BDUK Rural Gigabit Connectivity Hubs Evaluation

Report to BDUK by Belmana, with Hatch and Winning Moves

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Belmana
ANALYSIS FOR POLICY

Contents

Concepts and Acronyms	
BDUK	Building Digital UK
CTC	Connect the Classroom, a DfE Programme
DfE	Department for Education in England
EHC	Education, Health and Care (Plan)
FTIR	Future Telecoms Infrastructure Review
FTTC	Fibre to the Cabinet
GBVS	Gigabit Voucher Scheme, a BDUK product
GP	General (Medical) Practice
LA	Local Authority
LFFN	Local Full Fibre Network, a BDUK Programme
LSOA	Lower Super Output Area, a geography used for UK local areas
Mbps	Megabits per second, speed of broadband
NHS	National Health Service
OA	Output Area, a geography below LSOA for small areas
PSBA	Wales Public Sector Broadband Aggregation
RGC	Rural Gigabit Connectivity, a BDUK Programme
SG	Scottish Government
SFBB	Superfast Broadband (speeds of up to 80Mbps)
SWAN	SG's Scottish Wide Area Network
UFBB	Ultrafast Broadband (300Mbps or greater)
UPRN	Unique Property Reference Number

Executive summary

Building Digital UK (BDUK) commissioned Belmana, Hatch and Winning Moves to conduct an economic evaluation of its Hub product, which is being delivered through the BDUK Rural Gigabit Connectivity (RGC) Programme and Project Gigabit. The Hub product invests in connecting remote public buildings, such as schools, GP surgeries and libraries, to gigabit-capable broadband. The evaluation explores the impacts of these investments.

This first stage of the evaluation focuses on the RGC Hubs, and this interim report reviews the impacts of the Hub product by the end of 2022, a year after the delivery concluded. It answers the research questions: "what are the outcomes of the Hubs product across RGC?" and "what insights are there about how effective and efficient the delivery of the programme has been?".

This is part of a multi-staged evaluation. The second stage of the evaluation focuses on the parallel programme funding Hubs, Project Gigabit, that is delivering connections from 2023. There is a final third evaluation stage, to look again at the Hubs to consider the long-term impacts.

Findings

Benefits from providing better broadband in a public building occur at three levels. The first is in the services delivered at the building, mainly education and primary healthcare at primary schools and GP surgeries. This translates into better outcomes for the individuals that use the services or efficiencies in service provision. Secondly, there are benefits from bringing broadband closer to residences and businesses which are in areas otherwise distant from the gigabit capable network. The Hubs facilitate nearby residences and businesses to connect by raising awareness and reducing the cost of transitioning to faster and more reliable broadband. Finally, there will then be wider market effects as suppliers roll out further connections building from the new Hub infrastructure, delivering further local effects.

Enabling public sector efficiency. In schools, there is evidence that faster broadband leads to increased use of the internet in teaching and administration, and there is adoption of educational technology. Attribution to Hubs is complex as there has been considerable complementary public funding of the IT needed to make use of the reliable and faster broadband. These would also contribute to the internet use changes seen in schools. However, qualitative evidence suggests the faster broadband at the Hub has enabled the benefits from educational technology investments into schools in remote areas. Further initial value for money evidence notes schools supported through a Hub investment are switching their spending towards technology products more than comparator schools, indicating benefits of faster and more reliable broadband are being captured in teaching.

Availability. There is evidence of additional uptake of fast broadband at the Hub itself. In the immediate area surrounding the Hub, the study finds that the speed of broadband in postcodes of school Hubs grows faster than comparable postcodes. This is established carefully, looking at postcodes that have primary schools, and are equally distant from the broadband network and similar in other characteristics. The counterfactual analysis, which detects take up of broadband in the residences and businesses near to the Hubs at an area level (broader than postcode level) found

positive change, but so far this is not significantly different to comparable areas. This finding relates to the lowest level of geography for which the Office for National Statistics produces statistics, known as the Output Area[1] (OA).

Uptake. The speed of broadband in postcodes of school Hubs grows faster than comparable postcodes which have primary schools, are equally distant from the broadband network and similar in other characteristics. A third of the speed increases in Hub postcodes are attributable to the Hub products. At an OA level, the availability, which we define as the share of properties passed by the gigabit capable network, has increased faster than comparable areas so that more premises could be connected relatively cheaply and on a commercial basis. As the study is quite soon after the Hubs connection, the businesses and residences take-up of connection may be yet to occur.

Awareness, drivers and uSse in homes and business near Hubs. Evidence suggests that whilst suppliers have used vouchers in areas around Hubs these do appear to have been delivered separately and not as a joint community solution, despite community initiatives being involved in connectivity projects beyond the Hubs:

- Awareness of the Hub connection was low. Only a very small proportion say they use the Hub (2%, see p. 66) and that they understood the upgrade to the Hub enabled their own connection. Hubs were generally connected by the infrastructure provider Openreach, rather than suppliers, so awareness raising measures – such as marketing – may have been low.
- A key motivation for many surveyed residents close to a Hub to be part of a BDUK Gigabit Voucher scheme is being part of a community initiative, rather than supplier marketing in non-Hub areas with this effect more pronounced the further they are from gigabit connectivity.
- Use of the internet is similar for Hub and non-Hub voucher beneficiaries in households - most use is streaming, shopping, banking, and accessing healthcare online (80% to 92%). Those residents connecting to gigabit close to the Hub used their connection for working from home more (46% compared to 44%) and running a business from home more (27% compared to 23%).
- Satisfaction amongst households and businesses with connection is very high. Approximately 90% gave a positive response for reliability and download speeds. Positivity amongst those connected near to a Hub was slightly lower, but much higher than previously increasing 20%-40%. Those close to the Hub went on to report higher life satisfaction.

Estimating the full impact with Vouchers. Households and businesses that have been connected recently using a government funded voucher were surveyed and were analysed comparing those near Hubs to those not near a Hub. The benefits of the connections near to Hubs are similar to those seen in connected properties distant from Hubs. However, near to Hub areas, voucher recruitment is more likely to result from community networks, rather than supplier marketing. Also, residents close to a Hub are less satisfied with their connection, compared to residents in the wider vouchers sample, but a higher proportion of residents close to a Hub reported an increase in their life satisfaction.

[1] Output Areas are designed by ONS using Census Data to have similar population sizes and be as socially homogenous as possible, based on tenure of household and dwelling type. The minimum OA size was 40 resident households and 100 resident people, but the recommended size was substantially larger at 125 households. In comparison postcodes are on average 15 addresses but can contain up to as many as 100. (Source: https://www.ons.gov.uk/methodology/geography/ukgeographies)

In the **next phase of the evaluation**, which parallels the delivery of the Project Gigabit Hubs which will be the focus of evidence gathering, evaluation will also return to consider the effects of the RGC wave of the Hubs, considered in this phase. It will allow assessment of medium-term impacts on nearby areas and whether, in the years after Hub connections, households and businesses take up fast broadband connections building on the infrastructure put in place to connect Hubs. The phase will parallel GigaHubs delivery. This could also provide insight about the way direct and indirect effects beyond the public building occur. Questions include the extent and nature of community and supplier actions in maximising the wider benefits of public building connectivity.

Evaluating the outcomes of the Hubs product

Seeking to stimulate the broadband market, while enabling public sector efficiencies, the Hubs product was launched in 2019 funding physical gigabit-capable broadband infrastructure in eligible, mainly rural, public buildings. The schools, general practice surgeries, libraries etc connected by Hub funding were ones poorly served by broadband, in having download speeds slower than the average.

Outcomes are expected on broadband availability and the uptake of broadband, and this study is based on analysis of data about these outcomes. Ofcom measures broadband speeds and the coverage of gigabit capability at detailed geographies; BDUK tracks the publicly funded investments made into connecting properties also at property level. These measures are tracked over time and focusing on areas with and around the Hub investment illuminates the changes in the number of premises with access to gigabit capable broadband and the uptake of fast broadband. The study uses a counterfactual to compare changes seen with similar areas, identifying the additional effects of the Hubs.

Other outcomes are analysed using the results of surveys of households and businesses near to the Hubs that received a further BDUK product, the broadband voucher. Surveys ask about broadband performance, use and benefits before and after the connection the voucher supported. People's awareness of the Hubs and wider community effects of better broadband are explored. In-depth interviews provide follow up on survey findings.

The direct effects of the Hub investments in public buildings, particularly in schools, is explored using surveys of English primary schools[2] that received Hub support. Surveys ask about the quality of the internet, and whether Hub funded improvements lead to increased use in education, the adoption of educational technologies, and changes in school administration. In-depth interviews of school staff then corroborate survey findings. The study also integrates discussions with parish Councillors about the local context for some of the school Hubs.

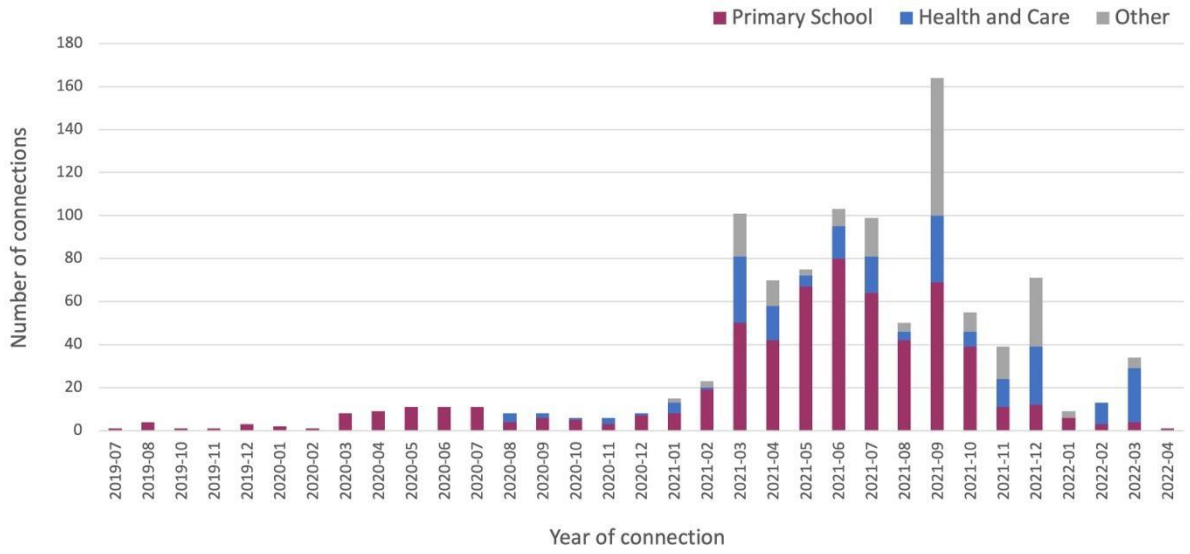
Delivering Hubs and the impact logic

First connections of Hubs were in summer 2019, with the number of connections picking up considerably in late 2020 (see Figure 1). There were 1,088 Hub connections, with most being in

[2] The report's analysis of primary schools parallels the focus of the Hubs product on primary schools. In England, DfE's digital standards state that secondary schools, all-through schools that combine at least two stages of a pupil's education, and further education colleges should have a connection with the capacity to deliver 1Gbps download and upload speed. The Hubs intervention could focus on primary schools not covered by this (though where secondary schools without access to gigabit capable connectivity are identified, they were considered for inclusion and a very small number of secondary schools were connected through the programme).

primary schools[3]. **Hub support is across all parts of the UK except London**: 595 are in England (59%), 216 in Northern Ireland (20%), 104 are in Wales (16%) and 173 in Scotland (16%). Around half of the UK's local authorities have at least one Hub, with none in London.

Figure 1: The number of connections installed in each month



Source: Analysis of BDUK Data

A key aspect of the product logic was **selecting eligible buildings in areas distant from the gigabit capable network.** Premises were identified through ten projects led by partner bodies such as local authorities, DfE, devolved administrations, that have prioritised public buildings poorly served by broadband. This worked well by integrating wider plans of suppliers, managers of public buildings, and the network operators such as Openreach.

Selection **placed gigabit infrastructure in areas where this was unavailable**. There are about 19,000 properties in the 997 postcodes where at least one Hub connection has been provided, and in 2019 none had gigabit availability. By 2022, this has changed with 7,500 properties having gigabit availability. The costs to connect these properties has been modelled, and around half the properties can be connected on a commercial basis (i.e., a broadband provider would bundle in the connection to the premise within a service contract).

Rolling out the Hubs has involved a limited number of suppliers. Connections in Hubs have been supplied primarily by Openreach, with a few local suppliers. **Suppliers felt their involvement earlier and with more information about the Hub product would have encouraged participation**, and generally viewed the related voucher product – that subsidises individual or groups of connections to residential and business premises – as more significant in their supplying of connections.

Impact on availability and Gigabit uptake at and near the public building

A first impact evaluation focus – on the additional availability and uptake of broadband at the public building – is on the areas that contained 528 English primary school Hubs. These were statistically

[3] The figures stated in this report may not align with BDUK performance report due to differences in methodology.

matched to areas with similar schools, in terms of size, pupil eligibility for free school meals, share of pupils with special education needs, and where the wider catchment area of the school was similar in terms of socioeconomics and broadband connectivity. Other variables – such as school expenditure on IT – were not used, as these were then analysed as outcomes of the Hub investment.

Ofcom provides data at postcode level. Postcodes level data makes detection of effects a little easier as postcodes cover a dozen or so properties of which one is the Hub. Postcode analysis finds broadband uptake and performance improvements at the school Hubs, and these are not seen in the postcode areas of comparable schools. There is a 28% improvement in speed of broadband in the 528 postcodes of supported schools. The counterfactual are the postcodes that include comparable schools, and these also see broadband speed changes, but around 35.7% of the changes seen in Hub schools is not seen in these similar schools, with confidence at 10% for the median model. Varying the models suggest differences are materially different.

Table 1: Uptake of Gigabit broadband at schools

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	528 postcodes in treated and matched				
Average download speed (Mbps, logged)	0.28	6 out of 9	0.10*	0.06 to 0.2***	35.7%

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

Initial value for money analyses then has looked at the spending of schools both receiving a Hub investment and the comparable schools. Schools supported through a Hub investment are switching their spending towards technology products more than comparator schools, indicating benefits of faster and more reliable broadband are being captured in teaching.

Centring on the school then means analysis can look at spatial effects around both Hub supported schools and the unsupported, similar schools identified in the matching. Broadband speed changes in nearby premises are also tracked. **Take up changes – measured through three indicators in Figure 3 – are positive but not significantly different to comparable areas.** The use of vouchers, the change in broadband speed and the number of fast connections increases in the areas around supported schools but not at rates different from the counterfactual areas.

Modelling has focused on English primary school Hubs but also considered the wider set of Hubs drawing counterfactuals for the GP surgeries and other public buildings and extending beyond England to all four nations. The evidence is at present less conclusive about take-up, partly because the study has so far undertaken the analysis at a relatively high level of geography (not postcode level), and so premise estimates are more challenging.

Table 2: Gigabit availability effects in businesses and residences near school Hubs

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	528 OAs in treated and matched, 463 when pool is same exchange				
Premises passed by BDUK funded projects	14.28	8 out of 9	7.08***	2.67 to 9.19***	49.6%
Gigabit availability (% premises)	10.83	3 out of 9	2.21	1.01 to 2.80**	20.4%
Gigabit availability (% premises, logged)	0.64	7 out of 9	0.33***	0.12 to 0.53***	51.3%
UFBB availability (% premises)	9.23	7 out of 9	2.99**	1.58 to 4.26***	32.3%
% of premises unable to receive 30Mbps	-1.51	1 out of 9	0.17	-0.34 to 0.90	-11.5%

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

Looking only at the changes in spending on educational technologies in school Hubs, there is evidence that benefits are on track to be greater than costs in monetary terms in that there is evidence of payback. The Hub schools are spending more on educational ICT than is the case in comparable schools and that this switching of resources, if maintained for five years, will be similar to the cost of the connection. This measure focuses only on one school activity and so would understate overall effects, not including other effects that the study finds but cannot be valued.

