to report an improvement in life satisfaction once you control for age, and that this result in net-additional wellbeing improvements per household being higher in rural and non-commercial areas. These findings therefore support BDUK's strategy to focus on non-commercial areas through Project Gigabit.

8.26 So far the evaluation has not been able to test whether this is also true for the additionality of economic effects. The evaluation has shown that businesses that have received vouchers have grown at a far faster rate than comparable untreated businesses in the wider business population, which suggests broadband upgrades result in stronger business performance. However this difference disappears when we compare to similar businesses who also applied for a voucher or who were based in the same exchange area. This could be explained by these businesses accessing a broadband upgrade through another route and therefore securing all of the benefits of the upgrade without a voucher. If this is the case, then we would expect to see higher levels of additionality for RGC vouchers delivered in 2021. This will therefore be a focus of the follow-up evaluation.

Plans for final evaluation

8.27 Although it has only been possible to provide a partial assessment of the impacts of the voucher schemes in this report, these will be assessed in full in the third and final evaluation, scheduled for 2026. This will:

- **analyse change over a longer period**. By 2026, the analysis should be able to access data for the 2023/24 financial year, giving us three additional years of data. This will allow more time for businesses to change their processes and activities in response to their upgrade and to have derived a greater range of benefits.

- **distinguish between the impacts of GBVS and RGC**. By this stage, it will be possible to include all of the business vouchers from the later scheme, which has been far more targeted on areas that are unlikely to receive access. This will allow us to construct separate counterfactuals for each scheme, reflecting the differences in approach and the areas connected.
- **estimate indirect benefits**. Assuming issues with the consistency of Connected Nations data at a local level can be addressed[61], we will be able to provide more conclusive evidence of the number of premises who have gained access to high-speed broadband without receiving a voucher. If these issues cannot be overcome, we will work with BDUK to understand how their monitoring data can be better used to estimate these indirect benefits. For example, using data available for projects which show how many additional premises have gained access.

8.28 The final evaluation will also assess whether GBVS was successful in stimulating the broadband market which was a key objective of this scheme.

[61] These issues are unlikely to reoccur in future years of the data as it becomes increasingly accurate in terms of UPRN coverage, comprehensive in terms of supplier contribution and therefore internally consistent from one year to the next.

Appendix A - Technical annex for counterfactual analysis of impacts on broadband performance and availability

Datasets used in the study

A.1 To undertake the counterfactual impact analysis, various datasets needed to be linked at output area (OA) level. This section presents a description of the datasets used and describes the approach taken to understand whether impacts can be attributed to the vouchers:

- **Coverage and performance data:** Ofcom publishes the Connected Nations reports on the UK's communications infrastructure, focusing on coverage and performance of fixed broadband and mobile networks. This report uses the annual report data from Ofcom Connected Nations from 2017 up to 2022, including an additional year since the analysis for the initial report.
- **Intervention data**: BDUK also provided data - the Vouchers Data - covering the timing, supplier, value and location of the voucher support and whether it was supported under the GBVS or RGC vouchers scheme. It also identifies whether the voucher was part of a project (where a supplier has aggregated a number of applications focused on a specific geographical area) or was a standard voucher (a standalone application from a household or business). The initial analysis has been updated using a more recent extract of the Vouchers Data from January 2023.
- **Commercial viability data:** Secondly, BDUK's FScore Model provides an estimated relative cost to build fibre to the premise when optimally routed from a nodal point of the UK core fibre infrastructure[62]. The value is an estimated build cost which is distributed and assigned a proportionate value, so that low values (0.01 to 0.1) reflect premises that have a low cost, while higher values (0.9 to 0.99) indicate the opposite. Then, with consultation with DSIT Digital Infrastructure Team, who own the model, it has used default benchmarks of estimated build cost to determine which premises can be connected commercially (i.e. likely to be be built by the market by 2025 without the help of public sector subsidy) from those considered non-commercial.
- **Economic statistics**: The modelling seeks to characterise areas in terms of their business population. For this, the ONS Business Register and Employment Survey has been used to provide data on employment at LSOA level for England and Wales (via Nomis). As well as total employment by LSOA, a variable measuring employment in digital sectors was constructed. The Nomis data is not disaggregated to geographic levels beyond the LSOA. So, for the OA modelling, the values for these variables would be based on the LSOA that the OA is in.

[62] This model uses four scenarios : 1. LSOA centres, 2. the parent exchange, 3. the nearest cabinet or exchange 4. the nearest cabinet if fibre enabled, else parent exchange

- **Other area characteristics controls**: ONS population density estimates at LSOAs, the 2011 Rural Urban Classification for LSOAs, Indices of Deprivation, and the Internet User Classification (IUC) from the Consumer Data Research Centre (CDRC), which allocates LSOAs to different categories based on how households interact with the internet. For OA level analysis, only LSOA level data is available.

A.2 The rest of this section explains the different sources in more detail.

A.3 An important point to note is that the analysis has been undertaken for England and Wales only. Although a number of the datasets are available for Scotland and Northern Ireland (e.g. Connected Nations and the BDUK monitoring data), many of the socio-economic datasets used for matching are not consistently compiled for each of the UK nations. Therefore, like earlier analysis, the analysis focuses on England and Wales. We are confident that the results can be applied to Scotland and Northern Ireland. However, the final evaluation report will include analysis of any differences in the context in which vouchers have been used in these countries or differences in economic performance that would need to be taken in to account.

Connected Nations Report

A.4 Ofcom publishes the Connected Nations and infrastructure reports on the UK's communications infrastructure. The annual reports track progress over time, focusing on the availability and performance of fixed broadband and mobile networks. This is published at a detailed geographical level (postcodes and output areas). The data enables year-on-year comparisons of the UK's communications infrastructure in terms of both the availability of broadband at different speed levels and performance (data on change in average speeds). This dataset is used to obtain the main outcome variables for the analysis.

A.5 As noted in the main body of the report, there are inconsistencies in Connected Nations data which mean it may not provide reliable and consistent data over time. This is partly explained by the fact Connected Nations relies on data provided by suppliers and does not provide full coverage of all fixed networks. However there are also a large number of output areas where the number of premises with access to different broadband speed levels decreases over time. This includes a large number of the output areas that have received vouchers, meaning the results are likely to be skewed by these inconsistencies (see paragraphs 2.6 to 2.19 for a full explanation of the inconsistencies in the dataset)

A.6 For this study, the data from the annual report is used as it is a final version for the year, filling gaps in the interim updates. The annual report data was used for each year from 2017 to 2022. Since the initial analysis, a full set of data for 2021/22 has been made available allowing an additional year of analysis for this study.

Fixed Coverage

A.7 Most of the variables on the fixed coverage focus on the proportion of premises that meet certain speed availability cut-offs. The data was collected in September of each year from 2017 to 2022. Table A.1 looks at the variables that have been compiled for different

reports about fixed broadband coverage. It also looks at the geographical level of detail that is available, with data files generally being by postcode or output area, and - for many variables - available for both levels of geography.

A.8 The table does highlight some data gaps. Most notable is that the data about the availability of full fibre is only available for the two earlier years and gigabit availability is only recorded in the most recent two years. These two series have been merged, based on discussions with BDUK. However, generally, the coverage is good especially for output area level data.

Table A.1 Variables available for fixed coverage by Connected Nations report year

Variable	Level	2018/19	2019/20	2020/21	2021/22
postcode	Postcode	X	X	X	X
oa11	OA	X	X	X	X
All Premises	Both*	X	X	X	X
All Matched Premises	Both*	X	X	X	X
Super Fast Broadband availability (% premises)	Both	X	X	X	X
Ultra Fast BB (100Mbit/s) availability (% premises)	Both			X	X
UFBB availability (% premises)	Both	X	X	X	X
Full Fibre availability (% premises)	Both	X	X		
% of premises unable to receive 2Mbit/s, 5Mbit/s, 10Mbit/s, 30Mbit/s	Both	X	X	X	X
Gigabit availability (% premises)	Both			X	X
% of premises below the USO	Both	X	X	X	X
% of premises with NGA	Both	X	X	X	X
% of premises able to receive decent broadband from FWA	Both	X	X	X	X
% of premises able to receive SFBB from FWA	Both	X	X		
% of premises with download speed: 0<2Mbit/s, 2<5Mbit/s, 5<10Mbit/s, 10<30Mbit/s, 30<300Mbit/s, >=300Mbit/s	Both		X	X	X
Number of premises with SFBB availability	OA	X	X	X	X
Number of premises with UFBB (100Mbit/s) availability	OA			X	X
Number of premises with UFBB availability	OA	X	X	X	X
Number of premises with Full Fibre availability	OA	X	X		
Number of premises unable to receive 2Mbit/s, 5Mbit/s, 10Mbit/s, 30Mbit/s	OA	X	X	X	X
Number of premises with Gigabit availability	OA			X	X
Number of premises below the USO	OA	X	X	X	X
Number of premises with NGA	OA	X	X	X	X
Number of premises able to receive decent broadband from FWA	OA	X	X	X	X

Variable	Level	2018/19	2019/20	2020/21	2021/22
Number of premises able to receive SFBB from FWA	OA	X	X		
Number of premises with download speed: 0<2Mbit/s, 2<5Mbit/s, 5<10Mbit/s, 10<30Mbit/s, 30<300Mbit/s, >=300Mbit/s	OA		X	X	X

Source: Connected Nations

Fixed performance

A.9 The variables available for fixed performance are presented in Table A1b. Most of them show the minimum, average and maximum download speed for different lines, as well as the data usage, and the number of connections. The data was collected in May of 2018/2019/2021/2022 and in June of 2020.

Table A.2 Variables available for fixed performance by Connected Nations report year

Variable	Level	2018/19	2019/20	2020/21	2021/22
oa11	OA	X	X	X	X
postcode	Postcode	X	X	X	X
Median upload speed (Mbit/s)	Both	X	X	X	X
Median download speed (Mbit/s)	Both	X	X	X	X
Median data usage (GB)	Both		X	X	X
Average upload speed (Mbit/s) for lines < 10Mbit/s, 10<30Mbit/s, 30<300Mbit/s	Both	X	X	X	X
Average upload speed (Mbit/s) for SFBB lines, and for UFBB lines	Both	X	X	X	X
Average upload speed (Mbit/s)	Both	X	X	X	X
Average download speed (Mbit/s) for lines < 10Mbit/s, 10<30Mbit/s, 30<300Mbit/s	Both*	X	X	X	X
Average download speed (Mbit/s) for SFBB lines, and for UFBB lines	Both	X	X	X	X
Average download speed (Mbit/s)	Both	X	X	X	X
Average data usage (GB) for lines < 10Mbit/s, 10<30Mbit/s, 30<300Mbit/s	Both**	X	X	X	X
Average data usage (GB) for SFBB lines, and for UFBB lines	Both	X	X	X	X
Average data usage (GB)	Both	X	X	X	X
Maximum upload speed (Mbit/s)	Both	X	X	X	X
Maximum download speed (Mbit/s)	Both	X	X	X	X
Number of connections (number of lines) < 2 Mbit/s, 2<5 Mbit/s, 5<10 Mbit/s, 10<30 Mbit/s, 30<300 Mbit/s, >=300 Mbit/s, >=30 Mbit/s	Both	X	X	X	X

Variable	Level	2018/19	2019/20	2020/21	2021/22
Minimum download speed (Mbit/s)	Both	X			
Minimum upload speed (Mbit/s)	Both	X			
Average data usage (GB) for Basic BB lines	Both	X			

Source: Connected Nations

Data supplied by BDUK

A.10 BDUK provided two further internal datasets for the analysis. A key dataset used in the counterfactual impact evaluation was the vouchers data, described elsewhere in the report. For the impact analysis, the vouchers data provides the main characteristics of the vouchers, including geographic variables, date of delivery, date of connection, status of the voucher, value of the voucher, scheme (divided into GBVS and rural), type (divided into project and standard) among others. The date of connection was used to define the year of treatment.

A.11 Since the initial analysis, the vouchers data has been updated (correct as of September 2022). More recent vouchers are included in this data, although these are too recent to be included in the modelling. However some of the characteristics of vouchers included in the previous data have been updated or modified. For example, some vouchers that previously were planned are recorded as connected in the new data. Also, some connected vouchers have subsequently been cancelled. This does change some of the treatment variables , though in a modest way, especially with some dates changing.