Turning to businesses, households and other users, **even though there is yet to be uptake of connections, Gigabit availability is increasing faster in areas with a Hub than comparator areas.** Properties are being brought closer to gigabit capability in supported areas, with 14.3 more premises passed by gigabit capable lines in the year after the Hub investment in supported areas and this is 7 more than in comparable areas. These are premises that can readily be connected to gigabit. Further, gigabit availability is rising quicker than comparable areas in the year after support, with around half (51.3%) of the 64% rise in the premises is additional. Around a third of the 9.23 rise in premises connected to ultrafast broadband in supported areas is additional.

This finding – that availability is increasing faster for areas near to Hubs – is strong within 400m of a Hub in Table 2 but is still evident when the areas included extent to 1km from a Hub. Around half the increase in premises passed and 40% of the gigabit availability growth that is found in the areas close to Hubs is not seen in comparable areas.

Does better broadband cause changes in public services?

Surveyed primary schools that received a Hub investment indicate that more reliable and faster broadband leads to increased use of the internet in service delivery, and administrative tasks. There is also adoption of innovative technologies. An online survey was sent to the 507 English schools that received a Hub investment. The survey was completed in October and November 2022, after the Hubs connection and there were 148 responses, of which 112 were complete. Changes seen in schools after being connected include:

- **Survey found high levels of satisfaction with the speed of connection**. 88% of 138 responses reporting fairly or highly satisfied, and 82% categorising reliability similarly. In the survey, 71% of 135 responses were very or fairly satisfied with the value for money of the connection.
- **Use of the internet in teaching activities increased.** Schools reported implementing innovative teaching practices, such as blended learning, and in the use of the internet in conducting formative and summative assessments. In the first, internet use being more than occasional was reported as 47% before the connection rising 22% to 69% amongst the 112 respondents after the connection. A rise of 26% is observed in the use of the internet for assessments.
- **Connectivity was used more often in a range of admin tasks (finance, pupil data management etc) than prior to the Hubs investment.** Also, workloads are reported as lessening due to technology. In 93 responses, 60% have seen workloads reduced already or are expecting this as technologies are adopted. This question replicated one in a national survey, which finds that 50% had this view.
- **Cloud storage use is growing after connection.** Share using only cloud storage 31%, higher than baseline 13%. The DfE EdTech Survey 2021 reports 12% of primary schools.

In English schools, the analysis of broadband speed changes at postcode level indicates that **Hub investments lead to 35.7% additional broadband speed improvement,** with the rest being estimated would have occurred without the support. Attribution from the additional speed at supported schools to the effects on education is difficult, primarily because alongside the faster connection, in-depth interviews reported the importance of parallel funding being available for the procurement of tablets, teaching IT, and improvements to within school Wi-Fi.

Some part of changes seen in these more remote schools could be attributable to the Hub products as interviews confirmed the dependency on fast and reliable broadband of school's use of the internet. Educational policy leads at national and local level view a **policy aim is equalising broadband performance across schools to attain standards of connectivity in remote areas comparable to the best.** Paralleling this, was a desire to avoid blocking the development of school-wide operations reliant on connections, such as widespread use of online assessments, with good broadband connectivity necessary if some schools were not to be left behind.

What impacts are being seen in the households, businesses, and communities near Hubs?

Analysis of uptake suggests households and businesses are yet to connect to the gigabit capable broadband infrastructure brought to areas that were previously distant from the network. However, some connections have been made near to the Hubs, such as those that were funded by the parallel BDUK vouchers product.

A survey of residential and business voucher beneficiaries where the connection was near (within a 5km radius) to a Hub asked about internet use, the effects of the improved broadband connections, as well as exploring the respondent's knowledge or experience of the nearby Hub. The survey uses a set of questions in a recent survey conducted to evaluate vouchers more generally, and results from that survey provide a comparator. The primary driver for household and business benefit is the voucher subsidised connection, but contrasting survey responses near to a Hub with those distant from the Hub teases out whether the mix of voucher and Hubs together provides some further effects.

The residential survey of voucher beneficiaries near Hubs had 1,518 respondents with 33 follow-up interviews. The comparator survey had 1,356 respondents and are similar in profile to residents in the comparison. Findings were:

Use of internet similar for Hub and non-Hub voucher beneficiaries. The comparison group and the Hubs sample are making greater use of the internet for personal, education and professional purposes. Use changes were similar whether near to a Hub or not, with some statistically significant differences with a slightly lower proportion of residents in the Hubs sample making greater use of streaming entertainment services and keeping in touch with family and friends.

There are community-level networks about broadband take-up schemes. Residents close to a Hub were more likely to have heard about the voucher through a local community initiative, and it was less likely to be through a broadband supplier, compared to residents in the voucher sample. Being part of a community initiative appears to be a key motivation for many residents close to a Hub in terms of upgrading their internet. This community effect is more pronounced the more distant the resident is from gigabit connectivity.

Less satisfied with connection than non-Hub sample but higher life satisfaction. Residents close to a Hub are less satisfied with their connection, compared to residents in the wider vouchers sample, but a higher proportion of residents close to a Hub reported an increase in their life satisfaction, due to the upgrade. The main reason provided by residents regarding this is the ability to work from home.

Awareness of the Hub is relatively low amongst residents. A very small proportion say they use the Hub (2%) and that they understood the upgrade to the Hub enabled their own connection. A low proportion is probably to be expected, as households would be very indirectly affected by the Hub. Also, as most Hubs were connected by the infrastructure provider Openreach, rather than suppliers of broadband, awareness raising through marketing about the connection – usually by suppliers – may have been low. Where respondents were able to say, roughly half of these agreed that the Hub's services were easier to access, the Hub uses its connectivity to communicate better, and the Hub offers new and better online services – although it should be noted that this is a small proportion (less than 10%) of all residents that responded to the survey.

In interviewing local councillors, there were **concerns about the focus on the centres of villages and towns.** Interviews at parish level indicated a concern that the properties not near the Hubs were less likely to have gigabit connectivity. Villages and towns were spread out having other activity centres outside the Hub, such as business parks on the outskirts of a town. There was a concern that the Hub's focus on a school or surgery connection, without simultaneously connecting the outskirts of the area, meant the network availability levels were lower than hoped.

There were 219 respondents to the business survey, all within 5km of a Hub. The comparator survey had 214 responses. **Businesses close to a Hub have experienced a wide range of business benefits, but these are similar to the wider voucher scheme.** Like counterparts in the wider voucher sample, entering new markets, adopting new sales methods and channels, and fostering new relationships was cited. Satisfaction levels amongst businesses close to a Hub remain high after the upgrade, with fewer businesses close to a Hub reporting to be dissatisfied or very dissatisfied after their upgrade

Reporting the findings

Table 1 indicates which chapter contains the findings. The findings are also mapped to the main research questions for the study:

- What insights are there about how effective and efficient the delivery of the programme has been?
- What are the outcomes of the Hubs product across RGC, focusing on the outcomes for enabling public sector efficiencies, on the broadband market and ensuring a full impact assessment?

Table 1.1: Findings mapped to research questions

Question	Findings	
	Evidence for findings	Chapter
Effectiveness/ efficiency	Selection processes used partner bodies to prioritise hard-to-reach public buildings taking account of wider connection plans and processes were designed recognising differing delivery models.	2
Effectiveness/ efficiency	Suppliers felt their involvement earlier and with more information about the Hub product would have encouraged participation.	2
Outcomes on broadband market	Suppliers of connections included community-based providers and suppliers other than Openreach.	2
Outcomes on broadband market	There are additional effects on the premises passed due to the Hub investments and availability measures increasing the number of premises that can be connected for no cost or on a commercial basis due to the support.	3
Outcomes enabling public sector efficiencies	The Hub investment correlates with additional download speed improvements in the connected schools, and the extent of this has been quantified.	3
Outcomes on broadband market	Near to Hub areas, voucher recruitment is likely to result from community networks, alongside supplier marketing with similar effects on broadband use, satisfaction etc to the wider voucher programme.	4
Estimating full impact	Residents close to a Hub are less satisfied with their connection, compared to residents in the wider vouchers sample, but a higher proportion of residents close to a Hub reported an increase in their life satisfaction.	4
Outcomes enabling public sector efficiencies	Surveyed schools indicate increasing the use of the internet in a range of teaching and administration activities after the connection.	5
Outcomes enabling public sector efficiencies	Users of public service that lived near to Hubs reported improved online services, but awareness is low of the Hub investments.	4

1. Introduction

Building Digital UK (BDUK) commissioned Belmana, Hatch and Winning Moves to conduct an economic evaluation of its Hub product, which is being delivered through the BDUK Rural Gigabit Connectivity (RGC) Programme and Project Gigabit. The Hub product invests in connecting remote public buildings, such as schools, general practice surgeries and libraries, to gigabit-capable broadband. The evaluation explores the impacts of these investments and is being conducted between 2022-25. This first stage of the evaluation focuses on the RGC Hubs, with a second stage focusing on the parallel programme funding Hubs, Project Gigabit, that is delivering connections from 2023. The final third stage, looks again at the Hubs to consider the more long-term impacts.

Programme overview

The Hubs product was launched in 2019 as part of BDUK's RGC programme. This is a "demand-side" intervention, aggregating the demands from multiple premises for speeds faster than 1000Mbps. Aggregation across public buildings means there are economies of scale, with BDUK working with local authorities and other government departments to identify appropriate sites. The product has funded eligible public buildings, described as 'Hubs', with physical broadband infrastructure to provide the school, general practice (GP) surgery, library etc with a gigabit-capable broadband connection. The investments target public buildings that are poorly served by broadband and are usually in rural areas. The Hubs can then lower costs to connect nearby businesses and residential properties as the reach of the gigabit-capable network increases. First connections of Hubs were in summer 2019, with the number of connections picking up considerably in late 2020.

Investing to improve rural connectivity

The RGC programme is testing a Hub model approach. The product involves identifying eligible public sector buildings which meet qualifying criteria set by BDUK. The criteria consider several factors, primarily targeting rural areas with a low threshold internet speed – sites must have a current download speed below 100Mbps (with sites below 50Mbps particularly prioritised). In addition, eligibility involves considering the funding required, State Aid compliance, and other broadband infrastructure planned investments (commercial or otherwise) in the area. Further criteria include value for money, and deliverability within the timescales of the programme.

Identifying eligible public buildings has been key. BDUK worked with strategic partners, including the Department for Education (DfE) and the Department of Health and Social Care (DHSC), and the Department for Environment, Food and Rural Affairs (DEFRA), as well as Devolved Administrations and Local Authorities. These partners identified eligible rural public sector buildings to act as Hubs. The lists were then tested using the criteria, with delivery commencing in 2019 but reaching a high level in 2021.

Related BDUK and other interventions

The evaluation is in the context of complementary policies. The Hubs provide a fast connection in a public building, such as a school. There is then support for the services provided in Hubs to use

digital technologies. For example, funding is allotted by DfE for educational technologies in classrooms through the Connect the Classroom (CTC) Programme.

There is a range of health and care services delivered using digital technologies that are being promoted in the National Health Service (NHS), as well as improvements in record management and administrative functions. Devolved administrations are also at the forefront of similar initiatives for Scotland, Wales, and Northern Ireland. Some of these policies include investments in faster connections, but many complement this, relying on the premises used for delivering public services securing adequate connectivity,

A related BDUK intervention, the Gigabit Broadband Voucher Scheme (GBVS), encourages greater take-up of gigabit-capable connectivity by residents and businesses. There has been a parallel Rural Gigabit Connectivity voucher scheme in rural areas. These are demand-side products, meaning that they are designed to stimulate demand for broadband connectivity: the vouchers are worth up to £2,500 to businesses and residents to cover the cost of installing gigabit-capable broadband. Many local authorities provide additional funding for businesses to help them upgrade to faster internet connections, alongside BDUK voucher schemes. Eligible businesses received additional funding of up to £3,000 to top up the existing gigabit voucher so that businesses could potentially receive up to £5,500 towards the cost of upgrading to a gigabit-capable connection.

Evaluation aims and objectives

The evaluation primarily focuses on the effects of the Hub and what impacts are attributable to the policy. As the Hub product is within a wider programme of demand-side and supply-side interventions and supports the delivery of public services, the study has covered process aspects, understanding the scoping and delivery of the Hubs product and how the Hub results in better outcomes. The research questions ask about direct (broadband) outcomes but then also their onward effects. The attribution of these to the Hubs investment and the logic of the policy is crucial to help identify how to test this. Identifying the logic of the policy is crucial to be able to attribute these effects to the Hub investments.

Evaluation aims and objectives

The overarching aim of the evaluation is to establish the connectivity impacts of Hubs. BDUK programmes have a standard set of overarching evaluation questions that must be assessed, in line with the Magenta Book and Green Book. Evaluation projects seek to answer or contribute to the overall understanding of these questions:

- What are the outcomes of the Hubs product across RGC and in Project Gigabit covered in a later stage of this evaluation?
- What has changed in individuals'/organisations' behaviour for these outcomes to come about?
- How effective and efficient has the delivery of the programme been?
- Was the investment cost-effective?
- What can we learn to improve future policy designs and implementation?

These questions are answered in relation to a BDUK benefits realisation framework, which includes three priorities: stimulating the broadband market, enabling public sector efficiencies, and ensuring an estimation of the full impact.

For the first priority, the evaluation aims to look at how the Hubs influence the market through stimulating investment, increasing competition, and addressing the market failure to provide gigabit-capable connectivity. A particular focus is on the non-commercial areas, where costs of connection are such that a connection on a commercial basis may be unlikely. The second priority is to be considered in terms of establishing measurable benefits to Hub site beneficiaries, especially where these can be monetised and/or estimated robustly. These differ by the type of Hubs, and this study focuses on the effects on educational services as schools are the main type of Hub site. The final priority, that the evaluation gives a full picture of impacts, is in the context of indirect local area benefits, and this requires a baseline estimate of both intervention and suitable counterfactual areas.

Methodology

The first stage of the impact evaluation considers early impacts on the performance of broadband, the effects of Hubs on the speeds and coverage of broadband, and then tracking effects as the Hubs make use of the connections. There are also wider broadband network effects as the local area sees the benefits of gigabit broadband in otherwise poorly served areas. Evidence gathering is structured in terms of three broad themes to understand the impacts of Hubs:

1. **Estimating impacts attributable to Hubs using a comparator.** These are estimated quantitatively, approximating changes in Hub areas and then comparing this to similar areas using econometric methods. The robustness of identifying what effects are additional and due to the policy involves using a counterfactual. This is possible econometrically on some effects of the Hubs, especially broadband performance, and coverage measures, but then the study also uses comparator evidence for resident, business, and public service effects.
2. **Impacts assessed qualitatively.** Qualitative evidence is collected about the uses enabled at the Hubs and looking at the residential and business effects of broadband, and these are assessed triangulating across areas, types of Hubs and the supplier perspective. This analyses the steps towards impacts, testing the logic of the Hub product, to intermediate actions and outcomes.
3. **Further understanding from surveys and data analysis.** The study involves surveys of businesses, households and Hubs. Qualitative evidence is combined with quantifiable data where possible with specific focus on analysing broadband uses where Hub investments are made.

The evaluation design is informed by the research team's parallel study evaluating the BDUK voucher schemes. Initial impacts and benefits of this scheme were analysed and published in 2022 with further findings in 2023 (Hatch et al., 2022 and 2023). The analytical findings focused on the vouchers' effect on broadband availability and performance using a counterfactual to understand additional effects. In addition, a benefit survey of residential and small business voucher recipients was conducted for that evaluation, which provided a survey instrument then used in this study for residential and business beneficiaries near Hubs.

Overall, primary data collection and secondary datasets compilation involved:

Counterfactual analysis of the broadband effects at and near Hubs. An area-level dataset that links together the annual Connected Nations reports on broadband performance and coverage, modelled costs to connect locations, management information about Hubs, socioeconomic data about areas, and data about other policies has been compiled. Propensity score matching and difference-in-difference is used to understand additional impacts in Hub areas. Many Hubs are primary schools and the data also incorporates information about English primary schools, such as the number of pupils and eligibility for free school meals, in finding a counterfactual area that also contains a school.