A.12 A second dataset provided was the FScore Model Output. This also has been updated since the 2022 initial analysis. The FScore modelling work was undertaken by the DSIT Digital Infrastructure Team (formerly DCMS). The original version of this model sought to identify the 20% most expensive to connect and dispersed properties in the UK. This dataset presents an index from 0 to 1 that reflects the ranking of each premise's estimated cost to build across the UK. A value close to 0 reflects premises that have an estimated cost to build value that makes them commercial (i.e. the market is likely to build to this premises before the end of 2025). Premises with an Fscore closer to 1 are considered to be non-commercial. Whilst the model is a useful tool for drawing conclusions at a national scale, results for small numbers of premises will be uncertain. The wider the area, the less uncertainty. Results from the FScore Model may be used to identify high cost to build premises and are still useful as long as the assumptions and caveats are known and the risks acknowledged. There are set out below:

- At a local level the estimated build costs of the F20 model are inaccurate as they draw from a central estimate of cost per metre with optimism bias applied. There is a large range for this assumption in local estimates based on the type of geographies, deployment locations (verge, duct or pole) for most locations. It is likely that the model underestimates urban costs and overestimates rural costs, on average

- There is a lot of uncertainty in premises build costs at the £615 threshold as smaller margins of error on cost estimation will affect a greater number of premises. This is because the shape of the cost-curve is a "hockey stick", where the incentive payment threshold of £615 occurs before the curve rapidly increases, which occurs at over £900.
- Within a local area, the relative costs of build are more reliable than absolute costs. However, the F20 model ignores topography which can result in some premises appearing easier to reach than in reality.
- The model assumes that fibre backhaul exists in an area. If fibre backhaul is absent, costs will be underestimated. This is particularly relevant for the sub-30Mbps areas.
- The model does not account for existing deployed fibre to premises. Where fibre is available, onward build costs for neighbours may be less than predicted
- The model builds fibre to the centres of premises. For buildings with large footprints, this gives an overestimate of costs.

A.13 The updated model provides a value proportionate to the cost of connection, so that low values reflect premises that can be connected at low cost, while higher values indicate the opposite. The premises have further been characterised in terms of their viability, primarily to differentiate those that can be connected commercially in that the market would reach on its own without further public subsidy. Those outside this category are considered to be non-commercial, although these properties can be further differentiated to additional categories (hold-up, uncommercial and non-value for money based on the estimated cost of connection). Together these roughly still account for just less than 20% of UK premises.

Nomis – Official Labour Market Statistics

A.14 The counterfactual modelling controls for differences in employment characteristics, between areas that received vouchers and non-supported areas, that might affect the selection for voucher support. The data was obtained from the Business Register and Employment Survey, which contains employment information at the LSOA level for England and Wales.

A.15 There are two variables derived using the Nomis dataset. A first is the total employment by LSOA: the model includes the logarithm of the total employment by LSOA in the year before support. This means that we use employment in 2018 for areas that received a voucher in 2019, and the employment in 2019 for areas that received a voucher in 2020, and so on.

A.16 Secondly, Nomis was used to identify whether an LSOA had high employment in digital sectors. A dummy variable indicates a high prevalence of employment in digital business. This variable was constructed using the industry percentage of employment by LSOA in the year before support.

A.17 The data obtained from Nomis is divided into eighteen industrial groups. For the analysis we consider seven industries defined as intensive in the information and communication technology which are: manufacturing, motor trades, wholesale, information & communication, financial & insurance, professional, scientific & technical, and business administration & support services. Then the percentage of employment is summed in these industries, and if it is greater than the mean in all LSOAs then it takes the value of 1 and 0 otherwise.

A.18 The Nomis data is not disaggregated to geographic levels beyond the LSOA. So, for the OA modelling, the values for these variables are based on the LSOA that the OA is in.

Other control variables

A.19 A further set of control variables was collected from the Office of National Statistics (ONS). These variables are:

- Population density: The number of people per square kilometre in Lower Layer Super Output (LSOA) areas in England and Wales.
- 2011 Rural Urban Classification for LSOAs: The Rural Urban Classification is produced using Census data, with the 2011 Rural Urban Classification being the latest version of the classification. The next Rural Urban Classification will be produced when the 2021 Census data has been published. We include a dummy identifying rural areas.
- Indices of Deprivation - Income and Employment Domains for England and Wales: These datasets provide a directly measured indicator of income and employment deprivation across all LSOAs in England and Wales, as at 2015-16, enabling comparable analysis across the two countries.
- The Income Deprivation Domain measures the proportion of the population experiencing deprivation relating to low income, and the Employment Deprivation Domain measures the proportion of the working-age population in an area involuntarily excluded from the labour market. In the analysis we include the deciles of the income domain rank.

A.20 One additional control variable was included from the Consumer Data Research Centre (CDRC).This relates to the 2018 Internet User Classification (IUC). The IUC is a bespoke classification that describes how people living in different parts of Great Britain interact with the Internet. It provides coverage for Great Britain at LSOA level (for England and Wales) and Datazone (for Scotland) level.

A.21 The IUC provides 10 unique profiles of neighbourhoods based on a number of characteristics, the mean attributes of which are summarised below. We include the different levels of this variable in the post-estimation regressions. The omitted category is the number 1 e-Cultural Creators.

Group Code	Group Name
1	e-Cultural Creators
2	e-Professionals
3	e-Veterans
4	Youthful Urban Fringe
5	e-Rational Utilitarians
6	e-Mainstream
7	Passive and Uncommitted Users
8	Digital Seniors
9	Settled Offline Communities
10	e-Withdrawn

Numbers of vouchers and treated output areas included in the modelling

A.22 The modelling assesses change in performance and availability in treated OAs in the year(s) after they received a voucher (or two years after a voucher for areas supported in 2019 and 2020). It is therefore necessary to assess impacts separately for each treatment year. The evaluation focuses on vouchers connected between October 2018 and September 2021 giving us three treatment years for analysis. We have not included vouchers connected after this date as it is unlikely that any effects on broadband performance or the availability of broadband at different speed levels would be reflected in Connected Nations 2022.

A.23 The analysis also does not include vouchers connected before October 2018. Although there were over 1,900 vouchers delivered before this date, the number of treated OAs is much smaller than in 2019, 2020 and 2021. Therefore we have focused on the three treatment years where we have a larger sample size, which is sufficient for us to assess the impact of vouchers overall and analyse how impacts vary in OAs that have receive support through different schemes or through different types of voucher.

A.24 In each year there were also a large number of vouchers issued in OAs that had already received vouchers in earlier years of support. To avoid the risk of contamination from support in earlier years these were not included in the modelling for these years. The modelling also removed vouchers that were used to connect premises in Scotland and Northern Ireland for the reasons stated above (see paragraph A.3).

A.25 Table A.3 shows how many vouchers and treated OAs were included in the modelling in each treatment year after making these adjustments.

Number of vouchers and treated OAs over time

Treatment year	Period covered	No. vouchers	No. vouchers in model (1st time support)	Number of treated OAs in model (1st time support)
2018	Oct 2017 to Sep 2018	1,939	0	0
2019	Oct 2018 to Sep 2019	10,480	7,996	3,144
2020	Oct 2019 to Sep 2020	15,159	8,692	3,435
2021	Oct 2020 to Sep 2021	15,741	9,304	1,426

Source: BDUK monitoring data. *does not include OAs which had been treated in earlier years.

Identifying the counterfactual areas

A.26 In order to assess the additional impacts of vouchers on the availability of broadband at different speed levels and broadband performance in local areas, it was necessary to identify supported areas and comparable unsupported ones with similar characteristics to act as a counterfactual.

A.27 A statistical technique called propensity score matching (PSM) then estimates a selection model to identify a counterfactual. The selection model is then tested and, if found to be robust, a difference-in-difference approach is used to understand whether the growth seen in supported areas differs from that in the control group.

Selection models

A.28 Matching was done through a statistical model that estimates the selection process to identify places more or less likely to get vouchers. The modelling used variables available before support at each of the two levels of geography, and were derived from the datasets noted above, such as total employment in an LSOA, population density, high digital employment, rurality, index of multiple deprivation (income), region dummies. A Probit regression is used to estimate what drives an area towards selection.

A.29 Three different models were developed. The main difference between the models related to whether, and if so how, broadband performance in the year before support was included. This is one of the main outcome variables of interest to the study, but can also be used as a matching variable to ensure areas included in control groups were starting from a similar position to treated areas in terms of average broadband speed or were on a similar trajectory prior to receiving a voucher. However we have also included a model which does not include broadband performance as a variable to avoid the risk that past change in performance correlates with future change in performance:

- **Model I**: includes total employment (ln), population density, high digital employment, rurality, index of multiple deprivation (income) at LSOA level, F20

LSOA/SO average and region dummies. The areas where the suppliers known to submit returns to the Connected Nations report are tagged as any Connected Nations supplier, OpenReach and Virgin. Excludes broadband performance.

- **Model II**: includes variables in Model I except supplier tags and broadband performance levels before support (but not change) at both OA and LSOA level depending on level of geography.
- **Model III**: includes variables in Model I and the change in broadband performance before support at the analysis level of geography.

A.30 The analysis also varied the sample from which the counterfactuals were selected. Three different samples were used, with the sample sizes shown in Figure A.1 and Table A.5:

- All areas: this is the largest pool and includes all the LSOAs or OAs in England and Wales that did not receive the voucher support.
- All areas but excluding those with high levels of employment at OA level: the sample was further restricted to correct for the observation that high employment levels (the largest 1% by employment) was such a common characteristic in supported areas that it was difficult to identify comparable unsupported ones. This probably reflects the high chance that at least one business in an area with a very high density of businesses would have received a voucher.
- Same Exchange OAs: the study team was provided with a table estimating the exchange serving each UK property. Our hypothesis was that exchange areas where at least one OA had been treated (i.e., received a voucher) would have similar infrastructure to untreated OAs served by the same exchange. This provided a third match pool.

A.31 Table A.4 presents a summary of the control group samples and their strengths and weaknesses.

Table A.3 Strengths and weaknesses of control group alternatives

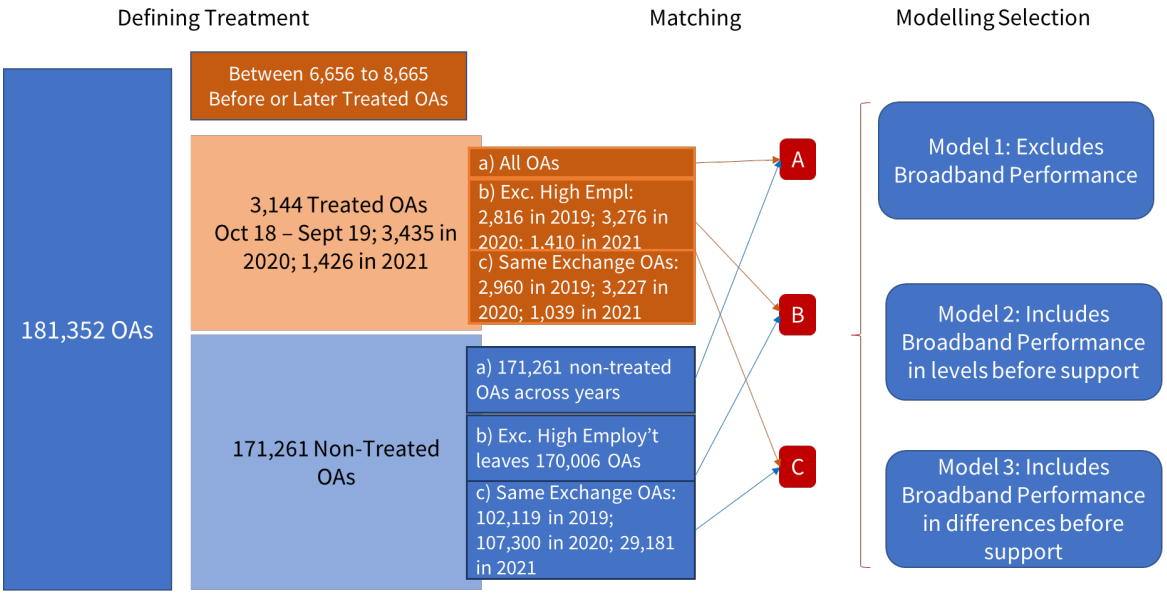
Description	Strengths	Weaknesses
Control group: All areas		
The first control group is obtained from the sample of all OAs in England and Wales that did not receive voucher support. This is the largest control group.	Large sample size with 171,261 OAs and detailed information on broadband connectivity, vouchers program characteristics, linked to geographic and socio-economic variables at the LSOA level.	High variability in the characteristics of the areas, which may be more difficult to find an appropriate control for the treated if the distribution of the covariates in both groups is significantly different.
Control group: All areas excluding high employment		
The second control group comes from all OAs as in the first case but excluding all the areas that are LSOAs with high	The intuition behind is that high employment may be correlated with an increase in the demand for faster broadband connectivity.	This sample maintains the high variability in the characteristics of the control group, being more difficult to find a good control if the

employment (the largest 1% by employment).	Thus, it can potentially affect the selection into treatment and the outcomes.	distribution of the covariates is different to the treated.
Control group: Same exchange areas		
The third control group correspond to the OAs that use the same exchange as the treated but did not receive voucher support. To create this group the study team was provided with a table estimating the exchange serving each UK property.	The strength of this model resides in comparing areas that have the same telecom infrastructure, which offers the possibility to control for unobservable variables depending on infrastructure, which is very sensitive for the policy. Moreover, when using this control group, we include in the selection model the distance (reported in km) from the centre of the area to the exchange[63].	A weakness of the model is that it was not possible to link all areas to a unique exchange therefore the sample size of treated is reduced.