Online survey of residential and business voucher beneficiaries. A survey of voucher beneficiaries within a 5km radius of a Hub. The survey asked about internet use, the effects of the improved broadband connections, as well as exploring the respondent's knowledge or experience of the nearby Hub. The analysis uses a set of questions that were asked recently in a large survey conducted to evaluate vouchers more generally, and this additional data provides a comparator.

Online survey of DfE school Hubs. BDUK worked with DfE to survey the Hubs that they nominated (all of which were primary schools in England) prior to their connection. Following connection, a follow up survey was conducted, exploring the use of the connection as well as changes due to it. This provides insight about effects in school Hubs.

In-depth interviews of staff at Hubs, suppliers, households, and businesses. Those working at schools, surgeries etc connected using the Hub product were interviewed about their use of the internet, and the changes attributable to the faster connection. The study also benefited from interviews of broadband suppliers, policy leads and – following the online survey of voucher beneficiaries – in-depth interviews of a sample of these connected properties.

There are some limitations to the approach and – at this first stage in the evaluation – some methodological challenges.

Firstly, the collection of qualitative evidence on an area level, allowing some understanding of the delivery of the Hubs from the local perspective, has proven difficult. This is primarily because the delivery was complex, with differing models across the Hubs, and the study began after the delivery was largely complete. This meant that many of the stakeholders that were involved in the early stages of the process were unavailable to provide evidence about the planning stages. In the next phases of the evaluation, which parallels the delivery of the Project Gigabit Hubs, it is expected to be possible to engage with stakeholders during the delivery, allowing an understanding of the moving parts as the connections are supplied.

A second challenge has been the assessment of effects in an environment where multiple policies are in place. For example, while gigabit capable connections to public buildings are being delivered through Hub investments, the extent to which indirect connections to residential and business premises are enabled by the Hub requires controlling for the popular voucher products that are targeting similar areas to the Hubs.

Untangling the effects of each policy is difficult and this challenge has led to the study collecting/compiling datasets in a manner that can be analysed controlling for the vouchers policy specifically. For the business and residential survey, the focus was on voucher beneficiaries near Hubs, allowing a comparison with the wider set of voucher survey responses. In compiling data about the support provided in areas, the study has benefited from the management information about the vouchers provided.

Structure of the report

The remaining chapters in the report cover:

Chapter 2: RGC Hubs Product Logic and Delivery. General background about the policy, including the "lollipop model" of the spatial effects of the Hubs policy.

Chapter 3: Effects of Hubs on Broadband. Focus on quantitative findings, looking first at Hub delivery, the wider datasets developed and the findings about additional broadband effects in areas supported by the Hubs product.

Chapter 4: Surveying residences and businesses near Hubs. Survey findings for voucher beneficiaries near to Hubs, covering residential vouchers and businesses, assessing these in relation to a comparator survey (drawn from the recent Gigabit Broadband Voucher Scheme Evaluation).

Chapter 5: Public service delivery outcomes in education. Findings from the BDUK survey of Hub investments into schools in England with some of the qualitative evidence about school education technology adoption.

Chapter 6: Area effects of the Hubs. Findings from case study evidence of school effects merged with some quantitative analysis of areas close to Hubs.

Chapter 7: Conclusions. Summarised findings of the study and the costs and benefits that can be assessed at this stage, feeding into future analysis to assess value for money.

2. RGC Hubs Product Logic and Delivery

This chapter looks at the Hubs product, focusing on the Rural Gigabit Connectivity (RGC) delivery that occurred from 2019-22. It explores the policy logic and then describes delivery providing an overview of the Hubs that have been funded and some changes on broadband availability and uptake trends. The chapter also considers evidence about the delivery model, using findings from interviews with suppliers and the policy leads.

Key findings are:

- The Hub product invested in connecting public buildings to gigabit capable broadband in areas which will not support commercial roll-out without some kind of subsidy. Between May 2019 and the end of March 2022, 1,021 connections have been made across rural UK. The evidence finds that the selection process did identify such buildings.
- Identification of Hubs was through partnerships between BDUK and a sponsor, such as central government departments and agencies, and local government. This enabled looking across a portfolio of hard-to-connect schools, General Practice (GP) surgeries, libraries and other public buildings and select those needing a connection. The logic of the Hub product is then for the connections to enable the public building to use digital technologies in delivering services, but then also gigabit capable networks closer to businesses and residences in remote areas.
- A final aim is to encourage a more competitive supplier market. Interviews highlight that there are some challenges in this regard, with the selection process using government partners potentially not introducing suppliers early enough to integrate the connections into their wider offer to the area near the Hubs. Some suppliers also noted that the focus on Openreach provisioning the connection meant their onward use to connect businesses and residences would incur Openreach access charges, potentially lessening the incentives for further connections.

Delivering broadband connections in rural areas

In 2018, the Future Telecoms Infrastructure Review (FTIR) estimated that around 80% of premises in the UK would be commercially viable to support two or more gigabit-capable networks. Around 10% are likely to be 'grey areas', meaning that, whilst they are commercially viable for one operator, there may be a role for Government intervention to ensure investment in these areas to resolve strategic uncertainties, with the final 10% of premises in areas which will not support commercial roll-out without some kind of subsidy. Investing in connecting public buildings is viewed to support this aim, and the RGC programme has provided a pilot to test driving gigabit rollout in the final 20% using investments connecting public sector buildings (Hubs).

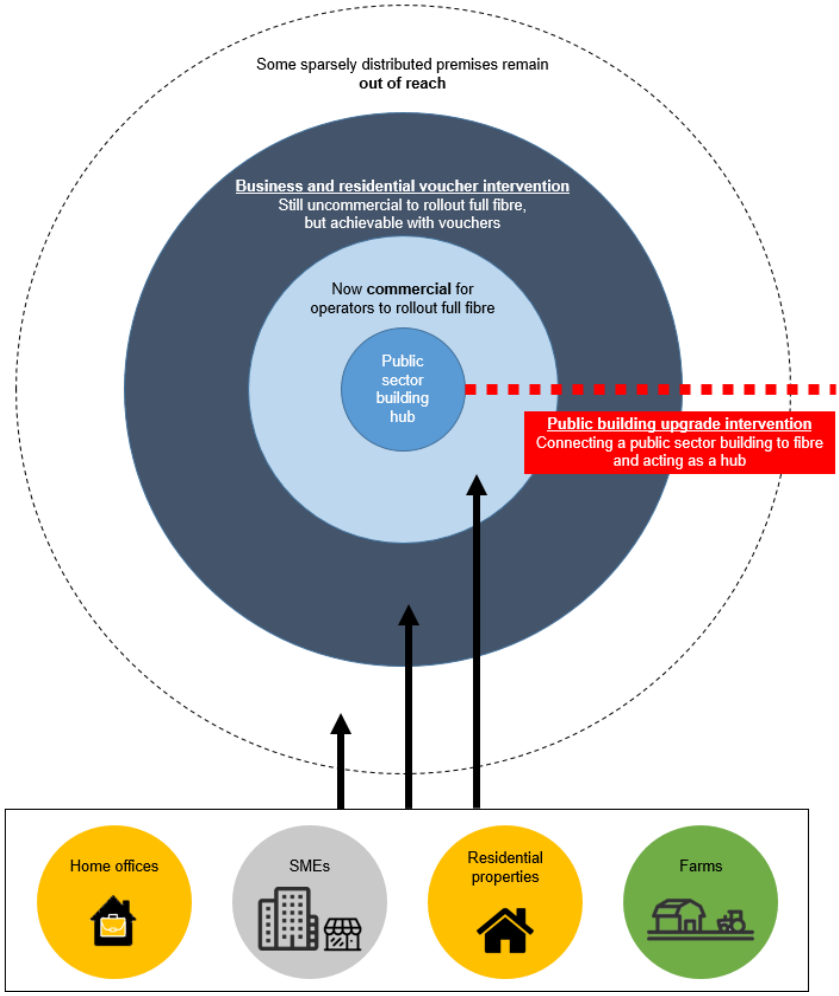
The Hub Product

The Hub product was first piloted in the 2017 Local Full Fibre Network programme, where it was Public Sector Building Upgrades. The RGC Programme, beginning in May 2019 and running until the end of March 2021, continued this type of intervention with delivery of the builds to be completed by the end of March 2022. The Hub approach involves identifying demand for gigabit connectivity to meet an area's connectivity needs, centring on the needs of eligible public sector buildings (such as (GP surgeries, libraries, and schools).

The benefit of this approach is three-fold. It will improve public service at the Hub, make it cheaper for nearby premises to connect to gigabit capability and draw in suppliers for the wider network. The benefits will be spatially spread out to benefit not only the Hub but also the wider community. In promoting the Hub product to key stakeholders (devolved local and national government, suppliers etc), Building Digital UK (BDUK) sought to visualise this staged and geographical model, developing the lollipop model, shown in Figure 2.1.

In the centre of the model, the provision of a gigabit-capable connection to a public building enhances a public service. If done as intended, the delivery of a connection to the public building will also allow for near immediate delivery of services to the neighbouring premises with little or no additional cost, and certainly at a cost that the market provision would meet. This is the lightest concentric circle in Figure 2.1.

Figure 2.1: Modelling Hub Effects in Nearby Areas



With supplier presence established through the Hub, they can stimulate business and residential demand to establish gigabit in the still uncommercial areas around the Hub, perhaps using the voucher product. Hence there is expected to be some overlap between Hubs and vouchers in the same intervention area.

The selection of the Hub is crucial, as this mix of public service and local outcomes meant navigating the needs of public buildings and the infrastructure plans of suppliers, as well as interacting with other broadband and digital policies. Sponsor bodies were identified, such as the Department for Education (DfE), the Scottish Government (SG), and local authorities (LAs) to list potential Hubs. An initial set of Hubs targeted areas that were deemed to be the hardest 10% to connect, where speed was lower than 50Mbps and that were classified as rural. This led to around 1,100 sites being identified. The scope and eligibility were broadened in December 2019, extending to the hardest 20% where speeds did not exceed 100Mbps. Build costs in such areas are highest and the Hub funding would meet these costs.

Table 2.1 lists the ten projects that were initiated through the sponsor bodies. Delivery was implemented through these projects with the largest being led from the DfE, the three devolved administrations and some medium sized ones delivered by local authorities. Often the projects involved the National Health Service (NHS). These projects were led by the sponsor bodies with

BDUK delivery leads, allowing the allocation of the RGC funding through the sponsored bodies who could then procure the connections.

Table 2.1: Hubs connected by Project, 2019-22

PROJECT NAME	Hubs connected (financial year)			
	2019/20	2020/21	2021/22	Total
Dumfries & Galloway Project		13	22	35
English Primary Schools Project	20	126	406	553
Full Fibre Northern Ireland RGC		14	193	207
Highlands (Phase 1) Project		33	4	37
Highlands (Phase 2) Project			0	10
NHS Scotland (Phase 1) Project		17	31	48
NHS Scotland (Phase 2) Project			36	36
Rest Of Wales Project			76	76
Shropshire, Telford & Wrekin Project		15	3	18
Other projects	1			1
Total	21	218	771	1021

There is a geographical dimension to some projects, such as the Highlands phased projects and Shropshire, Telford & Wrekin. However, by-and-large, the selection and delivery processes looked across regions, and then focused on particular types of Hubs. It is also noticeable that the connections made are relatively recent, with many occurring in the 2021/22 financial year.

Supplying Hub connections and then further residential/business connections

The connections were delivered through broadband providers, and the management information records the supplier for each Hub. This is summarised in Table 2.2.

The connection is generally provided by Openreach, responsible for 791 of the 1,021 Hub connections. This included 564 English schools, under the project led by DfE to connect primary schools in rural areas. In both Scotland and Wales, Openreach was the supplier for GP surgery Hubs, and in both cases the procurement was through extant framework contracts or other on-going supplier relationships with Openreach.

There were a mix of issues reported in delivering Hub connections. Most schools were generally happy with the application and installation process, recalling that most of the connection activity took place off-site. Issues included delays in connection. One interviewee stated that the "application process was very straightforward, but the connection process was very, very long winded caused by

delays due to infrastructure works". Another school highlighted how suppliers "got equipment in and running but it took a long time for Openreach to get the line in."

Hubs also observed that suppliers missed contracted timings, sometimes further exacerbated by poor communication about reasons for delay by the supplier. Also, issues arose about where new lines were routed within the school; in one connection, services lost to a neighbouring property appeared to be linked to the works. The individual observations of Hubs were confirmed by interviews at LA level, who also confirmed difficulties in timely delivery of broadband to the school.

Delivery of Hub investments were linked with the wider provision of online services in a Hub. Generally, schools have an ongoing supplier for broadband and their broadband service is managed by the school, often with the help of internal or consultant IT staff. The model for GP surgeries, libraries and emergency services for internet services can be more centralised, with the connection being part of a wider provision of online services handled by a body focusing on these services across a number of locations. Examples include the SG's Scottish Wide Area Network (SWAN) and the Wales Public Sector Broadband Aggregation (PSBA). These centralised providers deliver a range of IT services such as record management and provisioning of applications, as well as managing the broadband connection to the Hub. These are referred to as "aggregators" in this report. In these cases, interviews at Hubs would then consider broadband performance within a wider set of services provided by aggregators.

The aggregators would procure the delivery of connections through using their on-going contracts (called frameworks) with suppliers. An advantage to this was the ability to look across a portfolio of connected public buildings managed in the framework contract, helping to identify gaps due to remoteness from gigabit capability. For the delivery bodies and the central provider, issues around information flows and the enforcement of all contract conditions arose with their suppliers. This was partly due to the complexity of the contracting with different subcontractors, and partly due to wider delivery problems, such as communication issues between those developing the products, managing their delivery and those working onsite.

The gigabit-capable infrastructure at the Hub would allow supply to nearby premises. Whether the Hub connection was managed by the Hub or by aggregators, Table 2.2 indicates that Openreach is the main supplier of the infrastructure to the Hub, although they are constrained in leveraging further connections directly. This is due to there being obligations to allow a competitive environment in the deployment of fibre connectivity in a local area under competition policy. Building on the Hub's connection would then depend on other local suppliers to then deliver onward business and residential connections.

This in turn would rely on local suppliers and potential customers being aware that the Hub investments had been made. One route for this is that the Hub investments were made in the context of the routine delivery of telecom and broadband services to the Hub being by a local supplier, e.g. the provider of the telecom services for a school would be involved in various stages of the Hub connection though the infrastructure provision would be in the hands of Openreach.

Table 2.2: Hub connection by Supplier, 2019-22

SUPPLIER	Hubs connected (financial year)

	2019/20	2020/21	2021/22	Total
B4RN		3	3	6
B4SH		1		1
BT Openreach	14	191	580	785
Fibrus Networks Ltd		14	193	207
Redcentric/BT Openreach		2	3	5
Solway Communications Ltd		2	1	3
Wessex Internet	7	3		10
Wispire Ltd		2	1	3
Total	21	218	781	1,020

In some parts of the country, fibre networks are being created by organisations outside of Openreach. In Northern Ireland, Fibrus Networks has connected 207 Hubs, and is also a prominent digital infrastructure owner in rural and regional areas of the UK. Other smaller suppliers include Wispire, Wessex Intranet and around half a dozen further companies that supplied Hub connections.

Some local suppliers that are providing the Hub connections are not-for-profit. B4RN (Broadband for the Rural North) is a community-led provider that has built its own fibre-optic network to connect rural communities in Lancashire, Cumbria, and other parts of the UK, and has connected six Hubs in Cumbria/Lancashire. Similarly, community organisation B4SH (Broadband for South Hampshire) delivered a further Hub in the South Hampshire area.

Further stakeholders in the supply of gigabit connectivity in the areas around the Hub are suppliers of phone and broadband services to businesses and residences. The study made use of the voucher beneficiaries database to identify the suppliers in areas where Hub investments had been made. Suppliers providing connections using Gigabit Vouchers included Call Flow, covering thousands of homes and businesses in Kent, East Sussex, Hampshire & Berkshire; Airband Community Internet, connecting businesses and residences in Shropshire and accessing over 200 vouchers near Hubs; and KCOM, providing voucher enabled connections including in East Riding.

Stakeholder perspective on scoping, marketing, and delivering the Hub product

Qualitative evidence was gathered through interviews with stakeholders involved in delivering the Hub product. For the study, ten interviews covered policy leads in local areas, suppliers of Hub connections and the suppliers of gigabit residential and business service in the areas near the Hubs.

Discussions with DfE and the devolved administrations explored the effects of the Hub product on schools, highlighting that the aim of Hub investments was to equalise broadband performance in schools, and to attain standards of connectivity in remote areas comparable to the best, usually urban, areas. Paralleling this was a desire to avoid blocking the development of policies reliant on connections, such as widespread use of educational technologies (EdTech) or use of online

assessments: education departments would be reluctant to pursue these if remote schools were left out.

This was mirrored at local authority level, identifying a need to raise the connectivity of the most remote schools so that a relatively equal provision of educational services using digital services was possible. Good broadband access was seen as enabling the schools to then adopt further EdTech and a poor connection meant schools would be left behind.

Schools targeted for investments reported very poor internet speed (some with dial up connection levels) prior to the programme. Steps to maximise broadband performance in school sites had reached the limit given the connection levels in the local area. One respondent noted that the school had no plans to upgrade the broadband and viewed the Hub investment as meeting a significant gap: "It's fantastic, something we would have dreamt of, but never would have thought we could afford to do". The Hubs product was viewed as too good an opportunity to turn down, in terms of funding gigabit connectivity infrastructure in the school:

> *"Given the opportunity of 'we will pay for a new line, but you have to pay for line charges', we were going to grab that 100%."*

To select sites (beyond schools), sponsors identified an initial long-list and then found that, having engaged with suppliers, the investment for sites was not needed as gigabit capability would become available in the area as part of the wider programmes of Openreach and other network owners. The lists were also affected by the changes in the ways of working caused by the Covid pandemic. Estate strategies were reviewed in local and national government in the light of increased working from home and, in a few cases, the need to upgrade a public building lessened due to this.

Interviews with suppliers looked at how they had heard about the Hubs scheme. This was through different routes, such as involvement in other BDUK programmes, particularly the vouchers schemes. One said they had been involved in one of the first Hub projects delivered as part of the earlier BDUK Local Full Fibre Network (LFFN) programme (not covered in this evaluation), so their involvement in the RGC Hubs initiative followed on from that. Suppliers were primarily motivated by helping the public building, usually schools, with which they already had a strong relationship, but they were also attracted to the scheme as it offered another route to get fibre into rural and deep-rural communities in the areas that they serve. It provided a platform for further onward build into these communities (in both interviewee cases with the support of vouchers).

Suppliers reported that, having heard about the Hub product through the school, they then helped the schools to apply for the funding. Their view was that the scheme should have been promoted more widely with suppliers themselves, rather than relying on the Hubs. Then suppliers could have contacted the schools in their area to see if they would be interested in applying for the funding.

A key policy aim for Hubs was that this would provide a basis for further connections in the local area, as gigabit capable connections were brought closer to businesses and residential properties near the Hubs. Generally, this was viewed as possible, but a concern was that Openreach were the main providers of the connection, and, in some areas, the local suppliers were focused on developing their own network infrastructure. To use the Hub connection may then incur access charges at a point in their networks where they may have preferred to be using owned infrastructure.

Interviewees were also asked what could have been done to increase their involvement in the Hubs programme. Direct approaches to suppliers earlier, with them then able to market to the public sector customers was viewed as important, with clarity about the way to apply. Suppliers contrasted that the subsidy available through vouchers is very clear which makes it easy to assess viability, but

they had no indication of the maximum subsidy available for Hubs or of the range of subsidies that had been awarded on other projects.

The suppliers who heard about the scheme through BDUK said they would not have considered increasing their involvement in the Hubs programme. They had connected all the schools in their area who were interested in applying, and where there was a commercial case, with the resources available to them. Further, there was a view that connecting some Hubs involves a lot of resources but deliver relatively few additional premises, and that this distracts the supplier from their other planned rollout activities.

Chapter 4 in this report describes a survey of voucher beneficiaries conducted for the study focusing on properties within 5km of a Hub. Generally, awareness about the Hub investments in their area was low.

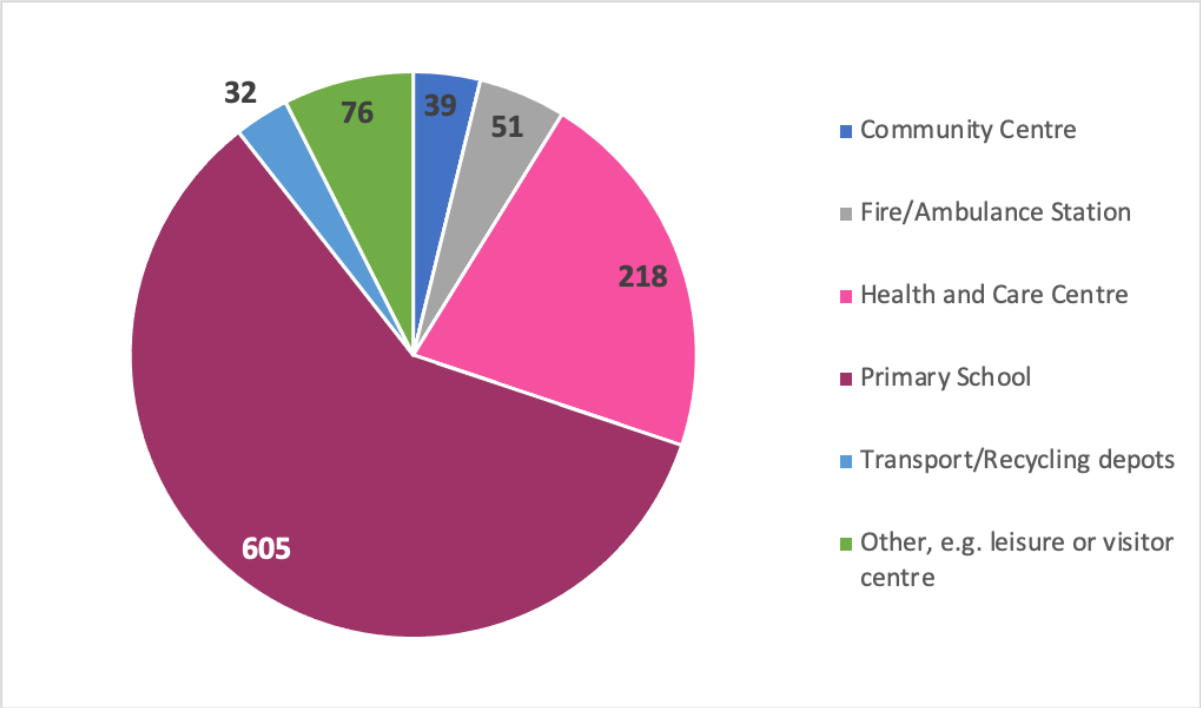
The survey responses could be contrasted with a survey of voucher beneficiaries not near to Hubs. Residents close to a Hub – when responding to a survey question about how they became aware of the voucher product – were more likely to have heard about the voucher through a local community initiative, and it was less likely to be through a broadband supplier, compared to residents in the wider sample of voucher beneficiaries. Being part of a community initiative appears to be a key motivation for many residents (45%) close to a Hub in terms of upgrading their internet.

The evidence also suggests that fewer residents close to a Hub had specific motivations for upgrading, such as accessing a reliable line (40% compared to 52% of the comparison sample), accessing faster download speeds (80% compared to 74%) and upload speeds (48% compared to 40%). Fewer residents close to a Hub wanted to use the upgrade for education (15% compared to 21%) or working from home (48% compared to 54%). Instead, more residents close to a Hub (8%) said they were happy with the connection they had at the time (compared to 5% in the comparison sample), albeit still a minority of the sample overall.

RGC Hub Product Delivery

This section provides an overview of the delivery of Hubs through the RGC programme. The focus is 1,021 Hubs that are spread across the four nations and represent a variety of public buildings. Figure 2.2 indicates how primary schools predominate with 605 investments, then GP surgeries with 218. The next sections characterise the areas that have benefitted from Hub investment, first at a lower super output area level and then drills into the postcode level information available about the Hubs.

Figure 2.2: Types of Public Buildings supported



Areas benefiting from Hub investments

Table 2.3 presents the summary statistics for the BDUK Hubs Evaluation. The level of analysis is at the Lower Super Output Area (LSOA). The "LSOA with Hubs" column characterises the 873 LSOAs with at least one Hub. LSOAs are the geographical units that underpin official statistics such as the Censuses. There are over 42,000 LSOAs in the UK and each has about a thousand properties, large enough to provide useful statistics but small enough to represent some of the geographical differences of local areas,

The table presents descriptive statistics for these LSOAs. The final column is a simple comparator of what occurs as the more rural LSOAs are considered. By removing all the London LSOAs, many large urban areas remain in the data, but this highlights what happens to the variables in the table as the coverage focuses more on the rural, recognising that the Hubs support has targeted such areas.

Data about the vouchers used to connect business and residential premises have been aggregated by LSOAs and then those with a Hub have been identified. Table 2.3 indicates that expenditure on vouchers in the Hub areas is higher than that in other LSOAs, at around three times greater.

This could be correlated with the relatively high level of costs for connections in the Hub areas. BDUK have modelled the cost of connecting premises to broadband using estimates of the distance of build needed to connect individual properties, called the F20 model. The model is used to identify areas that fall within the 20% hardest to reach locations for broadband connectivity. The areas with Hubs are characterised by having higher values of F20 compared to the samples of All LSOAs and all LSOAs excluding London. This reflects the rurality of the Hubs areas. They tend to be classified as rural more often, and they have low population densities. In terms of the demographic variables, the population density is around 10 times larger in the UK excluding London compared to the treated.

Table 2.3: Characterising the Hubs at LSOA level

Variable	Summaries for RGC Hubs		
Total Hubs spending	£28.1m		
Spending per Hub	£27,790		
Number of Hubs	1,021		
	LSOAs with Hubs	UK	UK excl London
Number of LSOAs	873	42,617	37,782
Total number of vouchers	8,694	71,054	66,904
F20 (mean)	0.83	0.51	0.55
Rurality (mean)	0.96	0.18	0.21
Population density 2020 (mean)	331	4421	3432
Total employment 2020 (mean)	685	794	746
Index of Multiple Deprivation income (decile)	6.88	5.50	5.59
Internet User Classification 2018	6.19	6.07	6.26
Number of premises (mean)	887	809	794

Source: Belmana with data from DCMS and ONS

Nevertheless, the average total employment is more homogeneous for the three samples. The index of multiple deprivation income (decile) is greater for the Hub areas showing they are more deprived areas. The Internet User Classification – measuring how people living in different parts of Great Britain interact with the Internet – and average number of premises seems to be similar for the three samples.

Table 2.4 summarises the broadband performance and coverage variables for these three types of LSOA. In general, the broadband coverage and performance is considerably lower in the Hubs LSOA compared to all the UK and all the UK excluding London.

Table 2.4: Indicators of broadband availability and speed 2020-21

Variable	Area covered		
	LSOAs with Hubs	UK	UK excl London
Gigabit availability 2020 (% premises)	11.90	27.70	28.90
Gigabit availability 2021 (% premises)	20.83	46.59	42.33
UFBB availability 2020 (% premises)	13.09	58.57	56.09
UFBB availability 2021 (% premises)	21.88	63.91	61.69
Average download speed 2020 (Mbps)	42.58	72.46	71.70
Average download speed 2021 (Mbps)	51.19	85.72	84.05

Source: Belmana with data from BDUK and Connected Nations

While the table provides a relatively well understood measure of broadband performance, the download speed measured in megabits per second, the table focuses on two classifications used in the main statistics in Connected Nations to understand coverage quantifying the share of properties that could access defined speeds. Gigabit type of broadband performance means one gbps and above of download speed is available, being an aim of the Hubs policies. The other category in Table 2.4, Ultrafast provides at least 300Mbps. The marked weaker coverage of the Hub LSOAs is expected, with the poor level of connectivity being a key criterion for the Hub product to be offered.

The average download speeds then focus on the extent to which premises that have a technology available then translates into adopting the available service level. Uptake of the fastest broadband connection available may not always follow directly from the premises being close to fast broadband. It can take time, with consumers waiting for contract endpoints, and it will reflect the use and needs of those living or working in an area. However, Table 2.4 indicates a consistency in uptake across the different areas, with speeds rising at similar rates in the three categories of areas as coverage improves.

Broadband Performance and Coverage in Hub Postcodes

The LSOA analysis highlights how the Hubs are in relatively rural areas, outside the major conurbations and with relatively low levels of gigabit connectivity and broadband speed. In such areas, the LSOA geography is not granular, with the areas being large especially in terms of broadband infrastructure costs. This section introduces the statistics about broad performance and coverage used throughout the report, Ofcom's Connected Nations, using the evidence at the most detailed level, individual postcodes. These cover about 20 properties on average.

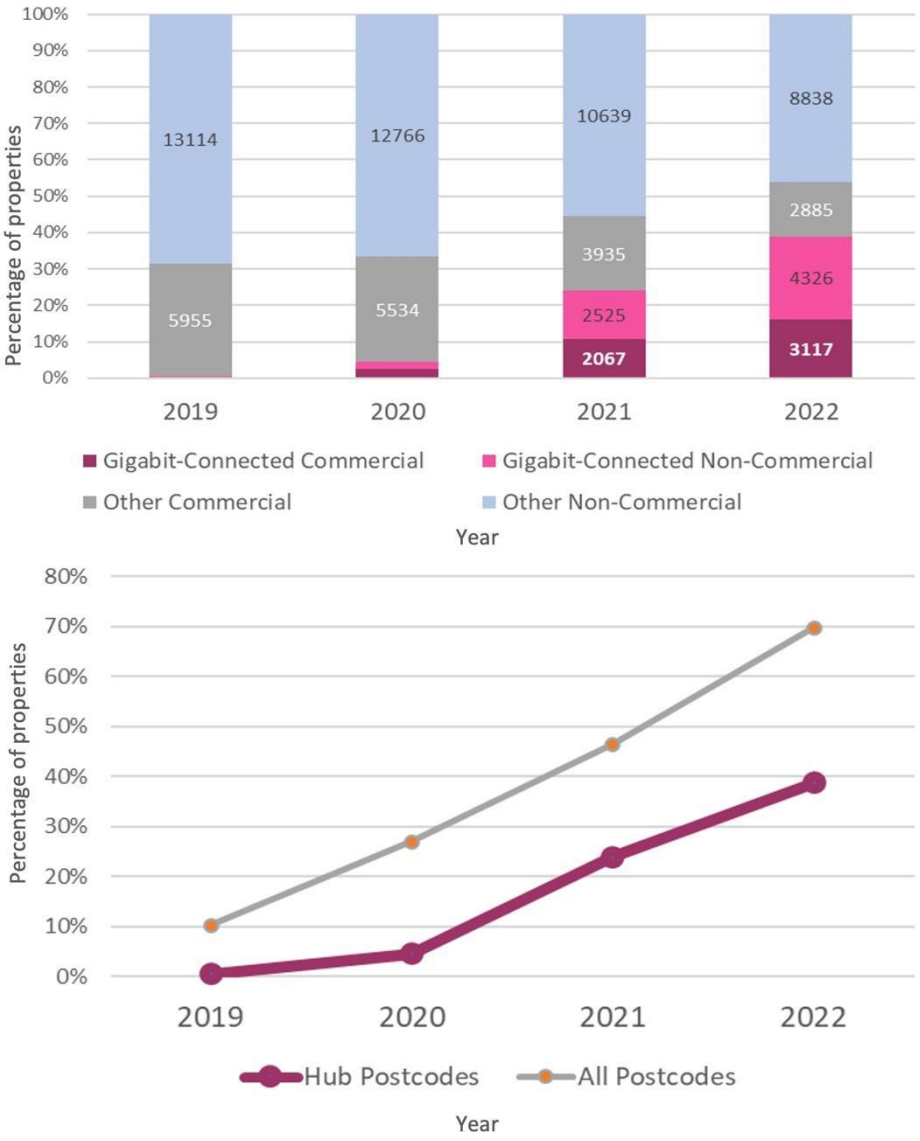
There are about 19,000 properties in the 997 postcodes where at least one Hub connection has been provided. Each postcode has been characterised in terms of the difficulty of connecting the properties and then categorised as commercial or non-commercial. The former category means cost of connection of the properties in the postcode is modelled as costing less than an amount that could be provided on a commercial basis. The modelling underpinning this assessment would not

take account of the Hub investment and so measures the access available without considering that the Hub would have brought gigabit connectivity closer to the premises in the postcodes.