A.32 By combining these different modelling approaches and sample pools, we developed nine different models for comparing treatment and control areas. A summary of the models and different samples is presented in Figure A1. There are 171,316 OAs in England and 10,036 in Wales that form the focus of analysis. Of these, 3,144 are treated in 2018-2019, 3,144 in 2019-20 and a further 1,426 in 2020-21.

[63] To find the coordinates of the exchange we calculate the weighted average of the longitude and latitude by exchange, weighted by the number of premises in the postcode. This assumption was tested in a random sample of 5 exchanges comparing the real location with our approximation obtaining a difference of 487 m., which is a reasonable approximation for the study.

Figure A.1 Summary of selection models and samples



Source

A.33 It was necessary to remove some vouchers and treated OAs from certain models due to the nature of some of the control group samples used. For example:

- One of the control group samples excludes OAs which had very high levels of employment. It was therefore necessary to remove those OAs which also had high levels of employment.
- Another sample was drawn from LSOAs which are served by the same exchange areas as treated LSOAs. It was therefore necessary to remove treated LSOAs that could not be linked to a single exchange.

A.34 The effect of removing these vouchers and treated OAs from the sample for each of the relevant models is shown in Table A.5. All of the models include a sample of at least 1,300 treated OAs and at least 6,000 vouchers in each year.

Table A.4 Number of vouchers and treated OAs in models which use different control group samples

	No. vouchers			No. treated OAs		
Control group sample	2019	2020	2021	2019	2020	2021
All treated OAs	7,432	7,807	9,304	3,144	3435	1,426
Excluding high employment	6,733	7,719	9,271	2,816	3,276	1,410
Same exchange LSOAs	6,313	6,365	9,304	2,960	3,277	1,309

Source: Belmana.

A.35 Table A.6 breaks down the number of vouchers included in each model by voucher scheme and voucher type. It shows the sample includes GBVS vouchers for the first two years of support, particularly in 2019 when the RGC scheme was in its infancy. The

GBVS scheme was focused on stimulating the rollout of gigabit capable broadband and maximising access for SMEs. There were few restrictions on eligibility for GBVS meaning a high proportion of vouchers were issued in urban and higher density areas.

A.36 The sample for 2021 is more weighted towards RGC vouchers, where eligibility was increasingly focused on the least viable areas for gigabit-capable broadband (rural and non-commercial areas).

A.37 The table also shows the split between voucher types (standard and project vouchers). These were evenly split in 2019 but were more heavily weighted towards project vouchers in 2020. In total, there were 9,257 of these vouchers delivered through 788 separate projects.

Table A.5 Numbers of vouchers by voucher scheme

Control group sample	Treatment year	Scheme		Voucher type	
		GBVS	RGC	Standard	Project
All OAs	2019	7,362	70	3,496	3,936
	2020	5,861	1,946	2,486	5,321
	2021	1,085	8,219	1,042	8,262
All OAs excl high employment	2019	6,663	70	3,104	3,629
	2020	5,776	1,943	2,418	5,301
	2021	1,052	8,219	1,034	8,237
Same exchange OAs	2019	6,276	37	3,094	3,219
	2020	4,942	1,423	2,216	4,149
	2021	1,085	8,219	1,042	8,262

Source: BDUK

Statistical matching and the selection models

A.38 Statistical matching was carried out by identifying unsupported areas with similar characteristics to those which had received a voucher in 2018/19, 2019/20 and 2020/21 on a one-to-one basis. For example, the levels of employment in supported LSOAs are high, with a mean of 1,261. This compares with the England and Wales average of 265, so the matching tends to draw unsupported areas with a high level of employment into the counterfactual.

A.39 Matching is done by estimating a statistical model for predicting whether an area is likely to receive a voucher based on its characteristics. The modelling must use variables available for areas in the year before they received a voucher, taken from the datasets described above. Variables include the number of employees, population density, high digital employment, rurality, index of multiple deprivation (income), region dummies. The modelling also includes the distance from the centre of the LSOA or OA to the exchange that is used by at least 60% of properties.

A.40 The selection modelling for this analysis uses a Probit model for treated areas in 2019, 2020 and 2021. The dependent variable takes a value of one for those in receipt of first support through vouchers in each of 2018/19, 2019/20, 2020/21 and zero for the

unsupported areas who did not receive any support. The modelling variables are described in the previous section.

A.41 Table A7 shows the characteristics of areas included in each of the models in each of the treatment years (2019, 2020 and 2021) when OAs are drawn from two different pools. One pool is all OAs and the other pool is one which excludes OAs with a high level of employment. A positive figure means there is a positive correlation between the variable and the likelihood that an area receives a voucher and vice versa.

A.42 The modelling highlights that the characteristics explaining whether an area receives a voucher are similar in 2019 and 2020. With regards to the fitness of the model the adjusted R-square is highest for the areas supported in 2021.

A.43 Overall, the models show good performance with coefficients taking the correct sign, such as being positive for employment and the share of employment in ICT industries. These characteristics mean an area is more likely to receive a voucher. The main difference between the different annual cohorts is the increased chance of an area receiving a voucher if it is in a rural area for areas treated in 2021. This corresponds with the increased provision of vouchers through the Rural Gigabit Connectivity programme in 2021, with the GB Voucher Scheme being the most active scheme in 2019 and 2020. The co-efficient for rurality is positive in all cohorts but triples in the final year suggesting vouchers were increasingly targeted on rural areas.

A.44 The Fscore non-commerciality indicator used in the OA-level modelling also takes the correct sign meaning higher build costs are correlated with an increased chance of receiving a voucher. The distance between an output area and its exchange also positively affects the chance of an area receiving a voucher. The scheme's aim of targeting the hard-to-connect areas then is validated in the selection models.

Table A.6 Selection models for all outcome variables - OAs

	Model I			Model II			Model III		
Treated in	**2018/19**	**2019/20**	**2020/21**	**2018/19**	**2019/20**	**2020/21**	**2018/19**	**2019/20**	**2020/21**
Pool	**All**	**All**	**All**	**Ex Hi Emp**	**Ex Hi Emp**	**Ex Hi Emp**	**Ex Hi Emp**	**Ex Hi Emp**	**Ex Hi Emp**
SFBB coverage				-0.01 (-24.05***)	-0.01 (-25.29***)	-0.01 (-19.19***)	-0.01 (-9.45***)	-0.01 (-9.74***)	-0.01 (-16.85***)
Average data usage (GB)				0.00 (-10.21***)	0.00 (-0.83)	0.00 (-0.88)	0.00 (2.21**)	0.00 (11.48***)	0.00 (7.69***)
Average upload speed (Mbit/s)				0.00 (9.10***)	0.00 (3.61***)	0.00 (1.39)	0.00 (-7.44***)	0.00 (-1.10)	0.00 (-2.28**)
Distance to exchange	0.03 (2.59***)	0.02 (1.65*)	0.04 (3.43***)	0.00 (0.12)	-0.02 (-1.61)	0.00 (0.09)	0.03 (2.47**)	0.02 (1.44)	0.02 (1.80*)
IMD income	0.00 (-0.24)	0.00 (0.92)	0.01 (2.35**)	-0.01 (-3.83***)	0.00 (0.83)	0.02 (3.26***)	-0.01 (-1.65*)	0.00 (-0.65)	0.01 (1.69*)
Employment (ln)	0.40 (53.98***)	0.32 (45.08***)	0.12 (10.28***)	0.38 (44.48***)	0.32 (40.65***)	0.11 (8.42***)	0.38 (45.99***)	0.32 (41.03***)	0.11 (8.62***)
ICT	0.23 (12.92***)	0.17 (10.77***)	0.05 (2.04**)	0.23 (12.69***)	0.19 (11.27***)	0.07 (2.68***)	0.22 (12.19***)	0.19 (11.47***)	0.07 (2.77***)
Rurality	0.08 (2.69***)	0.24 (8.96***)	0.78 (22.12***)	-0.04 (-1.10)	0.18 (6.56***)	0.80 (21.98***)	0.04 (1.38)	0.21 (7.69***)	0.78 (21.58***)
F20	0.42 (7.33***)	0.39 (7.11***)	0.51 (5.43***)	0.34 (5.62***)	0.31 (5.34***)	0.22 (2.31**)	0.43 (7.16***)	0.43 (7.62***)	0.38 (3.97***)
Population density (ln)	0.01 (1.14)	-0.01 (-0.91)	-0.04 (-3.25***)	0.05 (4.16***)	0.02 (2.07**)	-0.01 (-0.52)	0.01 (0.86)	-0.01 (-0.61)	-0.03 (-2.15**)
Constant	-5.57 (-34.47***)	-4.62 (-38.20***)	-3.98 (-22.86***)	-4.21 (-28.64***)	-3.81 (-29.13***)	-3.07 (-16.47***)	-5.32 (-38.21***)	-4.50 (-35.90***)	-3.74 (-20.75***)
Adjusted R-square	**0.16**	**0.11**	**0.20**	**0.16**	**0.12**	**0.22**	**0.14**	**0.11**	**0.22**
Observations	**170269**	**170536**	**168618**	**168702**	**169129**	**167349**	**168688**	**169115**	**167335**

Assessing impact

A.45 The performance data described above links across LSOAs and OAs over time, allowing changes in broadband performance to be tracked, a first difference. Comparing between the supported areas and the counterfactual areas (which is the second difference) quantifies the additional performance change that can be attributed to the vouchers. The Connected Nations annual report compiles data about fixed coverage (number of premises that are able to connect to broadband at different speed levels) up to September each year and for fixed performance (average download speeds) up to June.

Assessments of overall impact

A.46 After matching, estimates of the change in performance and coverage in areas that received vouchers can be compared to changes in counterfactual areas. The range of models used in the study means there are a large number of estimates of the difference between treated and counterfactual areas. The results are shown in Tables A8 to A12. These show changes across the following time periods:

- For vouchers connected in 2019/20 and 2019/20, we show change over a one year and two-year period from the year of support.
- For the most recent cohort, the fifth table covers the single year after support.

A.47 In each table, the impacts are presented for the three models described at paragraph A.29 and for the three sample pools described at paragraph A.30

A.48 These tables show change in a number of different outcome variables in the year(s) after support. These include the change in local area average download speed, the number of superfast connections (download speeds greater than 30 Mbps), the share of premises with slow download speeds of less than 30 Mbps, the share of premises that can access UFBB and the share that can access gigabit capable broadband.

Adjustments made for gigabit coverage in Virgin Media areas

A.49 Between September 2020 and January 2022, Virgin Media made a technological upgrade which meant all premises on its network (15.5 million premises) were able to access gigabit-capable broadband.