Figure 2.3 shows the penetration of gigabit-capable coverage in these properties. In 2019, with no properties having this available, the scale of the remoteness of the Hub areas can be seen. Two thirds of the properties are not categorised as being in postcodes that could be connected on a commercial basis. There are 13,114 that have connections that are not gigabit enabled and, too small to be seen in the figure, a further 50 that did have access to that level of broadband.

The figure then indicates how the availability of gigabit speeds increases over time. By 2022, properties that can access gigabit broadband has increased to almost 7,500 properties with more than half (4,326) in postcodes that are not deemed likely to be connected on commercial terms and 3,117 premises that could receive gigabit on a commercial basis. By 2022, however, while the split of premises with gigabit available is even, over 80% of the properties that do not have access to gigabit broadband are in the non-commercial category.

Figure 2.3: Availability of Gigabit in Hub Postcodes

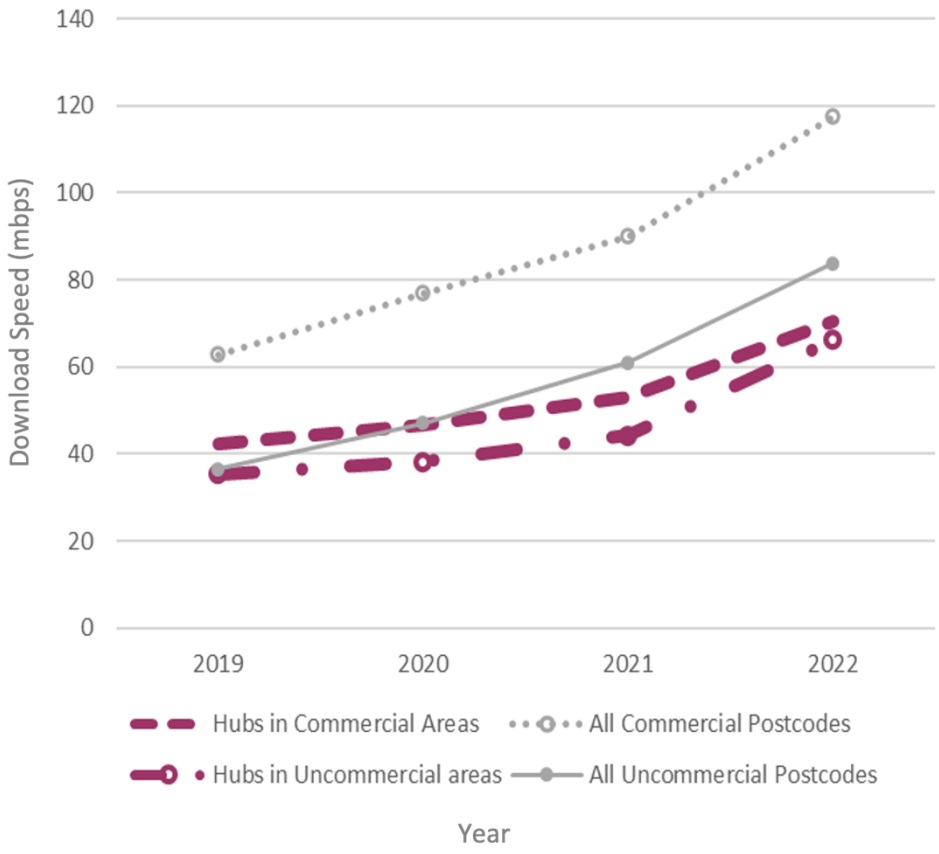


Source: Analysis of BDUK data linked to Connected Nations

The figure compares the share of postcodes which are gigabit capable in all Hub postcodes with all postcodes in the UK. The Hub areas start from a very low base and then rise at levels similar to the UK. However, the initial gap in coverage persists despite the growth in coverage,

The availability of gigabit speeds of broadband will be taken up by residential and businesses and then this should result in measured changes in the download speeds at postcode level. Figure 2.4 plots this for the Hub postcode areas in the thick plum lines. The lowest of the two lines – for the postcodes where modelling suggests that provision cannot be made on a commercial basis – can be contrasted to the wider picture about uptake in non-commercial areas. It indicates download speed rises are lower, but the growth in 2021/22 seems to pick up which is around the times Hubs were connected. Further, while the commercial Hub postcodes have higher download speeds than the non-commercial Hub postcodes, the speeds are far lower than other commercial areas in the UK.

Figure 2.4: Download speeds in Hub Postcodes



Source: Analysis of BDUK linked to Connected Nations

These results correlate with the Hubs product targeting the hard-to-reach areas. They indicate that the Hubs are in postcodes categorised as non-commercial. Further, even in the areas that are commercial, download speeds are lower than the average for such areas, suggesting that they are likely to be closer to the non-commercial/commercial border.

Conclusions

This chapter looks at the Hubs product, focusing on the Rural Gigabit Connectivity delivery that occurred from 2019-22. It highlights:

- **Hub investments until 2022**. Delivered through the RGC Programme from May 2019 with completed builds up to March 2022, these have provided 1,021 connections in eligible public buildings, primarily schools and GP surgeries.
- **Selecting eligible buildings has focused on areas distant from the gigabit capable network.** Public buildings were identified through ten projects led by partner bodies such as local authorities, DfE, devolved administrations, that have prioritised public buildings poorly served by broadband. This worked well by integrating wider plans of suppliers, managers of public buildings, and Openreach.
- **The connection is generally provided by Openreach.** It is responsible for 791 of the 1,021 Hub connections. There are then some community-based or regional suppliers (such as Fibrus Networks in Northern Ireland).

- **Suppliers were attracted by the Hub product.** It delivered fibre connectivity to rural and deep rural areas and provided a platform for further connections. But they felt that marketing of the Hub investments could be improved by contacting suppliers earlier. Also, the detail of the level of potential funding, timings for applications etc were unclear.
- **Delivery is linked to the wider provision of online services in a Hub.** This can be managed through an aggregator (common for GP surgeries). Some Hubs experienced delays in delivery and noted information about progress was sometimes limited.
- **The logic model envisages spatial effects beyond the supported areas.** The anticipated direct benefits are to the public services delivered in the Hubs enabling more digital technology in schools, surgeries etc. But then these connections bring the gigabit-capable network closer to hard-to-reach areas. Suppliers are more likely to be able to meet local residential and business demand for fast broadband.
- **Areas supported have low broadband performance and coverage.** In 2020, 11.9% of premises in the supported areas have gigabit available, less than half the 27.7% seen in the UK. Download speeds are 42,6 Mbps compared to 72.5 in the wider UK.
- **Provision of gigabit capable connections is unlikely on a commercial basis.** There are about 19,000 properties in the 997 postcodes where at least one Hub connection has been provided, and in 2019 none had gigabit availability. By 2022, this has changed with 7,500 properties having gigabit availability, and this being split evenly between commercial and non-commercial premises. However, over 80% of the properties that do not have access to gigabit broadband are in the non-commercial category.

3. Effects of Hubs on Broadband

The Hub product aims to widen and improve broadband coverage in rural areas, alongside other policies targeting remote areas, such as recent voucher support. This chapter looks at the effects of the Hub on broadband. Its focus is whether nearby broadband effects occur and can be attributed to the Hub. To estimate the impact of the Hubs support, non-recipient areas who are as comparable as possible to the recipient areas – called the counterfactual – are explored seeing if the changes seen in the Hub areas differ.

Any differences can be attributed to the Hub product in a causal sense, but ensuring the quality of the counterfactual is key. Challenges in identifying a comparison group of areas include untangling the effects of Hubs from other support and wider broadband investments or dealing with the possibility that Hubs have been delivered in all remote public buildings, exhausting the potential comparable areas.

Key findings:

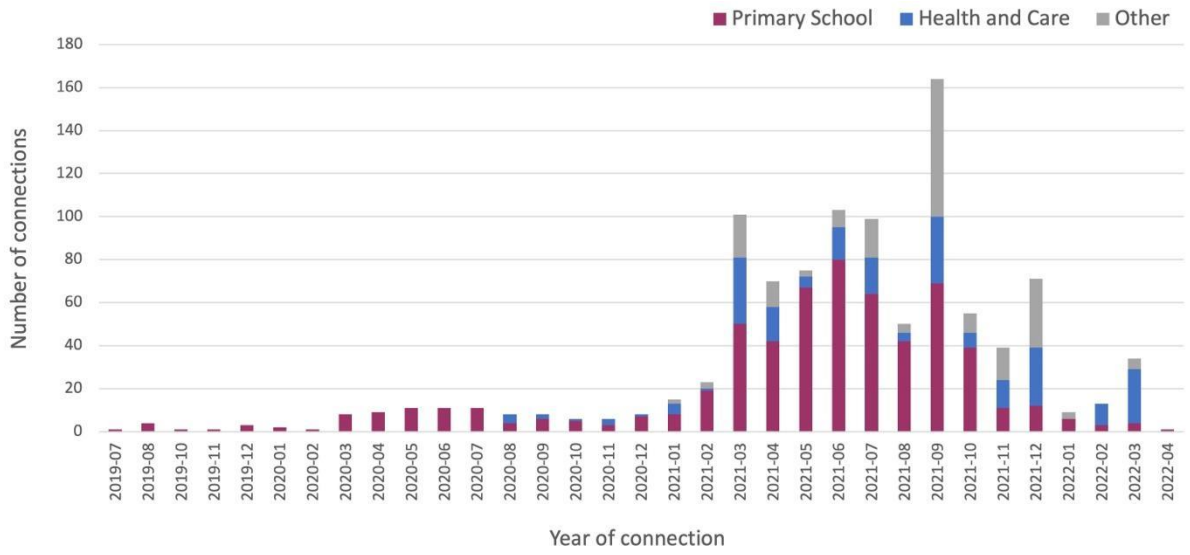
- Hubs are positively affecting availability of gigabit. There are 14.3 more premises passed by gigabit capability in the year after the Hub investment in supported areas and this is 7 more than in comparable OAs with schools. Gigabit availability is rising quicker than comparable OAs in the year after support, with around half (51.3%) of the 64% rise in the premises additional in the supported areas. Around a third of the 9.3 rise in premises connected to ultrafast broadband in supported OAs is additional.
- Postcode analysis finds broadband take up and performance improvements due to Hubs. Some part of the 28% improvement in speed of broadband in the postcodes that contain supported schools can be attributed to the Hub investment. The counterfactual postcodes include schools see broadband speed changes, but around 35.7% of the changes seen in Hub schools is not seen in these similar areas.
- At output area level, take up changes are positive but not significantly different to comparable areas. The use of vouchers, the change in broadband speed and the number of fast connections increases in supported areas but not at rates different from the counterfactual areas.

Product delivery and broadband in hard-to-reach areas

Figure 3.1 shows the progress of the Hub product over time as it has connected public buildings. It highlights the type of public building connected, which is mainly primary schools and health centres. The other category then covers a wide array of buildings, such as libraries, emergency services, community centres, and public buildings associated with tourism and culture.

The counterfactual impact evaluation approach often employs a before/after analysis and so timing when support occurs is crucial. The figure indicates the pick-up in connections in 2021, and much of the analysis focuses on this period.

Figure 3.1: Hub connections since 2019



Source: Analysis of BDUK

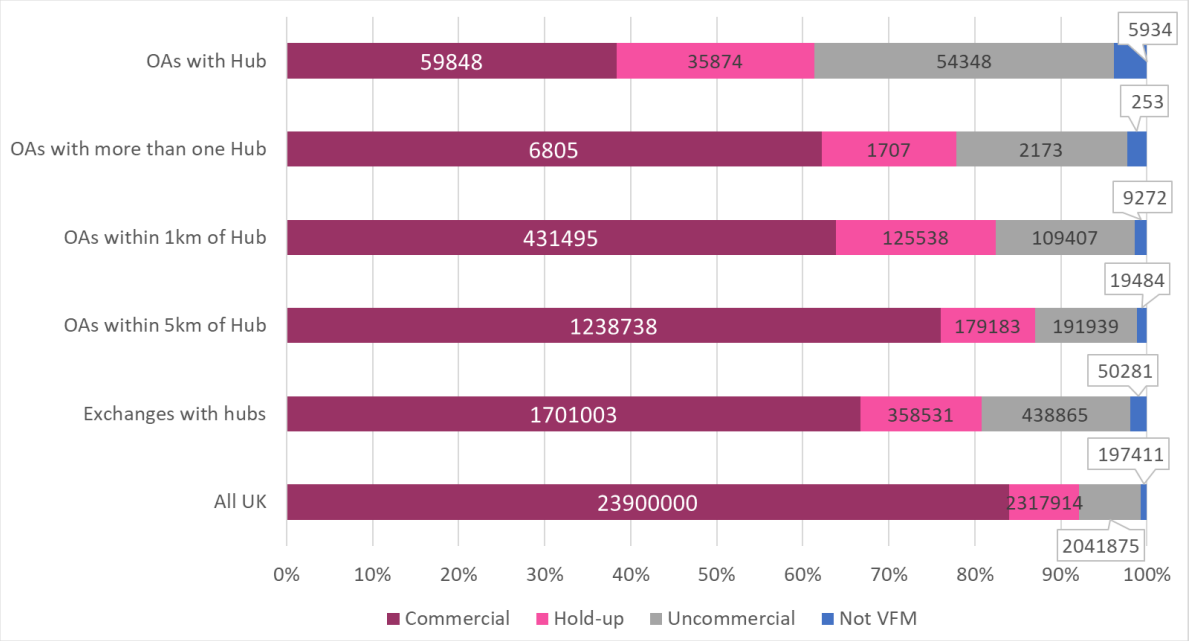
The regional spread of the Hubs correlates with the rural parts of the UK. Looking across the 1,088 Hubs, 595 are in England (59%), 216 in Northern Ireland (20%), 104 are in Wales (16%) and 173 in Scotland (16%)[4]. Around half of the UK's local authorities have at least one Hub, and there are none in London.

Furthermore, it is possible to analyse the access to broadband at a more granular, property level, which can reveal the connectivity levels in the areas where Hubs have been connected. The access to broadband for individual properties of the country has been categorised by Building Digital UK (BDUK) and Figure 3.2 shows the shares of properties that fall into the four categories. It looks at this in terms of the output area (OA), which splits the lower super output areas used in earlier analysis. This Census geography divides the UK into 10,036 OAs in Wales, 45,925 in Scotland, 4,363 in Northern Ireland and 171,316 in England. How easy it is to connect the properties in an OA is estimated by BDUK and then linked to which OA the property is in. This is used to place properties in terms of their proximity to a Hub.

The F20 modelling that BDUK uses to estimate the costs of connecting properties to the gigabit-capable network also categories properties by whether these costs could be expected to be met without subsidy, on a commercial basis. Across the UK, about 83% of properties are categorised as commercial, in that the provision of broadband should be on a commercial basis and the payments made by users of broadband would meet the cost of provision. These are properties where broadband performance is already likely to be high. Figure 3.2 highlights that the portion that could be connected on a commercial basis falls as the focus converges on Hub OAs, moving up the figure. Most marked is that the OAs with a Hub are largely not commercial.

[4] The figures stated in this report may not align with BDUK performance report due to differences in methodology.

Figure 3.2 Hubs and the provision of broadband on a commercial basis



The figure also introduces some of the geographic features that are used to determine comparable areas in the evaluation's econometric analysis that is presented later. There are around 5,600 telephone exchanges in the UK, and these define the local telecom networks. The output areas that are linked to the same exchange as a Hub have been identified using a BDUK model of this network. This then allows the property count to be estimated for this subset of areas. Exchanges cover quite large areas, and the figure highlights how exchanges serving Hubs have a higher share of properties that are not commercial.