A.50 At a local level, this network-wide upgrade (unrelated to vouchers or any expansion in Virgin Media's network) resulted in a substantial increase in the proportion of homes that were able to access gigabit-capable broadband, in some cases increasing from zero to 100%. This large increase in coverage makes it difficult for the modelling to detect additional effects of vouchers in any output areas where Virgin Media has a presence. Furthermore, if areas supported by vouchers were more or less likely to include premises supplied by Virgin Media, that would bias the results of the modelling and under or over-estimate the effects of vouchers.

A.51 To control for this, the evaluation has used the SamKnows database to identify all Virgin Media supplied exchanges. We have then identified all of the output areas served by these exchanges and removed these from the models (for both treated and control

areas). This has only been done for the analysis of changes in the availability of gigabit capable broadband. The network upgrades do not affect any of the other outcome variables including availability of UFBB and average download speeds.

A.52 This explains why the sample sizes for changes in availability in gigabit capable broadband are much smaller than for all of the other outcome variables.

Table A.7 Treatment at OA level: Connected vouchers between 01 October 2018 and 30 September 2019. Analysis of the output variables after two years in 2021

	Model I			Model II			Model III		
	Pool All OA's	OA's exc. high emp.	Same exchange OA's	Pool All OA's	OA's exc. high emp.	Same exchange OA's	Pool All OA's	OA's exc. high emp.	Same exchange OA's
Average download speed (Mbit/s)									
Treated	31.21	30.24	31.18	31.36	30.36	31.36	31.18	30.23	31.08
Control	24.36	23.85	26.11	27.78	26.40	28.29	27.14	26.09	27.89
Difference	6.85***	6.39***	5.06***	3.58***	3.96***	3.07***	4.03***	4.15***	3.20***
Number of connections >=30Mbit/s (number of lines)									
Treated	43.12	39.80	43.09	43.45	39.81	43.45	43.24	39.80	43.27
Control	30.55	30.33	30.79	27.09	26.66	28.37	27.59	27.85	28.19
Difference	12.57***	9.48***	12.30***	16.36***	13.15***	15.07***	15.65***	11.96***	15.08***
% of premises unable to receive 30Mbit/s									
Treated	-4.07	-4.04	-4.07	-4.05	-4.04	-4.05	-4.06	-4.04	-4.06
Control	-2.05	-1.71	-1.75	-4.25	-3.07	-4.11	-1.16	-1.09	-1.16
Difference	-2.02***	-2.33***	-2.32***	0.19	-0.97**	0.06	-2.90***	-2.95***	-2.90***
UFBB availability (% premises)									
Treated	9.90	10.55	9.90	9.87	10.54	9.87	9.88	10.54	9.88
Control	9.33	9.11	10.73	10.31	10.80	12.02	9.75	9.18	10.48
Difference	0.58	1.44**	-0.83	-0.45	-0.27	-2.15***	0.13	1.36**	-0.61
Untreated	167267	166043	102076	167259	166036	102068	167257	166034	102066
Treated	2960	2649	2960	2960	2649	2960	2960	2649	2960
Gigabit availability (% premises)									
Treated	18.66	18.98	18.59	18.50	18.92	18.50	18.53	18.95	18.53
Control	17.90	17.17	17.04	16.54	16.94	16.28	15.61	16.36	15.27
Difference	0.76	1.81	1.55	1.96	1.98	2.22*	2.92**	2.59**	3.27**
Untreated	24777	24633	25009	24776	24632	25008	24776	24632	25008
Treated	1164	1121	1164	1164	1121	1164	1164	1121	1164

Table A.8 Treatment at OA level: Connected vouchers between 01 October 2018 and 30 September 2019. Analysis of the output variables after one year in 2020

	Model I			Model II			Model III		
	Pool All OA's	OA's exc. high emp.	Same exchange OA's	Pool All OA's	OA's exc. high emp.	Same exchange OA's	Pool All OA's	OA's exc. high emp.	Same exchange OA's
Average download speed (Mbit/s)									
Treated	14.78	15.37	14.75	14.78	15.45	14.78	14.70	15.33	14.58
Control	10.58	10.80	11.41	11.83	11.97	12.36	11.95	12.05	12.64
Difference	4.20***	4.56***	3.34***	2.95***	3.48***	2.42***	2.76***	3.28***	1.93***
Number of connections >=30Mbit/s (number of lines)									
Treated	22.10	21.63	22.09	22.17	21.62	22.17	22.16	21.61	22.12
Control	15.53	15.79	15.58	13.78	13.80	14.34	14.58	14.60	14.31
Difference	6.57***	5.85***	6.51***	8.39***	7.82***	7.83***	7.59***	7.02***	7.81***
% of premises unable to receive 30Mbit/s									
Treated	-2.31	-2.18	-2.31	-2.30	-2.19	-2.30	-2.31	-2.19	-2.31
Control	-1.22	-1.15	-1.15	-3.10	-2.14	-2.73	-0.77	-0.86	-0.78
Difference	-1.10***	-1.02***	-1.16***	0.80***	-0.05	0.43	-1.55***	-1.32***	-1.53***
UFBB availability (% premises)									
Treated	5.11	5.23	5.11	5.09	5.23	5.09	5.11	5.23	5.09
Control	4.56	4.74	5.41	5.49	5.97	6.71	5.16	5.28	5.73
Difference	0.54	0.49	-0.31	-0.40	-0.74	-1.62***	-0.05	-0.05	-0.63
Untreated	167267	166043	102076	167259	166036	102068	167257	166034	102066
Treated	2960	2649	2960	2960	2649	2960	2960	2649	2960
Gigabit availability (% premises)									
Treated	7.83	7.69	7.75	7.73	7.65	7.73	7.71	7.63	7.71
Control	7.08	6.62	6.97	7.59	7.94	8.24	6.61	6.19	6.51
Difference	0.75	1.07	0.78	0.14	-0.29	-0.51	1.11	1.44*	1.21
Untreated	24777	24633	25009	24776	24632	25008	24776	24632	25008
Treated	1164	1121	1164	1164	1121	1164	1164	1121	1164

Table A.9 Treatment at OA level: Connected vouchers between 01 October 2019 and 30 September 2020. Analysis of the output variables after two years in 2022

	Model I			Model II			Model III		
	Pool All OA's	OA's exc. high emp.	Same exchange OA's	Pool All OA's	OA's exc. high emp.	Same exchange OA's	Pool All OA's	OA's exc. high emp.	Same exchange OA's
Average download speed (Mbit/s)									
Treated	44.31	44.18	44.31	44.31	44.18	44.33	44.32	44.19	44.32
Control	35.28	34.82	36.77	37.93	36.96	38.01	36.02	36.78	37.10
Difference	9.04***	9.36***	7.54***	6.38***	7.22***	6.32***	8.29***	7.40***	7.22***
Number of connections >=30Mbit/s (number of lines)									
Treated	25.26	24.81	25.26	25.26	24.81	25.27	25.27	24.81	25.27
Control	16.94	16.41	16.68	17.65	17.64	17.53	17.22	17.39	17.40
Difference	8.32***	8.39***	8.58***	7.61***	7.16***	7.74***	8.05***	7.42***	7.86***
% of premises unable to receive 30Mbit/s									
Treated	-2.64	-2.71	-2.64	-2.64	-2.71	-2.65	-2.64	-2.71	-2.64
Control	-1.29	-1.05	-1.27	-2.45	-2.56	-2.55	-1.32	-1.40	-1.36
Difference	-1.36***	-1.65***	-1.37***	-0.20	-0.15	-0.10	-1.33***	-1.31***	-1.28***
UFBB availability (% premises)									
Treated	13.67	14.04	13.67	13.67	14.04	13.67	13.66	14.03	13.66
Control	11.72	11.26	13.23	12.88	11.91	13.53	11.14	11.73	13.00
Difference	1.95***	2.78***	0.44	0.79	2.13***	0.14	2.52***	2.31***	0.66
Untreated	167279	166055	107266	167266	166043	107256	167261	166038	107252
Treated	3227	3076	3227	3227	3076	3227	3227	3076	3227
Gigabit availability (% premises)									
Treated	25.19	25.40	25.19	25.19	25.40	25.19	25.29	25.50	25.29
Control	23.41	22.93	26.31	22.25	21.13	23.78	22.36	22.45	23.65
Difference	1.79	2.47*	-1.11	2.94**	4.27***	1.41	2.93**	3.05**	1.64
Untreated	29162	29010	29594	29159	29007	29591	29158	29006	29590
Treated	1379	1351	1379	1379	1351	1379	1379	1351	1379

Table A.10 Treatment at OA level: Connected vouchers between 01 October 2019 and 30 September 2020. Analysis of the output variables after one year in 2021

	Model I			Model II			Model III		
	Pool All OA's	OA's exc. high emp.	Same exchange OA's	Pool All OA's	OA's exc. high emp.	Same exchange OA's	Pool All OA's	OA's exc. high emp.	Same exchange OA's
Average download speed (Mbit/s)									
Treated	18.06	17.50	18.10	18.10	17.50	18.11	18.10	17.50	18.10
Control	14.00	13.49	13.75	14.89	14.46	14.51	13.94	13.84	14.25
Difference	4.07***	4.01***	4.35***	3.21***	3.04***	3.60***	4.16***	3.66***	3.85***
Number of connections >=30Mbit/s (number of lines)									
Treated	18.78	18.18	18.85	18.85	18.18	18.85	18.85	18.18	18.85
Control	12.60	12.13	11.88	12.66	12.21	13.43	12.50	12.37	12.31
Difference	6.18***	6.06***	6.97***	6.19***	5.98***	5.43***	6.35***	5.82***	6.54***
% of premises unable to receive 30Mbit/s									
Treated	-1.33	-1.40	-1.33	-1.33	-1.40	-1.33	-1.33	-1.40	-1.33
Control	-0.60	-0.36	-0.39	-1.13	-1.16	-1.04	-0.48	-0.70	-0.48
Difference	-0.73***	-1.04***	-0.94***	-0.21	-0.24	-0.29	-0.85***	-0.70***	-0.85***
UFBB availability (% premises)									
Treated	6.95	7.23	6.95	6.95	7.23	6.94	6.94	7.22	6.94
Control	4.63	4.99	5.46	5.58	5.11	6.07	4.52	4.92	5.22
Difference	2.33***	2.24***	1.49***	1.37***	2.12***	0.87*	2.42***	2.30***	1.72***
Untreated	171204	169956	107266	171191	169944	107256	171183	169937	107252
Treated	3435	3276	3227	3435	3276	3227	3435	3276	3227
Gigabit availability (% premises)									
Treated	13.79	14.07	13.79	13.79	14.07	13.79	13.80	14.08	13.80
Control	10.21	8.91	9.76	9.76	9.28	8.73	9.30	8.12	9.45
Difference	3.57***	5.17***	4.02***	4.03***	4.79***	5.05***	4.50***	5.96***	4.35***
Untreated	29162	29010	29594	29159	29007	29591	29158	29006	29590
Treated	1379	1351	1379	1379	1351	1379	1379	1351	1379

Table A.11 Treatment at OA level: Connected vouchers between 01 October 2020 and 30 September 2021. Analysis of the output variables after one year in 2022

	Model I			Model II			Model III		
	Pool All OA's	OA's exc. high emp.	Same exchange OA's	Pool All OA's	OA's exc. high emp.	Same exchange OA's	Pool All OA's	OA's exc. high emp.	Same exchange OA's
Average download speed (Mbit/s)									
Treated	48.24	48.46	48.27	48.24	48.46	48.24	48.24	48.46	48.24
Control	17.27	17.81	20.74	18.39	18.20	21.70	20.35	20.59	22.36
Difference	30.96***	30.64***	27.53***	29.85***	30.26***	26.53***	27.88***	27.87***	25.88***
Number of connections >=30Mbit/s (number of lines)									
Treated	11.32	11.30	11.33	11.32	11.30	11.32	11.32	11.30	11.32
Control	5.63	5.60	6.96	5.97	5.85	6.91	6.72	6.16	6.59
Difference	5.69***	5.70***	4.37***	5.36***	5.45***	4.41***	4.61***	5.14***	4.74***
% of premises unable to receive 30Mbit/s									
Treated	-2.36	-2.46	-2.36	-2.36	-2.46	-2.36	-2.36	-2.46	-2.36
Control	-1.49	-1.19	-1.88	-2.25	-1.99	-2.63	-1.40	-1.32	-1.94
Difference	-0.87***	-1.27***	-0.48	-0.11	-0.47	0.27	-0.95***	-1.14***	-0.42
UFBB availability (% premises)									
Treated	7.11	7.24	7.12	7.11	7.24	7.11	7.11	7.24	7.11
Control	8.45	7.79	9.86	7.85	8.63	9.81	8.71	7.11	9.39
Difference	-1.34*	-0.55	-2.75***	-0.74	-1.38*	-2.70***	-1.60*	0.13	-2.28***
Untreated	162514	161418	28215	162503	161408	28211	162502	161407	28210
Treated	1241	1231	1241	1241	1231	1241	1241	1231	1241
Gigabit availability (% premises)									
Treated	8.43	8.44	8.43	8.42	8.43	8.43	8.44	8.45	8.45
Control	9.60	10.35	11.59	9.41	9.85	11.82	10.00	8.59	11.78
Difference	-1.17	-1.91*	-3.16***	-0.99	-1.41	-3.39***	-1.56	-0.14	-3.33***
Untreated	9978	9944	10305	9978	9944	10305	9977	9943	10304
Treated	962	961	962	962	961	962	962	961	962

Robustness Checks

A.53 This section explains how the robustness of the modelling has been assessed and how the sensitivity of the results to the definitions used in the models have been tested.