The figure also indicates the shares for circles around the Hub OAs, showing that a 5km distance would include many commercial properties, proportionately more than the shared exchange. This indicates how the geography of telecom networks may be material when looking at the connectivity of properties near Hubs, and how the Hubs are in hard-to-reach parts of the network.

Broadband in the Hub Areas

To undertake the impact analysis and find comparable areas as a counterfactual, characterising the areas served by Hubs is important. The previous section indicates that Hubs are being connected in areas that are remote in terms of the broadband network. That provides a start to characterise where Hubs are being delivered, but there are also socioeconomic, broadband coverage/performance and public service delivery drivers for a Hub investment. This section looks at the data that has been compiled to explore the Hubs connections. Various datasets are linked at an output area (OA) level and the Box indicates these (details are in Annex A).

Table 3.1 presents some summary statistics about the output areas where Hubs are located. It also presents summary statistics for all areas and the Hub areas in England where there is a primary school. This latter sample of Hubs can be modelled separately from other Hubs as the location and

characteristics of unsupported schools is known, and these unsupported schools' OAs provides a pool from which the counterfactual can be selected.

The table indicates the rurality of where Hub investments were made. On a range of measures – rurality, population density, as well as broadband related measures such as distance of the OA to a telephone exchange – there is an indication that the Hubs are located in remote areas, Also marked is that there is a difference between the supported areas and the wider UK in socioeconomic aspects and so, later in the analysis, such variables are introduced into the determination of a counterfactual.

BOX 3.1: Datasets developed to undertake the impact analysis

For coverage and performance data, Ofcom publishes the Connected Nations reports on the UK's communications infrastructure. Ofcom Connected Nations (using 2018 to 2022) tracks the availability and performance of fixed broadband and mobile networks, and this is published at a detailed geographical level (postcodes and output areas) which can then be averaged or aggregated at the higher OA level. Variables derived include the download speed, the coverage of gigabit capable technologies and the number of properties.

BDUK provided a range of data for the study. The Hub intervention data related to the 1,021 Hubs supported by mid-2022. Data covered the name, address and type of site, the time of the investment and connection, as well as the funding provided and the supplier that connected the Hub. The Gigabit Broadband/RGC Vouchers Data covered the timing, supplier, value, and location of recent voucher support. 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) and the details of individual premises passed by the project. The commercial viability of UK locations is modelled by BDUK using the F20 Model estimating the cost to install fibre to each UK premise.

The modelling seeks to characterise areas. 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) and equivalent series for Scotland and Northern Ireland. A variable measuring employment in digital sectors was constructed. Other LSOA characteristics are derived from Census 2021: such as population density and the 2011 Rural Urban Classification. The estimates for Indices of Deprivation have also been integrated into modelling.

Many of the Hubs are primary schools. A public dataset provides the location and key characteristics of English primary schools. The variables used in the analysis focused on the number of pupils, and the proportion of students that were eligible for free school meals and support for special educational needs.

Table 3.1: Summary Statistics for output areas, 2019

	All OAs with a Hub	Hub OAs with a primary school	All OAs
	N=964	N=530	N=231,783
Proportion rural (%)	92.1	95.9	19.8
Pupils in school	n.a.	145.5	279.5
Proportion entitled to free school meal (%)	n.a.	13.3	18.0
Proportion receiving SEN support (%)	n.a.	2.7	7.0
Employment in LSOA	422	491	265
Population density LSOA	101	102	1774
Employment in digital businesses, 2019	54.3	62.0	49.5
Value of vouchers in OA (£ per OA)	£901	£1272	£120
Count of Vouchers	0.4	0.6	0.1
% premises Full Fibre available	12.2	14.0	41.4
Average download speed, 2021 (Mbps)	46.9	48.0	83.5
No of connections >=30 Mbps	76.2	87.4	81.4
% premises unable to receive 30 Mbps	14.6	15.4	4.0
% premises Ultra fast	13.0	15.0	61.1
Distance to exchange (km)	1.6	1.8	1.3
F20 Score	0.8	0.9	0.5

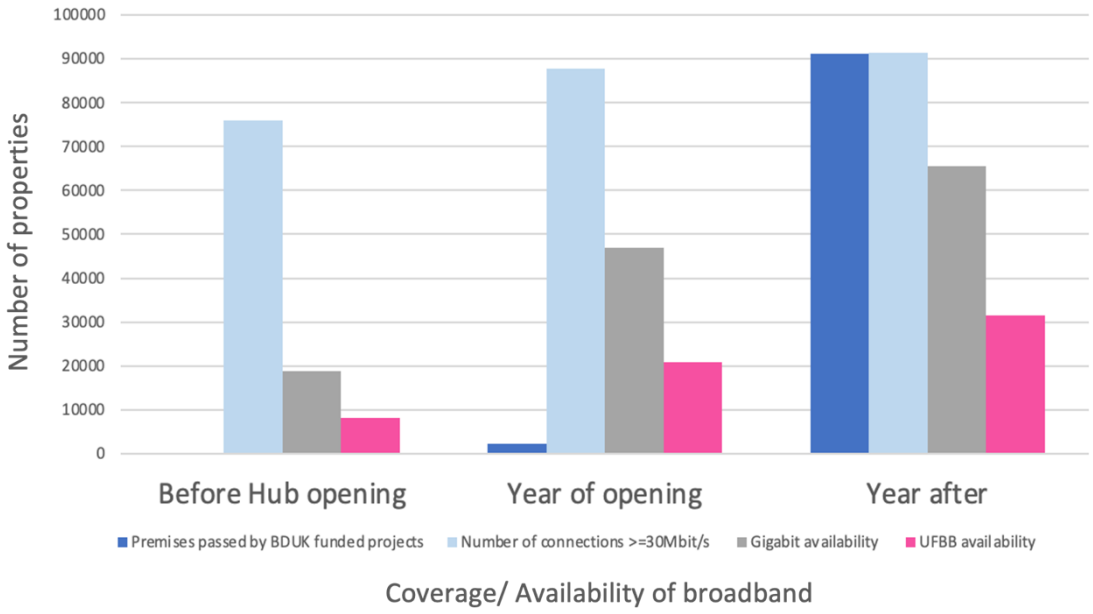
The compiled data provides the broadband coverage and performance – primarily from Connected Nations – for each output area in the UK. After linking in the location of Hub investments, it is possible to track the changes seen in the 964 supported output areas (i.e. where a Hub has been connected) especially focusing on the year after support where sample sizes are sufficient to understand overall changes seen in the recent, post-Hub years.

Figure 3.3 shows the number of properties in terms of the coverage/availability of broadband technologies. There are approximately 170,000 properties in the OAs where a Hub has opened and the figure indicates the number that could connect to UltraFast Broadband (UFBB) and Gigabit, centring the results on the year the Hub opens. These two measures both increase, with the faster Gigabit coverage rising from 11% of properties to 39% by the year after the Hub opening. UFBB – where speeds are at least 300Mbps – coverage rises from 5% to 19%. There is a rise in the number of properties achieving good levels of broadband speeds, achieving speeds of 30mbps or more.

The figure also indicates some of the effects of BDUK policies and how many premises are passed by BDUK funded projects that can enable connectivity for groups of properties. Voucher projects supported groups of premises to be connected. The purpose of such projects was to not just supply the beneficiaries but to do this in a way that enabled further connections.

The records provided by BDUK indicate a very substantial number of properties are passed by projects in the areas where Hubs have been connected. These are the premises that become connectable following the gigabit capable infrastructure passing the premises. This correlates with an increase in the numbers and value of vouchers that are secured in the Hub OAs, with around 1,000 vouchers in the year after support, rising from 250 in the year before Hub opening. There is a fourfold increase in the value of vouchers, reaching £2m in the year after Hub opening.

Figure 3.3 Broadband coverage and performance in Hub areas



A key question about these changes seen in the data is what is attributable to the Hubs policy. Attribution is primarily about broadband outcomes, such as whether improvements in coverage or performance in an area can be associated with the Hub opening. An approach is to compare the changes seen in supported areas with unsupported, comparable areas. Any changes not seen in the counterfactual can provide an insight about the effects of support.

BOX 3.2: Developing counterfactuals and tracking additional effects

To attribute effect, the most common quantitative approach is to construct a counterfactual, modelling what would have occurred without the support and then viewing any changes seen in the Hub area not seen in the comparable ones as due to the investment.

The first stage is to define the support, with the Hub product providing fast broadband to a single property. Its direct effect on the network is necessarily quite limited, and of a different magnitude to interventions such as the vouchers where hundreds of thousands of properties are directly connected through the supplier. The pathways by which the further indirect effects may then materialise would be at an area level, with the area defined as being close to the Hub and so most likely to be able to extend on the connection provided to the public building.

In the modelling to find comparable output areas, this geographical/network effect is articulated in defining the treated area, firstly looking at the postcode and output area where a Hub has been connected, and then widening this to consider output areas within a kilometre of the hub as supported. This was a simple proxy to check for wider effects beyond the public building.

A second strand to the selection modelling has been to reduce the pool from which the counterfactuals are chosen. Analysis starts from all output areas but then restricts the comparator to proximate areas, either in terms of being geographically close (in a circle 4-5km from a Hub) or in the telecom network sense, in sharing a telephone exchange with a Hub. Proximate areas can act as a good comparator because they will share many of the technical and socioeconomic characteristics of the supported areas, and therefore be more comparable. Where restricting selection to a defined pool of areas has been most effectively used is the modelling focusing only on drawing comparators from areas where there are schools. The selection modelling only drew the counterfactual from output areas known to have a primary school. Matching then included variables about the schools.

Propensity score matching was used to model selection for the Hub support. This is a statistical technique that establishes the features of a typical supported Hub area, allocates a score to it and then finds unsupported areas with similar scores because they have similar characteristics. A series of models were estimated from which analysis is drawn. There were five different sets of variables used in the selection models and these were applied to different pools of unsupported areas. The annex provides details, but models are broadly similar having rurality, socioeconomic characteristics and measures of the broadband infrastructure. The five alternatives then added in broadband performance variables, such as the speed of broadband before the Hub investment and whether an area received voucher support before Hub investment. The modelling that restricted to areas with a primary school included the number of pupils, the share of pupils eligible for free school meals and the share that did not have English as their first language were used.

Where selection modelling is considered robust, a difference-in-difference approach was used. It explored whether the growth seen in supported areas and the control group (the first difference) differs significantly in the two groups (the second difference). Any significant difference was an estimate of the additional effects of the support.

Broadband uptake effects in Hub supported areas

The effects that can be seen in Hub areas were compared with output areas that were statistically matched as a counterfactual. The Box 3.2 indicates the approach taken, propensity score matching

to identify comparable areas and difference-in-difference to see if they perform differently. This section summarises the results of modelling the additional effects on the uptake of broadband in the Hub areas looking at what happens after support and comparing this to what is seen in the counterfactual.

Effects on broadband uptake in supported areas with schools

A first set of models focused on schools in England, matching supported output areas to comparable areas that have schools and are in England. Three separate selection models were created with different variables to assess what drives a school to receive the funding. Each of these three models were applied to three different groups of English schools (a group with all schools in the evaluation, only schools in areas with the same telephone exchange as a Hub and those between four and five kilometres from a Hub). This provides nine different models.

Table 3.2 summarises results about the effect of support, focusing on the outcomes related to broadband uptake. It firstly shows the changes seen at the supported output areas, so that the gross change means that 0.51 more vouchers were provided to properties in the Hub areas after support. The changes are measured from the baseline of the year before support to the year after. One-year changes are the focus because the Hubs opened relatively recently limiting the number of years observed.

The table then summarises the nine counterfactuals. Each would provide an estimate of changes seen in comparable but unsupported output areas. The table indicates how many of the nine models estimate significantly different changes for the supported areas relative to the counterfactuals, and then tabulates the results of the median for the effect across the nine models.

The table indicates an increase in the number of vouchers that are provided to businesses and residences in the 528 output areas in England where school Hubs have been connected. While this increase is not seen in the comparators, the differences are insignificant in all the models. The monetary value of the vouchers also is not changing in a manner that differs from comparable areas. Both these measures of uptake of broadband connections are growing in the period from before support, so there are more gigabit capable connections occurring. However, analysis suggests the changes are no different with what might have been expected anyway, and without the Hub.

Arguably, this could show the matching has worked. The supported areas are similar to comparators in being as likely to be beneficiaries of voucher support. This may mean they are as likely to benefit from the Gigabit Connectivity Voucher Scheme as the areas with Hubs, making them suitable as a comparator. An alternative way to look at this is that, had the areas benefited from proportionally more vouchers, then any effects may be attributed to this rather than the Hub.

Table 3.2: Broadband uptake effects of Hub school support

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	528 OAs in treated and matched, 463 when pool is same exchange				
Number of vouchers in OA	0.51	0 out of 9	0.15	0.00 to 0.35	28.6%
Value of vouchers in OA (£)	1093.99	0 out of 9	348.31	191.1 to 781.0	31.8%

Number of connections >=30Mbps (number of lines)	8.56	0 out of 9	0.15	-0.41 to 0.33	1.8%
Average download speed (Mbps, logged)	0.22	1 out of 9	0.01	-0.03 to 0.05***	5.4%

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

Other measures of broadband uptake are also not showing the supported areas outperforming comparable areas. Additional growth is not seen in the number of fast connections or the speed of average download. In both measures of broadband performance, there is growth in the Hub areas, but the period has generally seen speeds rise across all of the UK and – even in the comparable areas – that growth is similar to the Hub areas.

Effects on broadband uptake in all Hub areas

Table 3.3 widens the pool of OAs from which the counterfactual is drawn. It firstly considers more than just school Hubs in England so that there are 949 OAs in this analysis. It then also includes all UK OAs in three of the models, with the other models then selecting only from the OAs with the same telephone exchange as a Hub and the OAs that are in the area 4-5km from a Hub.

Table 3.3: Broadband uptake effects of all Hub support

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	949 OAs in treated and matched				
Number of vouchers in OA	0.34	0 out of 9	0.11	-0.15 to 0.24	33.2%
Value of vouchers in OA (£)	594.16	0 out of 9	32.73	-349.76 to 328.37	5.5%
Number of connections >=30Mbps (number of lines)	7.30	3 out of 9	0.54	0.22 to 0.95**	7.4%
Average download speed (Mbps, logged)	0.22	0 out of 9	0.00	-0.02 to 0.01	-1.9%

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

The results for the additional effects of the Hubs are similar to those seen for school Hubs. The changes seen in the supported areas are generally positive in gross terms: there are a greater number of fast broadband connections, download speeds increase and the uptake of voucher connections increases. However, the pace of changes seen is no different to comparable areas, with only three estimates for the additional number of fast connections providing evidence of additional effects.

Effects on broadband uptake in postcodes with supported schools

Table 3.4 focuses on the postcodes of the supported schools and the counterfactuals. A challenge for the direct effect of the Hub investment on an area is that it is likely to be modest as only one premise is supported in improving their connection. Analysis at the output area level covers many

premises. In other support measures, such as broadband vouchers, the number of properties that are connected to gigabit capable connections is generally high at OA level. However, only one or sometimes two Hubs are connected in an OA, so the gross direct changes in the Hub areas can be lost in the OA-level area analysis.

In the modelling focusing on schools, the postcode for the Hub and that of the school in each of the counterfactual OA can be extracted and then linked to the postcode level data in Connected Nations. This then makes detection of effects a little easier as postcodes cover a dozen or so properties of which one is the Hub. The table presents the difference-in-difference estimates focusing on the postcode level data about the 538 supported Hubs. Matching has still used OA level modelling, but the school postcodes for counterfactuals can be identified using the school data.

Table 3.4: Broadband uptake effects at postcode level

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	528 postcodes in treated and matched				
Average download speed (Mbps, logged)	0.28	6 out of 9	0.10*	0.06 to 0.2***	35.7%

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

Download speed is the focus here and the 28% growth in speeds seen is significantly higher than the counterfactual in six of the models. The median model suggests that the difference is about 10%, so that 35.7% of the growth seen in the supported Hub postcode's speed improvement is additional and not observed in comparable school postcodes. The results are only significant at 10% for this median model, but the focusing on postcodes suggests that the properties nearest the supported Hub are taking up the connectivity. As the counterfactual postcodes are also schools, the Hub investment can be seen to have caused these local areas to have a higher take up rate than would have occurred anyway.