A.54 The modelling robustness was evidenced by taking multiple models and then reporting findings in a manner that allowed the size and significance of any effects to be easily assured, and – recognising that the analysis focuses on multiple outcomes – there is not undue emphasis on particular sets of measures of impact.

Model outputs and overall results

A.55 The modelling of broadband performance and coverage at OA and LSOA levels involved a range of different models and a large range of different outcome indicators. This makes it difficult to select a preferred model on the basis of which appears to be the most robust as this may vary for different outcome indicators

A.56 The approach taken has been to develop a number of models that are repeatedly used for all outcome indicators, different geographies and over time. This allows cross-checking of the models to assess the consistency of results and, where this is the case, to then summarise findings in a balanced way. There were three dimensions to this.

A.57 A key dimension has been to use nine models, with each using a different set of selection variables and sample pools. Reporting of results then focused on the median difference-in-difference results from these models and how many of the nine models confirmed a significant difference-in-difference. The median estimate has the advantage of not being overly influenced by outliers, and the frequency of finding significant results helps to judge the confidence of this central estimate.

A.58 A second dimension has been the ability to repeat analysis over different periods and at a high and low levels of geography, and to assess whether these are consistent with each other. The consistency of the resulting estimates over all the outcomes is quite marked, which increases confidence that the key findings are robust.

A.59 The robustness tests of other counterfactual analysis for this study focused on the productivity effects on businesses. Here, where the outcomes were essentially two measures with one being well-measured (employment), the focus on robustness checking could be on diagnostics for each model. To some extent, such as diagnostic approach was used in the broadband performance and coverage analysis.

A.60 The third dimension was applying the standard tests for propensity score matching. This included an assessment of whether the treated and counterfactual groups were balanced across all indicators, whether the matching had found counterfactuals for all supported areas and whether the outcome variables for treated and counterfactual groups were on a similar trajectory prior to receiving support. In each case, the models passed all of these tests.

Appendix B - Technical annex for firm-level analysis

Outline of method

B.1 The firm level analysis combines statistical matching with difference-in-difference techniques to look at the employment, turnover and productivity effects on businesses that received a voucher.

B.2 Businesses that received an upgrade have been identified in data at the ONS Secure Research Service[64] and linked to records in the ONS Business Structure Database (BSD). The BSD is a rich data source providing data on a wide range of business characteristics which are measured consistently over time. The BSD can therefore be used to match treated businesses to a control group of businesses with similar characteristics, but also to compare the change in employment and turnover of businesses in the treated and control group over time. The analysis has also been linked to the Annual Survey of Hours and Earnings which provides insight about the salaries associated with jobs in the businesses.

B.3 The counterfactual here are groups of businesses that did not receive a voucher but are similar in terms of measurable characteristics such as size and industry, as well as indicators of broadband infrastructure. These have been identified using propensity score matching (PSM). The robustness of the modelling has been enhanced through analysis of pre-intervention data on the performance of businesses. This ensures that treated and control groups were on a similar trajectory prior to receiving the voucher (in terms of employment and turnover), which increases our confidence that the two groups are similar.

Time periods assessed

B.4 The most recent year available in the BSD relates to the financial year 2020/21. It is based on a snapshot in time of the Inter-Departmental Business Register (IDBR) taken in around April 2021, with the reporting period for the firm generally being the most recent financial year. There are therefore time lags in the data which mean it is not possible to assess the effects of vouchers connected after April 2021. Any vouchers connected in the 2020/21 financial year will also have had limited time to translate into a measurable impact on business performance.

B.5 This also means that the modelling results are based mainly on the effects of vouchers delivered through the GBVS scheme rather than the RGC scheme which were only used to connect premises from 2020 onwards.

Datasets for firm level analysis

B.6 The main dataset used for analysis is the BSD. This captures all businesses registered for VAT and/ or PAYE income tax and so includes all significant businesses operating in

[64] This work contains statistical data from ONS which is Crown Copyright. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

the UK. The annual updating means BSD provides a wide range of economic variables consistently across businesses and over time, particularly around business age, turnover, employment, sector and survival.

B.7 To the BSD we link other public data available at firm level. This includes whether a company received funding from Innovate UK, whether it holds a patent (both indicators of how innovative a firm is) and whether it is tracked by the commercial data company Beauhurst (an indicator that it is a high growth company). These additional variables assist in selection modelling as it allows us to assess whether the businesses that received vouchers display innovative behaviour and to match with comparable businesses that display similar levels of innovative behaviour.

B.8 The turnover and employment performance of firms in 2020/21 was heavily affected by the Covid-19 pandemic, with many businesses closed for long periods. Equally, in some sectors, use of digital technologies would have risen in importance in order to mitigate the restrictions on business travel and working from home. It was therefore necessary to control for this to ensure that firms in control groups were affected in a similar way to businesses in the treated group. This was done by matching by sector (since effects varied primarily on a sectoral basis), however we also controlled for this by using data on whether businesses received furlough payments and using dummies for observations in the Covid year.

B.9 Other data sources used in the modelling include Connected Nations (to measure average broadband speed in the output area) and BDUK's cost model which estimates the cost of connecting premises at UPRN level.

Identifying a counterfactual

B.10 Propensity Score Matching has been used to identify control groups of unsupported businesses. This can then form the basis for difference-in-difference analysis to understand whether the growth seen in businesses that received a voucher and the control group (the first difference) differs significantly between the two groups (the second difference). Any statistically significant difference is an estimate of the additional effects of the voucher on business performance.

B.11 We have developed a total of 15 different counterfactual models to perform the analysis. Each model is made up of different combinations of:

- Three sample pools of businesses. Each pool represents a different population of businesses that meet certain criteria. These are explained in more detail below.
- Five different selection models. Each model uses a different set of variables to match treated businesses with those in the sample pools.

B.12 The fifteen combinations of different control variables and sample pools result in different specifications and results. There are then ways to assess their quality and pick the most appropriate model (see below).

B.13 In order to identify control groups, we have drawn from three different pools of businesses. These are:

1) All businesses in the ONS business register covering all employers and VAT payers

2) Cancelled standard voucher applicants

3) Businesses in output areas served by the same exchange as those businesses that have received a voucher.

B.14 Restricting the pools to certain subsets of businesses has a number of advantages. The cancelled voucher applicants are businesses who have a proven interest in the voucher scheme. This is likely to correlate with hard-to-measure business characteristics such as the management or business interest in faster broadband. Drawing from this pool therefore helps to mitigate one of the main risks in PSM, which is 'selection bias'. This occurs when there are important characteristics which influence whether a business receives support or not, which cannot be measured. There are, however, reasons why these might not be a suitable comparison, for instance if the voucher was cancelled because it was determined the business did not need public funding for an improved connection.

B.15 Restricting the sample to businesses from the same exchange area as businesses that have received a voucher means that the analysis can be focused on businesses in areas with similar infrastructure to treated businesses. This therefore provides an indication of what happens to those businesses who do not use vouchers but may have the option of upgrading their broadband given the availability of fibre in the local area. The risk here is that a large proportion of businesses in the local exchange area may have gained improved connections anyway via a project, in which case these businesses could also be viewed as treated.

Selection models

B.16 The variables included in the selection model is quite rich, in that ONS BSD when linked to other firm level and other data can characterise businesses in economically meaningful ways. As well as size, age and location, there are proxies for innovativeness both at categorical level (e.g. using the industry code to link to a dummy around knowledge intensity) or at firm level (e.g. businesses that have a patent or receive Innovate UK funding). Other categorical data linked to location can identify rurality and measures of broadband access such as average area download speed, estimated cost to build etc. A full list of variables included in the models is provided below.

Table B.1 Variables included in selection models

Business characteristics	Location/broadband characteristics
• Turnover (and recent change) • Employment (and recent change) • Number of live local units • Age of company • Innovation variables (status as a scale up, high technology, patent	• Urban/rural • Average download speed • Estimated cost to build for UPRN ('commerciality')

owner and/or previous IUK project beneficiary) • Industry (high tech knowledge intensive services, ICT, level of competition in industry) • Whether company was recipient of furlough

B.17 Five different models have been used, with each using a different set of variables which are then used to match businesses from each sample pool. Each model then results in a different control group of businesses. The different selection models are:

- Preferred Control Group 1: selection modelled on categories for turnover and employment, the number of premises, and age of the company. Innovation related characteristics used are binary variables for Beauhurst tracking, status as a scale up, high technology, patent ownership and being past IUK project beneficiaries. Binaries also for the business' industry highly knowledge intensive services, information & communication, and a variable for level of competition in the industry. Average broadband speed at output area and the location being in the South East (including London) or not was additionally used, and an indicator of being a recipient of furlough or not.
- Alternative Control 2 and 3: uses the same variables as the preferred control group but introduces a variable for manufacturing and low pay. Additionally, it introduces the past turnover growth at industry level and business' employment growth.
- Alternative Control 4 and 5: uses the same variables as the alternative controls 2 and 3 but replaces the 1-year lagged level of turnover growth of the industry with the companies' previous year of turnover growth.

Profiling the businesses that received vouchers

B.18 Selection modelling requires data for at least the year before the voucher was connected. A sample of 15,436 businesses meet this requirement. Table B.2 compares the characteristics of these businesses with the wider business population, the control group based of cancelled voucher applicants and a median of the results from the matched fifteen models.

B.19 Businesses that received vouchers employ 22 people on average. This is more than the wider population. However, as vouchers targeted small and medium sized businesses, the wider population is trimmed of the largest businesses, reducing average employment. Voucher beneficiaries also had a higher level of turnover compared to the wider BSD (£3.1mil compared to £1.8m) and were more productive (£189k per employee compared to £147k per employee in the wider population). The average age of voucher beneficiaries was also higher than the wider BSD (14.8 versus 10.9 years of activity). This

may be a consequence of the suppliers targeting businesses that are more mature, or at least at a stage where they can expect to see the benefits over time of the connection.

B.20 Companies that received vouchers were significantly more high-tech (19% compared to 13% in the wider BSD), more likely to be in the manufacturing sector (9% compared to 4% in the wider BSD) and less likely to be in low paying sectors (21% compared to 28% in the wider BSD). The companies that received vouchers were also more likely to be in knowledge intensive service sectors.

B.21 In terms of innovation proxies, voucher beneficiaries were more likely to be patent holders (3% compared to 1% in the wider BSD) and recipients of IUK funding (2% compared to 0%). Additionally, more voucher beneficiaries received support through furlough than the wider BSD (51% compared to 19%).

B.22 The table also shows that, after matching, the control groups are much closer in terms of these characteristics than the wider BSD.