Using postcode level data focuses on a relatively small number of properties, of which one will be the school Hub. A further conclusion that can be drawn from this analysis is that some, and possibly most, of the 28% improvement in speed of broadband is in the supported school, and this can be attributed to the Hub investment. There is evidence of the changes in school broadband speed being additional and due to the Hub investment. The counterfactual are postcodes that include schools that also see broadband speed changes, but around 35.7% of the changes seen in Hub schools is not seen in these similar schools.

Broadband availability effects in Hub supported areas

The taking up of a faster broadband connection covered in the last section is predicated on the availability of gigabit connectivity in an area. Connected Nations tracks the number and share of properties that can be connected to different technologies and this section looks at whether Hub areas see changes in this and whether any changes are additional. The analysis uses the same matched counterfactuals as the analysis of broadband take up.

Broadband availability in the Hub OAs and the surrounding areas

Table 3.5 estimates the difference-in-difference for five measures of broadband availability focusing on the effect at OA level of support provided to schools in England. Modelling involves three selection models applied to all OAs with schools in England, those with schools but also sharing a telephone exchange with a Hub and the OAs with schools that are 4-5km from a Hub.

The findings on availability are:

- There are 14.3 more premises passed in the year after the Hub investment in supported OAs and this is 7 more than in comparable OAs with schools. The Hub investment is associated with significantly higher premises passed, properties that can be connected at no additional subsidy.
- Gigabit availability is rising quicker than comparable OAs in the year after support, with around half (51.3%) of the 64% rise in the premises additional in the supported areas.
- Around a third of the 9.3 rise in premises connected to ultrafast broadband in supported OAs is additional.

Table 3.5: Availability effects of Hub school support

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	528 OAs in treated and matched, 463 when pool is same exchange				
Premises passed by BDUK funded projects	14.28	8 out of 9	7.08***	2.67 to 9.19***	49.6%
Gigabit availability (% premises)	10.83	3 out of 9	2.21	1.01 to 2.80**	20.4%
Gigabit availability (% premises, logged)	0.64	7 out of 9	0.33***	0.12 to 0.53***	51.3%
UFBB availability (% premises)	9.23	7 out of 9	2.99**	1.58 to 4.26***	32.3%
% of premises unable to receive 30Mbps	-1.51	1 out of 9	0.17	-0.34 to 0.90	-11.5%

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

Table 3.6 looks at OAs beyond schools in England. There is a similarity in the results, in terms of the outcomes proving to be significantly different to the counterfactual, with additional growth seen in premises passed and gigabit availability logged growth. The gross changes seen in premises passed is much higher in size, though the additional growth is similar to the OAs in England with schools.

There is a difference in which of the two measures of access to fast broadband indicates additional effects. The changes seen are similar in sign, with both indicates improving faster in the supported areas than in the control areas. Whereas at school level, the access to UFBB measure rises significantly in most models and the share of properties that are unable to access fast broadband falls is not significant (in Table 3.5), this is reversed when looking across all supported OAs. The decline in premises unable to receive fast broadband – at 2.2% - is significantly different to that seen in comparable areas that fall at about 0.8% faster rate.

Table 3.6: Availability effects of all Hub support

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	949 OAs in treated and matched				
Premises passed by BDUK funded projects	92.23	3 out of 9	15.33***	-2.05 to 49.13	16.6%
Gigabit availability (% premises)	11.87	3 out of 9	-0.45	-2.88** to 0.32	-3.8%
Gigabit availability (% premises, logged)	0.62	9 out of 9	0.24***	0.15** to 0.31***	38.2%
UFBB availability (% premises)	10.99	1 out of 9	0.69	-0.73 to 1.98**	6.3%
% of premises unable to receive 30Mbps	-2.18	7 out of 9	0.81	0.67 to 1.29***	-37.1%

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

In the previous chapter, a postcode level analysis indicated the number of premises in Hub areas where gigabit capable connectivity was available. In 2019, the premises in the postcode areas had very little availability and there was growth seen in the subsequent years. Table 3.7 seeks to estimate what portion of that growth is additional.

This evidence models only the 528 school hubs in England, and then associates an unsupported school in a comparable output area, i.e. the selection modelling is at OA level. The analysis then focuses on the postcode where the schools are located, extracting the data about gigabit availability at that level. The growth in gigabit availability is 32% over the year after support, and this is 21% higher than that seen in the postcodes with similar schools.

Table 3.7: Broadband availability effects at postcode level

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	528 postcodes in treated and matched				
Gigabit availability (% premises, logged)	0.32	9 out of 9	0.21***	0.18** to 0.26***	64.3%

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

Like the result at postcode level of additional speed changes, this result is important in that it associates a change in the broadband network in the small area around the Hub support. To some extent, the availability of gigabit capable connectivity following the Hub investment is unsurprising, in that it reflects that the Hub connection brings gigabit closer to the premises nearest to the school. However, Table 3.7 highlights that this does not occur in comparable small areas that also have a school.

Conclusions

This chapter explores the main Hub and broadband datasets, such as the lists of Hubs supported and the Connected Nations statistics about small area broadband speed and coverage. The analysis links together datasets, including about the broadband infrastructure and public buildings, primarily schools, to help to identify areas that share the features of the Hubs. This data linking provides a range of counterfactuals and these are used to understand what, if any, effect of the Hubs on broadband can be determined quantitatively. The focus is on changes in availability of gigabit capable connectivity and on the uptake of this leading to faster average broadband speeds.

- **Hub support is across all parts of the UK.** Looking across the 1,088 Hubs, 595 are in England (59%), 216 in Northern Ireland (20%), 104 are in Wales (16%) and 173 in Scotland (16%). Around half of the UK's local authorities have at least one Hub, and there are none in London.
- **Counterfactual analysis has to identify unsupported remote areas.** On a range of measures – rurality, population density, as well as broadband related measures such as distance of the OA to a telephone exchange – Hubs are located in remote areas.
- **Counterfactuals have been drawn from various pools of areas.** A set of models were run matching all the supported output areas to comparable areas drawn from the UK, but insight was also found by restricting to areas that have schools and are in England. Data was compiled so that matching a counterfactual could take account of area characteristics, characteristics of the school and the fact an area had a school in it.
- **Hubs are positively affecting availability of gigabit.** There are 14.3 more premises passed by gigabit capability in the year after the Hub investment in supported areas and this is 7 more than in comparable OAs with schools. Gigabit availability is rising quicker than comparable OAs in the year after support, with around half (51.3%) of the 64% rise in the premises additional in the supported areas. Around a third of the 9.3 rise in premises connected to ultrafast broadband in supported OAs is additional.
- **Postcode analysis finds broadband take up and performance improvements due to Hubs.** Some part of the 28% improvement in speed of broadband in the postcodes that contain supported schools can be attributed to the Hub investment. The counterfactual postcodes include schools see broadband speed changes, but around 35.7% of the changes seen in Hub schools is not seen in these similar areas.
- **At output area level, take up changes are positive but not significantly different to comparable areas.** The use of vouchers, the change in broadband speed and the number of fast connections increases in supported areas but not at rates different from the counterfactual areas.

4. Surveying residences and businesses near Hubs

This section presents the results of a survey of voucher beneficiaries – comprising both residential and business beneficiaries – where the connection was near (within a 5km radius) to a Hub and where the respondent had been connected. The survey asked about internet use, the effects of the improved broadband connections, as well as exploring the respondent's knowledge or experience of the nearby Hub.

The analysis uses a set of questions that were asked recently in a large survey conducted to evaluate vouchers more generally, and results from that survey provide a subset of older voucher recipients to understand the potential effect of the Hubs in terms of a comparator. The research also involved further qualitative data gathering, interviewing individuals in more depth about their experience with broadband, the local Hub and the effects of the improved internet access.

Key findings:

- The residential survey encompassed 1,518 residents residing near a Hub and 1,356 residents in the comparison group. These groups shared comparable demographic characteristics, including age, employment, household size, and income. However, notable statistical variations emerged in household type, housing tenure, and occupation.
- The influence of community-level networks was evident in the voucher awareness, as residents close to a Hub were more likely to learn about it through local initiatives, emphasising their pivotal role in motivating internet upgrades.
- Both the Hubs sample and the comparison group exhibit comparable patterns of internet use, spanning personal, educational, and professional domains. While slight differences surface, with the Hubs sample showing slightly lower engagement in streaming entertainment and connecting with family/friends, residents residing near a Hub express lower contentment with their internet connection. Nevertheless, they report heightened life satisfaction due to the upgrade.
- Regarding the impact on businesses, the survey encompassed 219 respondents situated near a Hub, alongside 214 participants from a comparison group. Businesses in proximity to Hubs enjoyed a range of advantages, including expansion into new markets, adoption of innovative sales approaches, and the cultivation of fresh relationships. Notably, businesses reported elevated levels of satisfaction following the upgrade.

Surveying voucher beneficiaries

To understand the effects of investments into Hubs in local businesses and households, a survey was undertaken focusing on premises near the Hubs that benefited from a BDUK voucher in the recent period. Paralleling investments in Hubs, there has been a broadband voucher scheme run by BDUK seeking to encourage fast broadband connections targeting separately businesses and residential users. This provided contact details, and the survey sought to establish the impact of the Hubs.

The sample of voucher beneficiaries for the survey focused on the businesses and residences located within a 5km radius of a Hub and that had received a voucher between December 2021 and September 2022. A database of 7,964 voucher beneficiaries was developed, whose properties lay within the vicinity of 314 Hubs. The nearest Hub to the respondent ranged across the types of Hubs, but most of the sample was close to a primary school Hub.

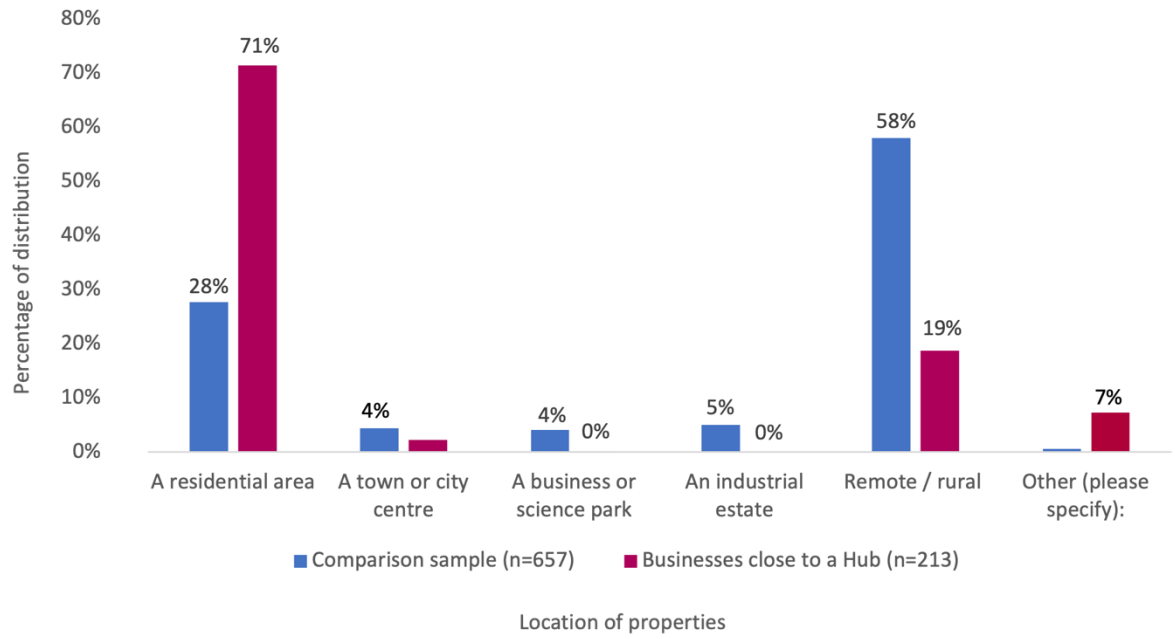
Two surveys were designed, one for businesses and one for residential users. In designing the survey, questions were replicated from a survey undertaken in 2021 for business vouchers and in early 2022 for residential vouchers, conducted for an evaluation of the GBVS. Also, a mixed method approach was used, comprising an online survey and follow up telephone interviews in some of the groups to boost the response rate.

Overall, there were 1,518 respondents to the residential survey of which 1,085 responses were from beneficiaries of a residential voucher and the beneficiary was a residential type. A further 453 business voucher beneficiaries responded using the residential survey. This was because – while they secured a business voucher – their connection was to their residence perhaps supporting a home business. There were 219 responses to the business survey, of which 19 were recipients of a residential voucher. In addition, 63 qualitative interviews were conducted following up on the online/phone survey where respondents were willing to be contacted. There were 33 residential in-depth interviews and 30 with those who had business vouchers. These were semi-structured, using an interview framework that allowed interviewees to expand and explain responses but covered some core topics.

Analysis has been conducted to identify statistically significant differences in responses between residents close to a Hub and residents in the wider voucher sample (comparison group). The residential beneficiaries of residential vouchers – of which there are 1,058 – were compared to 1,356 respondents from the residential survey of the Gigabit Vouchers Scheme evaluation. The comparison group for the business survey also used the earlier evaluation responses, using a sample of 214.

The demographic profile of the residents that live close to a Hub is broadly similar as the profile of residents in the comparison sample. No significant differences were found regarding age of respondent, employment status, household size and income. There were some statistically significant differences between the two groups regarding household type, housing tenure, and occupation. The voucher beneficiaries near to Hubs are less likely to be owner-occupiers and be in professional occupations. This may provide context for caveating responses to some aspects of broadband that are asked about in the survey, such as uses associated with working for home, where occupation and tenure may be a driver for behaviours.

Figure 4.1 Location of upgraded premises



Source: Survey of Business Voucher Beneficiaries Living Close to a Hub

The analysis found statistically significant differences between the businesses surveyed near the Hubs and the comparison survey. Figure 4.1 presents the location of the premises upgraded. A higher proportion of businesses close to a Hub (71%) are in a residential area, compared to 28% of businesses in the comparison group. In contrast there are lower proportions of businesses close to a Hub that are on a business or science park, an industrial estate or in a remote or rural area with no premises nearby compared to those in the comparison group. Finally, a higher proportion of businesses close to a Hub are less established, with 29% of these being between one and five years old, compared to 15% of businesses in the comparison group.

Effects reported by residential voucher beneficiaries

Residents were asked how often they use the internet, and in what ways they are making greater use of the internet, i.e. for personal, education or professional purposes. They were also asked about the importance of the upgraded connection in enabling them to make greater use of the internet. The Hubs survey also included a series of new questions which explore residents' awareness and use of the Hub in their vicinity.