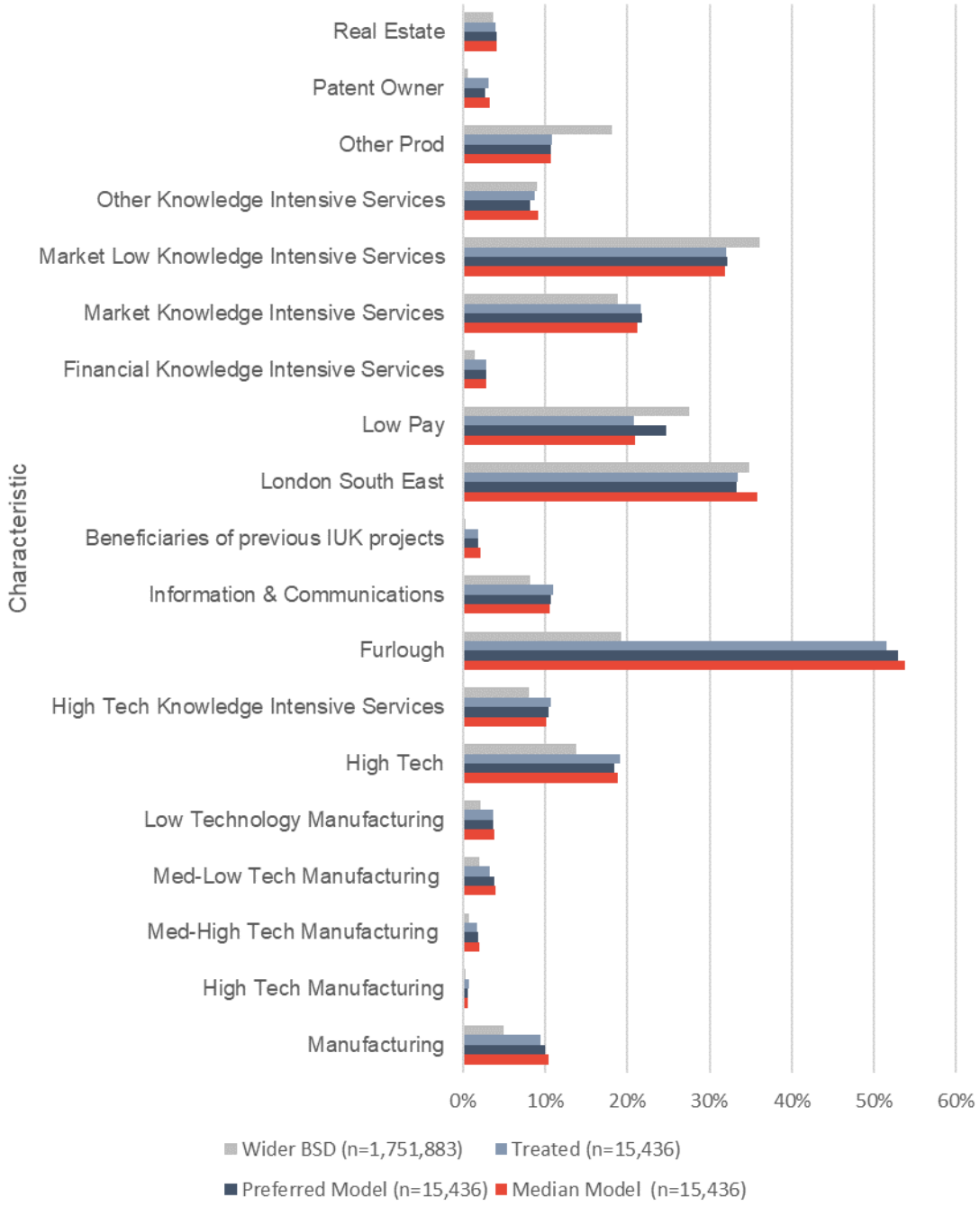
Table B.2 Summary comparison of voucher beneficiaries and control groups

Variable	BDUK Vouchers Mean (n=15,436)	Wider BSD Mean (n=3.5m)	Mod I Cancelled after Matching (n=15,436)	Median Model (n=15,436)
Business Size				
Employment	22	10	26	25
Real turnover (£'000)	3,095	1,768	4190	3564
Real productivity (£'000)	189	147	230	224
Industry Classification				
Low pay	21%	28%	24%	21%
High-tech	19%	13%	19%	18%
Manufacturing	9%	4%	9%	10%
High-tech manufacturing	1%	0%	1%	1%
High-med tech manuf'ing	2%	2%	2%	2%
Market-KI services	22%	19%	18%	21%
High-tech KI services	11%	8%	10%	10%
Innovation Proxies				
IUK project before	2%	0%	2%	2%
Patent holder	3%	1%	3%	3%
Coronavirus impact				
Receiving Furlough	51%	19%	51%	53%
Business demographics				
Local units	1.8	1.4	1.8	1.8
Years of activity	14.8	10.9	15.6	15.9

Note: Summary statistics calculated for the base year using BSD data and other public datasets. Wider BSD statistics calculated for the financial year 2019/20. Real turnover calculated using sector specific deflators and expressed in thousands of pounds using 2021 as base year. Knowledge intensive (KI) sectors as identified by Eurostat using indicators of skills mix. Coronavirus Job Retention Scheme data from HMRC indicates if a company received support for employment on furlough. Real productivity is a function of real turnover per employee.

B.23 Table B.2 compares businesses that received a voucher with the wider BSD and control groups across a wider range of variables. Again, this shows that the treated and control groups are much more aligned after matching.

Figure 8.1 Characteristics of voucher beneficiaries and comparators



Source Belmana

Robustness checks

B.24 There are a range of checks undertaken to test the robustness of PSM. A first is whether the matching provides a counterfactual that looks similar to the supported businesses. The summary statistics and balance tests, indicate that the matching generally aligns the counterfactual to the supported in a range of characteristics. These are presented above.

B.25 A second set of tests looks at whether the range of supported businesses is matched, as it is sometimes found that a matching model finds some businesses cannot be matched to a comparator. This is usually considered by looking at the propensity scores and - if there is a problem - then there would be unmatched outliers. This is not the case with the modelling for vouchers.

B.26 A crucial check is the extent to which the pre-support trends in outcome variables match. If the selection model is not working adequately, this is often revealed by seeing that supported businesses were on a different employment or turnover growth trajectory prior to support to the counterfactual. If this is found to be the case, a solution is to include past employment or turnover growth in the selection modelling, so that the matching is forced to select businesses on a similar past growth trends. However, it is considered less than ideal to include the outcome variables - such as employment growth - in the selection model as it can bias the analysis of post support growth.

B.27 The supported businesses were on a positive pre-support growth trajectory. This was also observed in businesses that were selected using PSM, but drawing from the pool of cancelled voucher applicants or businesses from the same exchange area. As is often the case in PSM, restricting the pool of businesses from which selection takes place can ameliorate matching issues where there may be unobserved characteristics that are difficult to control for (e.g. how growth orientated the owners of the firm are). The selection model is then applied to businesses that already are similar to supported businesses in some ways (bar not receiving the support), which often explains why they are on similar growth trajectories. In a statistical sense, this means any unobserved characteristics of the supported businesses that are correlated with being more growth focussed, are more likely to be shared by businesses from the treated and control groups.

B.28 On this basis, the preferred model used the cancelled voucher applicants, matched without using the past growth in outcome variables.

Appendix C - Area level analysis of business impacts

C.1 This strand of the analysis focuses on business outcomes but at an area level, aggregating the performance of all businesses in output areas where a business receives a voucher. The approach is similar to other econometric analyses in the study. It combines statistical matching with difference-in-difference analysis to assess the impacts of the voucher support on wider economic outcomes in the supported areas.

C.2 The main underlying dataset for the analysis is the Business Structure Database (BSD) at local unit (LU) level which is an administrative dataset which records the annual employment of each local unit of an enterprise. A local unit may be a plant, shop, office or other place of work, and provides the location of jobs within multi-establishment businesses. The data is available for statistical use at the ONS Secure Research Service.

C.3 Using the BSD, a panel dataset is created with annual employment and real turnover estimates for each of the 171,372 OAs analysed. Additionally, the BSD allows tracking of the new businesses created in an OA as well as business relocations.

C.4 This OA-level panel dataset is linked with information about vouchers by determining the locations of the treated businesses from the firm-level analysis. This dataset identifies 8,512 treated OAs, which contained at least one of the businesses including in the firm level analysis. The year of support was defined as the year where the first business was connected using a voucher.

C.5 For each of the treated OAs a comparison OA was identified using propensity score matching (PSM). PSM estimates the likelihood of receiving a voucher using a selection model and then matches each treated OA with the comparison OA with the closest likelihood of being treated i.e. the propensity score. The main limitation of this methodology is the dependence on the specification of the selection model. Therefore various specifications are taken into consideration and the preferred model is selected based on the quality of the matching, whether areas were on similar trajectories prior to receiving support and balance tests.

Datasets for business effects at area level analysis

C.6 We use the ONS Business Structures Database (BSD) at local unit level. A distinction between local unit and enterprise is made when analysing the BSD. The local unit is an enterprise or part thereof (e.g. a workshop, factory, warehouse, office, mine or depot) situated in a geographically identified place. Depending on the size and type of activity, an enterprise can therefore span a single or several local units.

C.7 The BSD at enterprise level provides a snapshot of employment and turnover each year and can be linked over time to provide a panel. In order to get a detailed geographical breakdown of the economic activity of a business the analysis is carried out at local unit level. The BSD at local unit level reports only employment and location of a local unit over time, thus it can be used to track employment and location decisions of individual business establishments. However, annual turnover is only reported at enterprise level which does not allow for an accurate representation of economic activity in OAs where there are local

units. To overcome this, local unit level turnover is imputed based on turnover per head ratios for the relevant enterprise. However this gives rise to measurement issues; for example, this approach is known to bias turnover estimates for the headquarters of a business versus an operational unit.

C.8 The annual BSD snapshots are linked over time to provide a panel. The most recent year available in the BSD covers the financial year 2020/21. This dataset allows analysis to track businesses' performance over the last four years. Additionally, the panel includes relocated firms and new businesses in a given area by providing the output area of each local unit for each year. The dataset used for the analysis contains information on total employment, turnover, the number of new local units and their employment, and the number of newly relocated businesses and their employment. This information is available for all 171,372 OAs in the United Kingdom.

C.9 Using the BSD the local units can be tracked over time, particularly the growth in the number of jobs and businesses and how this changes in the years after support. Furthermore, as local units have identifiers, this allows relocations into an OA to be distinguished from new business units, both in terms of any new employment that was created by spatially stable firms and the employment that was brought into the OA as a result of a relocation.

C.10 Additional variables were linked to the OA-level panel dataset to provide a better characterisation of supported and unsupported areas. The additional variables included information from the FScore Model which is used as a proxy of the average estimated cost to build ('commerciality'), information from the Connected Nations dataset such as average download speed, the number of connections and gigabit availability, as well as demographic information such as population density, and income deprivation deciles.

C.11 8,512 treated OAs which received BDUK business vouchers could be identified. The areas which benefitted from vouchers were identified by linking the list of businesses which claimed a voucher to the BSD using their Company House Registration Numbers (CRNs). This allowed us to identify the location of the business supported in the BSD. Additionally, using the business vouchers which were cancelled an additional 2,299 comparison OAs were identified, these are referred to as "cancelled OAs". This latter group of OAs provides a useful comparison as they expressed "intention to be treated" which can be used as a proxy for having specific unobservable characteristics which are linked to applying for a voucher. Explicitly controlling for these characteristics would not be feasible as these are not observed in the data. However, the validity of this comparison group is dependent on the reason for rejection being independent from the outcome variable.

C.12 The outcome variables were tracked for treated areas as well as for comparison areas. The counterfactual was identified using propensity score matching, where various selection models were considered. The variables used for the matching models were the log of employment, the log of the number of local units, number of new local units, number of relocated local units, the log of employment from relocations measured in the base year as well as past growth. In addition, to eliminate unobserved differences due to spatial characteristics the comparable areas are also restricted to within a certain geography from the treated area (eg. matching within region/local authority district). The various models

considered different groups of these variables. From the estimated models a preferred and alternative model where chosen based on the quality of the matching - whether it managed to balance variables both those included and excluded in the model - as well as whether the comparison groups experienced similar past trends.

C.13 The 8,512 supported OAs are tracked from the financial year before receiving the BDUK voucher, the base year. In order to find a unique treatment effect for vouchers which have been delivered across several years the data is "stacked", in that the data for a supported area is centred on the base year of the support. This can vary across the OAs, but the centring then compiles employment data in relation to the base year (rather than the actual year).

Selection models

C.14 The variables included in the selection model is quite rich. As well as size, age and location, there are proxies for innovativeness both at categorical level (e.g. using the industry code to link to a dummy around knowledge intensity) or at firm level (e.g. businesses that have a patent or receive Innovate UK funding). Other categorical data linked to location can be used to measure the degree of rurality and measures of broadband access such as average area download speed, estimated cost to build etc. A full list of variables considered in the models is provided below.

Table C1: Variables included in selection models

OA characteristics	Broadband characteristics
• Log employment (and recent change) • Log turnover (and recent change) • Number of live local units • Number of new local units • Number of relocated local units • Employment from new local units • Employment from relocated local units	• Median download speed • Average estimated cost to build for UPRN ('commerciality')

C.15 As well as using alternative selection models in terms of different mixes of variables used in the modelling, modelling is replicated for different pools of businesses:

- all OAs
- with cancelled standard voucher recipients
- within the same region
- within the same county
- within the same MSOA
- within the same Workplace Zone

C.16 The approach is to then both to establish best estimates and then test robustness using the range of alternative models. Where the various models stabilise, converging on a set

of similar results, this provides a high level of confidence that estimation of additional impacts is strong.

C.17 Often, different models can provide differing results. Then the approach is to use robustness tests. The main test in selecting the most robust models is to focus on ones that provide the best match in terms of the distribution of the control variables in the treated and comparison group. This is checked using balance tests. Additionally, having similar pre-support trends between supported and counterfactual areas is crucial for the validity of the analysis. The strength of this test is that it suggests selection modelling has identified areas that were on similar growth trends before support.

C.18 The 2020-21 BSD year will be affected by the impacts of Covid on economic activity, however the impact of the pandemic should affect the treated and comparison group on average by the same amount, thus this should not affect the difference-in-difference estimates.

C.19 Table C2 shows the variables included in each model. The model specifications were selected by first assessing which key variables were strongly predictive of receiving a voucher, then by assessing various combination of parsimonious model specifications which allowed to nest more complex specifications of the model. The models considered tend to be parsimonious as matching models which explicitly match on few variables but obtain a good match on other variables which are not included in the model are preferred to models which include many variables in the selection models but that provide a poor match quality.

Table C2. Variables included in probit model for different specifications

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Log employment	X	X	X	X	X
Log real turnover	X	X	X	X	X
Log number of local units	X	X	X	X	X
Number of new local units	X	X			X
Number of relocated local units	X	X			X
Log population density		X			
Median download speed (Mbps)	X	X	X	X	X
F20 model output	X	X	X	X	X
Previous employment growth			X		X
Previous real turnover growth			X		

Previous number of local units growth					X

Model selection and robustness checks

C.20 The different specifications of the selection models were compared based on the quality of the matching they produced. This can be judged by whether the comparison group resembles the treated group in terms of observable characteristics and previous growth trends. In order to provide more robust estimates for the estimated effects, as well as the preferred matching model an alternative model is also selected in order to show the dependence of the results on the specification of the model.

C.21 This section describes the model selection for the matching pool where all untreated OAs were included. This matching pool proved to be more consistent than restricting the match to either nearby areas or the cancelled OAs as it allows a bigger sample to find similar areas.

C.22 The summary statistics for the treated and comparison groups can show whether there are differences in the distribution of the matching variables in the treated and comparison groups. Table C3 shows the average of several variables for both the treated group and the comparison groups selected by each model specifications.

Table C3. Summary statistics for treated and comparison groups for different model specifications

Variables	Treated	Model 1 (Preferred)	Model 2 (Alternative)	Model 3	Model 4	Model 5
Log employment	5.78	5.44	5.83	5.43	5.45	5.46
Log real turnover	10.31	9.92	10.37	9.90	9.93	9.93
Log number of local units	3.84	3.59	3.88	3.59	3.61	3.60
Number of new local units	9.36	4.78	7.05	5.73	5.47	5.01
Number of relocated local units	6.97	3.44	5.26	4.20	3.85	3.00
Log population density	7.11	6.98	6.99	6.99	6.97	6.96
Median download speed (Mbps)	33.79	33.46	33.53	33.32	33.54	33.41
F20 model output	0.55	0.56	0.55	0.56	0.56	0.56
Previous employment growth	3.2%	3.1%	7.5%	3.5%	2.8%	2.8%

Previous real turnover growth	5.4%	7.2%	10.8%	6.5%	6.6%	6.3%
Previous number of local units growth	3.1%	3.1%	6.3%	2.8%	3.1%	2.2%

C.23 The table shows that PSM helps us to identify areas which are on average similar to the treated OAs along several dimensions. However, different model specifications perform better for different variables. This may be because certain variables are not included in the selection modelling, thus are not explicitly matched for, alternatively different models give different relative importance to the variables which should be closely matched as can be seen from the probit model coefficients. In this case, Model 1 is selected as the preferred model as it provides a good match alongside almost all variables considered apart from the number of new and relocated local units. Model 2 is chosen as an alternative specification as it also closely resembles the treated group on most variables, however this close match is at the expense of the previous trend in employment and turnover growth which appears to be higher in the control group relative to the treated.

C.24 Table C4 offers a way to check for the robustness of the results for different model specifications as it shows the DID estimate for each of the comparison groups taken into consideration. The estimates are consistent across most models, and the preferred model often lies as a central estimate compared to the various specification. This suggests that the DID presented offer a robust estimate of the average impact of the vouchers to different model specifications.

Table C.4 Difference-in-difference estimates for different model specifications

Period	Model 1 (Preferred)	Model 2 (Alternative)	Model 3	Model 4	Model 5
Employment in supported areas					
Year of support	0.56%*	0.73%	1.10%	0.50%**	0.44%**
2 years after	0.74%*	1.08%	1.35%	0.75%**	1.13%
3 years after	1.77%**	2.25%	3.75%*	1.31%*	2.27%
Real turnover in supported areas					
Year of support	1.92%***	1.39%**	1.85%**	1.68%**	1.39%**
2 years after	0.94%	1.20%	1.57%*	1.82%**	1.21%
3 years after	1.36%	1.63%	3.22%*	3.01%*	1.65%
Note: Significance levels are 1% (***), 5% (**) and 10% (*); Difference in Difference is treated minus control					

Appendix D - Residents Survey Questionnaire

Email

Good morning X

I am writing from Winning Moves on behalf of Building Digital UK (BDUK), part of the Department for Digital, Culture, Media & Sport (DCMS). We are contacting residents who approved a voucher that helped reduce the cost of building and providing your broadband connection, either through the **Gigabit Broadband Voucher Scheme (March 2018-May 2020)** or the **Rural Gigabit Connectivity Programme (March 2019-March 2021)**.

More information about the schemes can be found here https://gigabitvoucher.culture.gov.uk

Tell us what you think

You applied for voucher support in MONTH / YEAR. We realise that this may feel a long time ago, but your views are still important to us.

As a beneficiary of the voucher support, we would really like to know what you think about the scheme, and how it has affected your use of the internet.

The information you provide will help to inform the development of future services and support.

How to take part

To take part please click the following link: [insert link]
It shouldn't take more than 10-15 minutes to complete.

Further information
Winning Moves is conducting the research on behalf of BDUK. All the information you provide will be kept confidential and stored securely in accordance with GDPR. Further details of this can be found in Winning Moves Privacy Notice at www.winningmoves.com/privacy-notice

If you have any queries, please contact us on bduk@winningmovesresearch.com.

Thanks in advance for your time, and sharing your views.

[Insert signature]

Telephone introduction

Good morning / afternoon. My name is [X] and I'm calling you on behalf of Building Digital UK, from a company called Winning Moves. We understand that you upgraded your broadband in [insert month/ year] – and you approved a voucher subsidy to help with the cost of building and providing your broadband connection. We'd like to ask you a few questions to understand how your use of the internet has changes and whether you've benefitted from it. It would take about 10-15 minutes, depending on your answers. Would we be able to go through them now?

Before we start, there are a few things I need to make you aware of:

- The call might be recorded just for training purposes.
- All responses will be anonymised.
- Data may be published but it will not be possible to identify individual people or businesses from any published data.
- Winning Moves will keep any information that you share with us confidential and store it securely in accordance with the General Data Protection Regulations (GDPR)
- You have the right to stop the interview at any point.
- We have a privacy notice which gives more detail of this. Would you like to note down the web link? www.winningmoves.com/privacy-notice

Online Survey Introduction

Thank you for accessing this brief survey. The survey explores your decision to upgrade your broadband connection, the voucher process, as well as any effects on your household.

By continuing with the survey you are agreeing to your responses being shared with Building Digital UK (BDUK), part of the Department for Digital, Culture, Media & Sport (DCMS) in an attributable format. Data may be linked to other surveys or datasets for analytical purposes and data may be published, but it will not be possible to identify any person, business or address from any published data.

For technical issues with the survey, please contact us by email on ___. If you need to change an answer to a question, use the previous button located at the bottom of each page, rather than your browser's back button.

Thank you for your time.

About you

1) What is your age?

- Under 18
- 18 to 24
- 25 to 39

- 40 to 64
- 65+
- Prefer not to say

2) What is your current employment status?

- Employed full time(+35 hours a week)
- Employed part time (less than 35 hours a week)
- Self-employed
- Unemployed
- Retired
- Full time student
- Inactive for another reason
- Prefer not to say

About your household

3) How many people are in your household? *[capture verbatim]*

4) We would like to understand the upgrade experience for different types of household. Please tell us which of the following best describes your household?

- One person household
- A couple with no children
- A couple with at least one child
- Lone parent with at least one child
- Two or more unrelated adults
- Multi-family household
- Other – (please specify):

5) Within your household, how many children are there in full-time education?

- None
- 1
- 2
- 3
- 4
- 5 or more – how many?

6) What is your current annual household income?

- Less than £10,000
- £10,001 to £20,000
- £20,001 to £30,000
- £30,001 to £40,000
- £40,001 to £50,000
- £50,001 to £60,000
- £60,001 to £70,000
- £70,001 to £80,000
- £80,001 or more
- Prefer not to say

7) Which of the following best describes the tenure of your home?

- Owned outright
- Owned with a mortgage
- Private rented
- Social rented
- Other
- Prefer not to say

8) Thinking about the adults in your household, do any of them currently work in the following occupations. Please select all that apply.

- Managers, directors and senior officials
- Professional occupations
- Associate professional and technical occupations
- Administrative and secretarial occupations
- Skilled trades occupations
- Caring, leisure and other service occupations
- Sales and customer service occupations
- Process, plant and machine operatives
- Elementary occupations (including sales and services elementary occupations, agricultural, fishery and related labourers in mining, construction, manufacturing and transport)
- Other (please specify)

9) Now thinking about going online when you are at home – this address – how often would you say you personally do this nowadays when connected to your home internet connection only? Please exclude internet access from mobiles/smartphones if you are accessing the internet via your mobile phone service provider. Access can be for any purpose ranging from checking your emails to online shopping or using social media.

- More than once a day
- Once a day
- 2-3 times per week
- About once a week
- About once a fortnight
- About once a month
- About once every 2-3 months
- About once every six months
- Less often
- Never
- Don't know

Decision to apply for voucher/upgrade connection

10) How did you first hear about the voucher scheme?

- Through a broadband supplier
- Through a local authority
- Through my landlord
- Through an online search
- Other (please specify)

11) Did you actively seek the voucher or were you contacted by another organisation (e.g. a broadband supplier, local authority or landlord) and asked if you would like to take part in the voucher scheme?

- I / we actively sought the voucher
- We were contacted by another organisation
- Other (please specify)

12) What were the main reasons why you applied for or accepted and approved the voucher? (tick all that apply)?

- To access a reliable, uncontested line
- To access faster download / browsing speeds
- To access faster upload speeds
- To access dedicated customer service and technical support
- I was persuaded by the provider that contacted me
- No specific motivation, but given the incentives the benefits appeared worthwhile
- Other (please specify)

13) What were your wider goals and motivations for seeking an upgraded internet connection? Tick all that apply

- For personal/ household use e.g. accessing / streaming entertainment, keeping in touch with friends and family, accessing health and other public services
- For education use
- For working from home / running a business
- Other (please specify)
- No specific goals or motivations

14) Why had you not upgraded your broadband connection previously?

- It was too expensive
- It wasn't available where we are located
- We wouldn't have known what to do with it
- We weren't aware of the benefits at the time
- We were happy with the connection we had at the time
- Other (please specify)

15) What would you have done about your broadband connection if the voucher had not been available? Please select the most appropriate statement from the list below

- We would have bought the same connection anyway, at the same time
- We would have bought the same connection, but at a later date
- We would have bought a connection at the same time, but one with lower performance (eg, a lower speed/a consumer grade connection, contested line)
- We would have bought a lower performance connection at a later date
- We would have moved to new house to get the connection speeds we require
- We would have considered a connection, but decided not to proceed
- We would not even have considered an upgrade to our connection

The application process

16) Who led the application process on your behalf?

- I / we did
- A broadband provider
- My landlord
- Other (please specify)

17) Please rate each of the following:

	Very satisfied	Satisfied	Neither satisfied nor dissatisfied	Dissatisfied	Very dissatisfied	Don't know
The ease or simplicity of the voucher process						
The length of the application process						

18) If you wish to make any comments about the application process please do so here. *[capture verbatim]*

Your connection now

19) How would you rate your satisfaction with your broadband service before the upgrade?

	Very satisfied	Satisfied	Neither satisfied nor dissatisfied	Dissatisfied	Very dissatisfied	Don't know
Reliability						
Download / browsing speeds						
Upload speeds						
Value for Money						

20) If you wish to make any comments about what broadband connection was like before the upgrade, please do so here: *[Capture verbatim]*

21) How would you rate your satisfaction with your broadband service after the upgrade?

	Very satisfied	Satisfied	Neither satisfied nor dissatisfied	Dissatisfied	Very dissatisfied	Don't know
Reliability						
Download / browsing speeds						
Upload speeds						
Value for Money						

22) If you wish to make any comments about what broadband connection is like after the upgrade, please do so here: [*[Capture verbatim]*

How you are using the internet

23) Are you now doing any of the following for the first time, more often, more easily or more effectively?

Personal / household uses

	For the first time?	More often?	More easily?	More effectively?	No – we are not currently doing this
Streaming entertainment services (e.g. Netflix)					
Online gaming					
Using social media e.g. Facebook, Twitter, Instagram etc					
Keeping in touch with friends and family though video chat (Skype, Zoom, Facetime)					
Accessing health, NHS, local and government services online					
Online shopping					
Online banking					
Cloud storage and file sharing					

For education use

	For the first time?	More often?	More easily?	More effectively ?	No – we are not currently doing this
For children's education and schooling					
For an adult to study a professional qualification					
For other general adult learning e.g. online training, learning how to do something by watching online					

For professional / business use

	For the first time?	More often?	More easily?	More effectively ?	No – we are not currently doing this
Search for a new job					
Starting a new business					
Running an existing business from home					
Work (as an employee) from home e.g. check / send emails, video calls, downloading and uploading files, operating a web site or blog, running software					

24) Please tell us If there are any other services from those listed above, that you have used for the first time, more often, more easily or more effectively? (*Capture verbatim)*

25) *[If answered yes (i.e. ., 'for the first time', 'more often', 'more easily', 'more effectively')] to Q23]* And of those that you have used for the first time, more often, more easily or more effectively, how important was your upgraded connection in being able to do it?

Personal / household uses

	Very important	Important	Neither important of unimportant	Unimportant	Very unimportant
Streaming entertainment services (e.g. Netflix)					
Online gaming					
Using social media e.g. Facebook, Twitter, Instagram etc					
Keeping in touch with friends and family though video chat (Skype, Zoom, Facetime)					
Accessing health, NHS, local and government services online					
Online shopping					
Online banking					
Cloud storage and file sharing					

For education use

	Very important	Important	Neither important of unimportant	Unimportant	Very unimportant
For children's education and schooling					
For an adult to study a professional qualification					
For other general adult learning e.g. online training, learning how to do something by watching online					

For professional / business use

	Very important	Important	Neither important	Unimportant	Very unimportant

	of unimportant
Search for a new job	
Starting a new business	
Running an existing business from home	
Work (as an employee) from home e.g. check / send emails, video calls, downloading and uploading files, operating a web site or blog, running software	

26) Did you receive any help, training or support to use or make the most of your enhanced connectivity?

a. Yes
b. No

27) (If 26a) Who provided the support?

- Friend or relative
- Internet Service Provider
- Consultant
- Training provider
- Other (please specify)

Impact of the broadband connection on your household

We would like to understand how broadband upgrades affect people's use of the internet and whether and how it has made a difference.

28) Have you had a change in life satisfaction as a result of your upgraded broadband connection?

a. Yes, the upgraded connection has increased my life satisfaction
b. No, the upgraded connection has not affected my life satisfaction
c. Yes, the upgraded connection has decreased my life satisfaction.

29) (*If 28a or c)* On a scale of 1-10 where 1 is not at all and 10 is completely, how satisfied were you with your life before your broadband upgrade?

30) *(If 28a or c)* On a scale of 1-10 where 1 is not at all and 10 is completely, how satisfied are you with your life now, after your broadband upgrade?

31) We would like to understand whether upgraded broadband connections have affected how lonely residents feel. Has the upgraded broadband connection affected how lonely you feel?

a. Yes
b. No

32) *(If 31a)* Before the upgrade to your connection, how often did you feel lonely?

- Often/always
- Some of the time
- Occasionally
- Hardly ever
- Never
- Prefer not to say
- Don't know

33) (*If 31a)* And now, after the upgrade to your connection, how often do you feel lonely?

- Often/always
- Some of the time
- Occasionally
- Hardly ever
- Never
- Prefer not to say
- Don't know

34) (this will only bring up the options that the respondent selected in Q21) Please tell us, have any of the following internet uses had a positive impact on your life satisfaction?

	Yes being able to do this has had a positive impact on	Being able to do this has not had a positive impact on	No we have not done this

	my quality of life	my quality of life
Streaming entertainment services (e.g. Netflix)		
Online gaming		
Using social media e.g. Facebook, Twitter, Instagram etc		
Keeping in touch with friends and family though video chat (Skype, Zoom, Facetime)		
Accessing health, NHS, local and government services online		
Online shopping		
Online banking		
Cloud storage and file sharing		

For education use

	Yes being able to do this has had a positive impact on my quality of life	Being able to do this has not had a positive impact on my quality of life	Yes being able to do this has had a positive impact on my quality of life
For children's education and schooling			
For an adult to study a professional qualification			
For other general adult learning e.g. online training, learning how to do something by watching online			

For professional / business use

	Yes being able to do	Being able to do this	Yes being able to do

	this has had a positive impact on my quality of life	has not had a positive impact on my quality of life	this has had a positive impact on my quality of life
Search for a new job			
Starting a new business			
Running an existing business from home			
Work (as an employee) from home e.g. check / send emails, video calls, downloading and uploading files, operating a web site or blog, running software			

35) Have you/ your household seen any of the following benefits as a result of your improved connection?

	Yes this has been a major benefit	Yes this has been a minor benefit	No, we have not benefitted from this
Reduced frustration/stress from using the internet			
Started a business			
Found a new job or improved your career prospects			
Gained new skills and qualifications through online learning			
Achieved greater flexibility or better work life balance (e.g. through working from home)			
Saved time by doing more things online			

36) If there are any other benefits from your upgraded connection for your quality of life please describe them here. [capture verbatim]

37) As a direct result of your upgraded connection, have you reduced the amount of travel that you do?

    a. Yes

b. No

38) (*If 37a)* Based on a typical week, please provide a rough estimate of:

a. How many fewer miles you travel each week compared to if you had not got the upgraded connection

b. How much time you save each week from reduced travel (in hours)

c. How much money you save in transport costs each week (£)

39) (*If 35a)* What would have been your main mode of transport for undertaking these journeys? (if you use two modes of transport, please select the one that you use for the longer distance)

- Car – petrol
- Car - diesel
- Car - electric
- Train/metro
- Bus
- Tram
- Cycling/walking

40) (*If Q35 Got a new job / improved career prospects)* You said that you have found a new job or increased your salary as a result of your upgraded connection. What has been the increase in your annual income compared to your previous job or employment status? (provide answer in £ before tax and including annual bonuses) *[capture verbatim]*

41) (*If Q35 started a business*) You said that your upgraded connection has allowed you to start a business. What has been the change in your annual income compared to before you started the business? (provide answer in £ before tax) *[capture verbatim]*

42) *(If Q35 Gained new skills or a qualification)* Please provide details of the skills you have gained. If you have gained a qualification please confirm the specific qualification here. *[capture verbatim]*

43) Have you experienced any of the following disbenefits, related to your use of the upgraded connection? If you answer yes to any of the following please state whether it was a major or minor disbenefit.

	Yes, this has been a major disbenefit to me / my household	Yes, this has been a minor disbenefit to me / my household	No this has not been an issue for me / my household
Reduced social contact or increased loneliness			

Poorer mental health			
Less or lack of sleep			
Less or lack of exercise			
Other physical health problems			
Longer working hours			
Increased home energy usage and bills			
Internet security issues			
Poor or unreliable connection			
It is costing us more/it is too expensive			

44) If there are any other disbenefits from your upgraded connection for your quality of life please describe them here. *[capture verbatim]*

Covid pandemic

45) Would you say that your new/upgraded broadband connection contributed to your household's ability to adapt during the pandemic?

- Major positive effect
- Minor positive effect
- No discernible effect
- Minor negative effect
- Major negative effect
- Not relevant (eg, only received the new broadband connection at a late stage)

46) *(If q45 'major positive effect'/ 'minor positive effect'),* what were the main ways in which the broadband connection helped you to adapt (tick all that apply):

- Enabled members of the household to work from home
- Avoiding the need to go in shops by doing more shopping online
- Enabled members of the household to continue to attend school, college or university lessons remotely
- Access health services or health information online
- Allowed us to access entertainment services and other things to do during lockdowns
- Other (please specify)

47) *(If 'q45 major negative effect'/ 'minor negative effect'.)* Please provide brief details below [Capture verbatim]

Close

Thank you for your time, your feedback is much appreciated

48) There will be ongoing evaluation work relating to BDUK's investment into broadband upgrades, and we would like the opportunity to be able to refer back to the responses you've given us so we can streamline any further questions we may wish to ask you, so please can I just check:
    - Would it be OK to contact you again if we have further questions for you? Yes / No
    - Are you happy for us to link the responses you've just given us to any further surveys you complete with us, to save you time? Yes / No

49) Finally, would you like to take Winning Moves telephone number or the MRS freephone number, to check the work we are doing?
    - MRS - 0800 975 9596
    - Winning Moves – 0121 285 3800

Redirect respondent to: https://www.gov.uk/guidance/building-digital-uk

Appendix E - Base sizes for residents survey

Category	Description	Number of responses
Commerciality	Commercial	1,327
	Non-commercial	3,337
	Unknown	264
Scheme	GBVS	1,125
	RGC	3,803
Rural/urban location	Rural	4,527
	Urban	401
Age group	18 to 24	18
	25 to 39	408
	40 to 64	2,572
	65+	1,866
	Prefer not to say	64
Employment status	Employed full time (+35 hours a week)	1,748
	Employed part time (less than 35 hours a week)	426
	Full time student	13
	Inactive for another reason	69
	Prefer not to say	90
	Retired	2,013
	Self-employed	523
	Unemployed	46
Household type	A couple with at least one child	1,635
	A couple with no children	2,265
	Lone parent with at least one child	164
	Multi-family household	259
	One person household	516
	Other	9
	Prefer not to say	8
	Two or more unrelated adults	72
Households with school age children	Household contains school age children	1,334
	Household does not contain school age children	3,594
Household income	Less than £10,000	90
	£10,001 to £20,000	294
	£20,001 to £30,000	433
	£30,001 to £40,000	464
	£40,001 to £50,000	433
	£50,001 to £60,000	375
	£60,001 to £70,000	251

	£70,001 to £80,000	220
	£80,001 or more	1,001
	Don't know	80
	Prefer not to say	1,287
Tenure	Owned outright	2,693
	Owned with a mortgage	1,533
	Prefer not to say	215
	Private rented	372
	Shared ownership	9
	Social rented	90
	Tied Accomodation	16
Whether household contains people working in different occupations	Managers, directors and senior officials	1,249
	Professional occupations	1,635
	Associate professional and technical occup	332
	Administrative and secretarial occupations	386
	Skilled trade occupations	327
	Caring, leisure and other service occupati	391
	Sales and customer service occupations	294
	Process, plant and machone operatives	42
	Elementary occupations (e.g. sales and ser	183

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