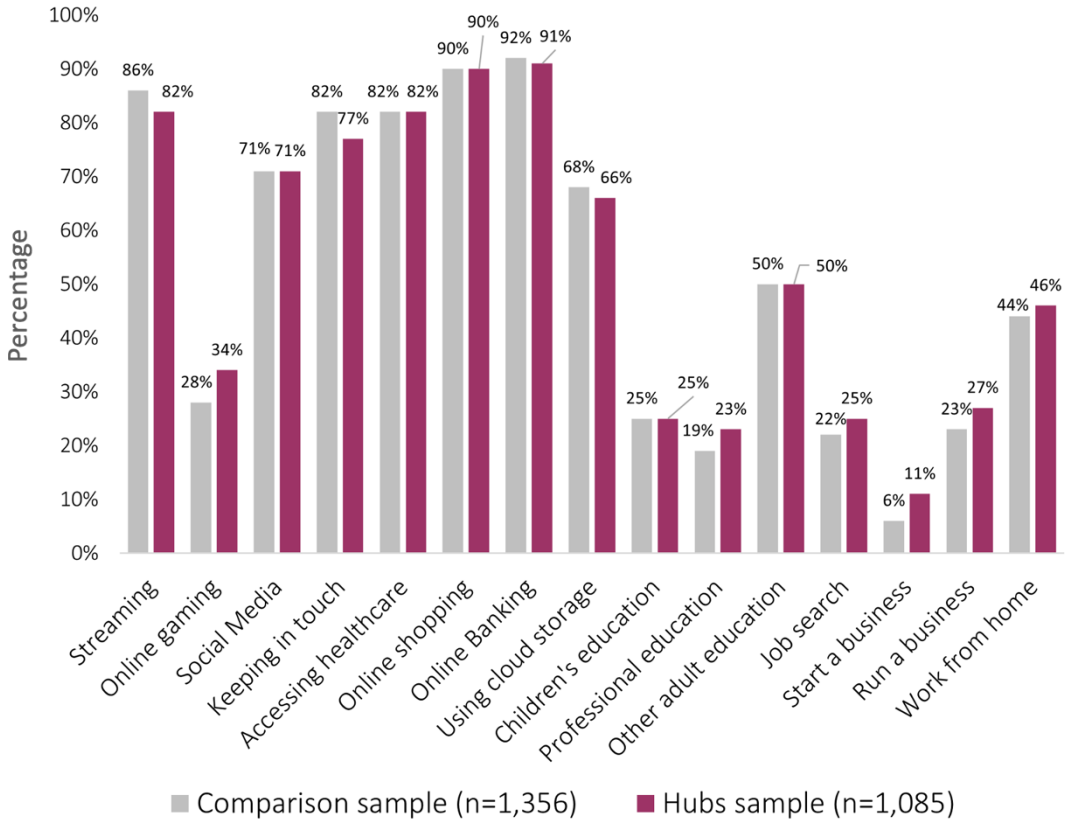
This section of the report details the findings from these questions, for the Hubs respondent sample as a whole, and noting any statistically significant differences between demographic groups or by voucher type received, where evident.

Use of the internet

On use of the internet, the questions asked replicated those asked of the comparison sample. Overall, the proportions of residents in the comparison group and the Hubs sample that are making greater use of the internet for personal, education and professional purposes are broadly the same. However, some small statistically significant differences were found in the data – a slightly lower

proportion of residents in the Hubs sample are making greater use of streaming entertainment services and keeping in touch with family and friends.

Figure 4.2 Proportion of residents making greater use of the internet for personal, education and professional purposes



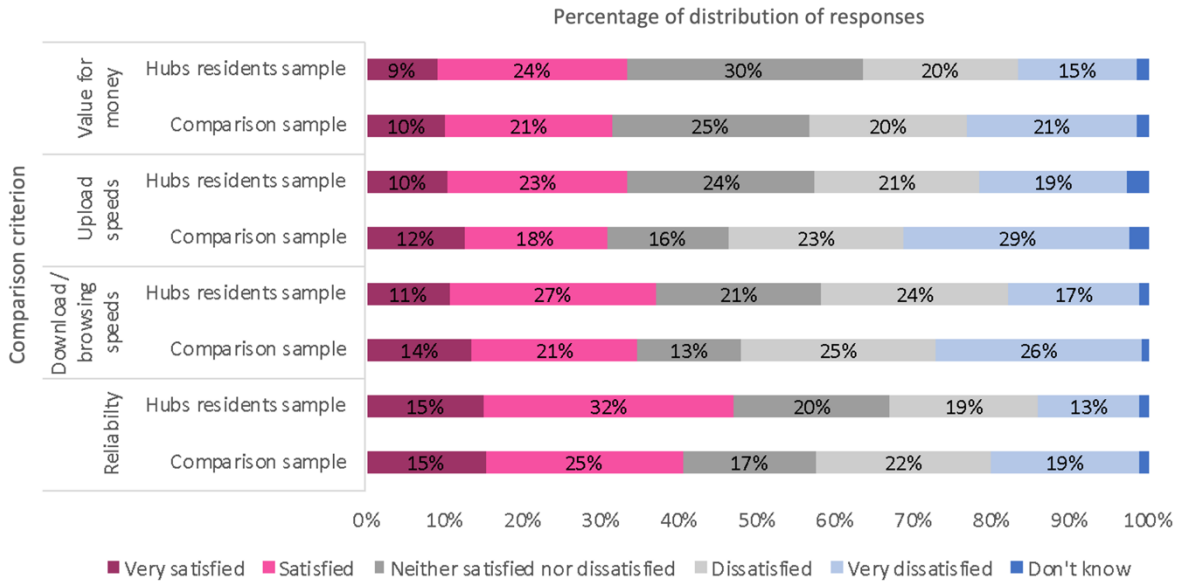
Source: Survey of Residential Voucher Beneficiaries

It is possible that this difference may be affected by the timing of the survey, with residents close to a Hub being surveyed later when streaming entertainment and keeping in touch with family and friends online is less important than in earlier stages of the pandemic when the comparator survey took place. Conversely a slightly higher proportion of residents in the Hubs sample are making greater use of the internet for online gaming and to start a new business. These differences are shown in Figure 4.2.

Broadband performance and residents' upgrades

Some differences were found in responses relating to how residents close to a Hub had benefited from the upgrade. The surveys asked about household satisfaction with broadband before the voucher upgrade and, overall, residents close to a Hub were more satisfied with their connection before the upgrade than the surveys for the voucher recipients more distant from the Hubs. However, as the broadband was upgraded, the improvements appear to matter more to respondents near Hubs. A higher proportion of residents close to a Hub reported an increase in their life satisfaction, and this would be attributed to the upgrade. When asked what aspect of the faster connection mattered, it was the ability to work from home.

Figure 4.3 Residents satisfaction with their connection before the upgrade (Comparison sample n=1,356; Hubs resident sample n=1,085)



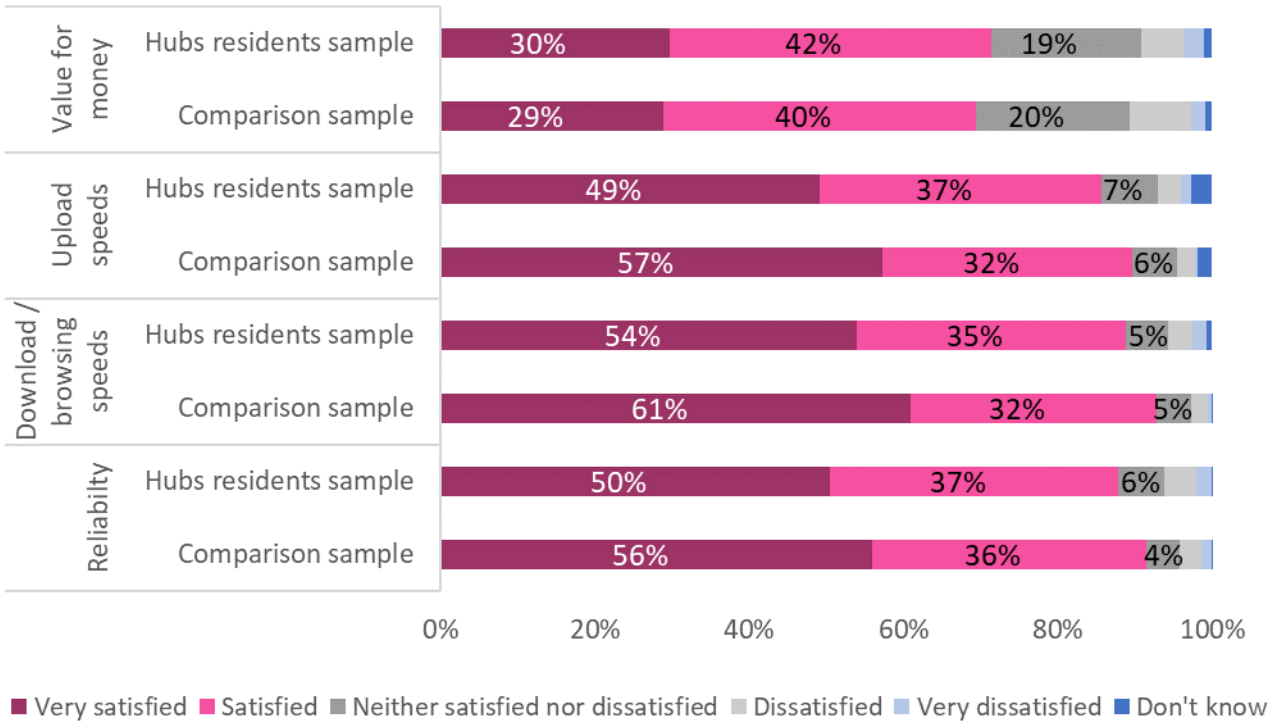
Source: Survey of Residential Voucher Beneficiaries

Despite a smaller proportion of Hubs residents reporting that they were very dissatisfied with their connection, many mentioned similar issues to those expressed by residents in the comparison sample. The key problems noted amongst residents were the slow speeds and unreliability and the impact that this had on trying to undertake daily tasks. Residents talked about the regular "maintenance work" that they had to personally do to retain and improve their connection. Some residents talked about the negative effects that this had on their lives.

> *"Constantly dropping the connection interfering with Internet browsing and streaming of programmes."*
>
> *"It was slow and unreliable, it was difficult to work remotely which had an impact on our family life"*
>
> *"With three teenagers accessing the internet for school purposes and for leisure plus working from home it was almost impossible and affected the education of our children and the ability to work from home."*

Following the upgrade, residents close to a Hub are less satisfied with their connection, compared to residents in the wider vouchers sample. More residents close to a Hub said that they had experienced an issue with a poor or unreliable connection after their upgrade (19% compared to 12%), which may help to explain why satisfaction levels after the upgrade among the group are lower.

Figure 4.4 Residents satisfaction with their connection after the upgrade about value for money, speeds and reliability (Comparison sample n=1,356; Hubs resident sample n=1,085)



Source: Survey of Residential Voucher Beneficiaries

Satisfaction with broadband performance – in terms of speed and reliability – was generally high after the upgrade and respondents were asked about the drivers for this. A key strand was the performance of the faster connection, with residents focused on the noticeable difference in internet speeds and with the improved reliability of their connection. Some residents also expressed that they felt they were receiving better value for money with an improved service.

Another area of satisfaction mentioned by residents in the survey, and in the subsequent qualitative interviews is a move to a local broadband supplier and receiving good customer service from them.

> *"We have noticed a faster speed, but the real win for us is that the company is local to use, and the customer service is excellent. You can reach them immediately and get to speak to the relevant person and they respond really well. It is also cheaper than our original supplier."*

> *"It has been hugely beneficial having the reliability and the excellent support of a local company."*

Examples of the improved quality of support included examples of the supplier's ability to respond to issues over the weekend, and the efficiency with which installation had been progressed.

Satisfaction with the broadband has risen but, comparing the survey of voucher beneficiaries near to Hubs with those in other areas indicates a slightly lower level of satisfaction with their broadband.

Those very satisfied or satisfied is routinely over 80%, but it is two or three per cent lower for the voucher recipients near a Hub.

This difference could be due to the timing of the two surveys differing with the survey for this evaluation taking place later. The survey of the voucher beneficiaries not close to Hubs may then have views more affected by experiences of the Covid period. A higher proportion of residents in the comparison sample report that their upgrade contributed to their household's ability to adapt during the pandemic. For example, almost half (43%) of residents close to a Hub said that they only received the new broadband connection at a later stage i.e. after the main lockdown in 2020.

Residents were asked if they had experienced any challenges as a result of their upgrade. They were provided with a prompted list and were asked to select all that applied to them. The evidence suggests that a higher proportion of residents close to a Hub (19%) experienced an issue with a poor or unreliable connection, compared with 12% of residents in the comparison sample.

> *"We joined Sky Broadband superfast supposedly – 500 mbps. We've never actually achieved these speeds and, on several occasions, we're only getting 30-40 mbps even when sat right next to the router."*

Also, the qualitative evidence did indicate some specific challenges in these more rural Hub areas, with more respondents reporting reliability issues.

> *"When the electric gets cut off, we can no longer access the phoneline, whereas before we could plug in an old phone & still have phone usage."*

There were no differences in the proportions of residents experiencing any of the other challenges prompted on in the survey i.e., 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, the cost of their connection / broadband contract.

Despite residents' satisfaction with the connection being slightly lower for residents close to a Hub, a higher proportion of residents close to a Hub reported an increase in their life satisfaction, due to the upgrade. Life satisfaction questions asked in a standardised way provides evidence of an important benefit of the improved connectivity. Respondents were asked what drove this somewhat higher level of life satisfaction. The main reason provided by residents regarding this is the ability to work from home, and this benefitting their work / life balance. The households near to Hubs were less likely to be owner occupiers and in professions than the comparison households, marking out this result, as these household characteristics are generally regarded as less correlated with working from home,

This is a widening of life satisfaction across households, rather than a deepening in those already reporting life satisfaction. The evidence suggests that higher proportions of residents close to a Hub, and residents that received a business voucher have seen an increase in their life satisfaction following their upgrade, compared to their counterparts. However, the average increase in life satisfaction is the same across the groups. As a result of a faster and more reliable connection, residents explained that their home and working life had improved.

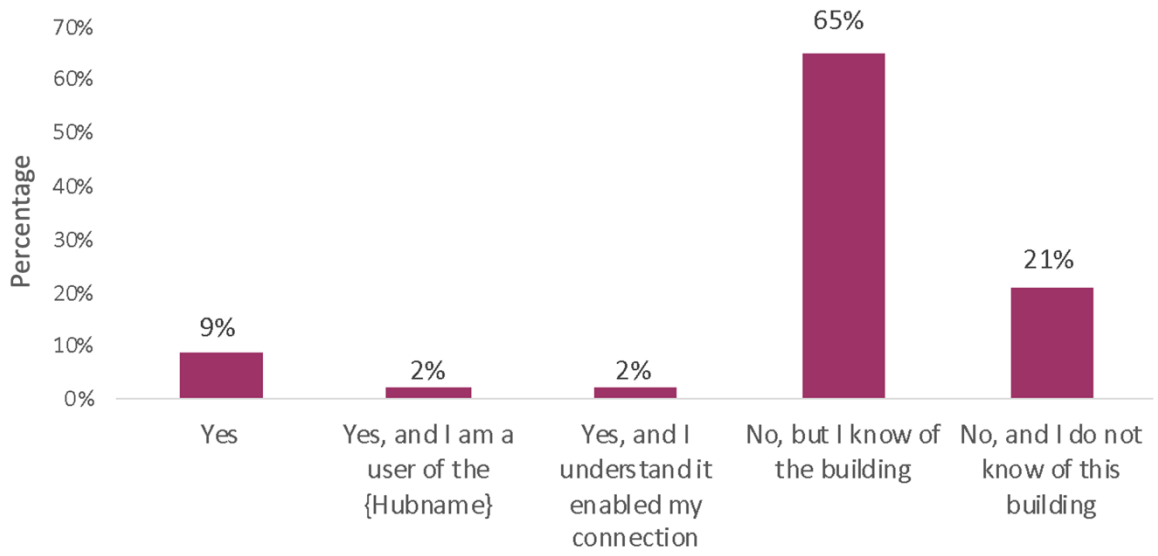
> *"I can now experience all the benefits of quality broadband and my family can all work from home without any buffering or calls dropping out."*

A lower proportion of residents in the Hubs sample said they had reduced the amount of travel that they do as a direct result of their upgraded connection, compared to residents in the comparison sample. The average and median reduction in miles per resident is the same across the two groups. This finding could be an effect of the difference in timing of the surveys, with residents close to Hubs being surveyed later with things opening up more following the pandemic and its associated restrictions.

Awareness of the Hub

Awareness of the Hub is relatively low amongst residents (13% aware). A very small proportion say they use the Hub (2%). Similarly, a very small proportion (2%) said that they understood the upgrade to the Hub enabled their own connection.

Figure 4.5 Residents awareness and use of the Hub (n=1,518)



Awareness of the Hub is higher amongst residents who received a residential voucher. A small statistically significant difference was found in the proportion of residents that said they were not aware of the Hub building; 25% of those receiving a business voucher selected this option compared to 19% of residents who received a residential voucher.

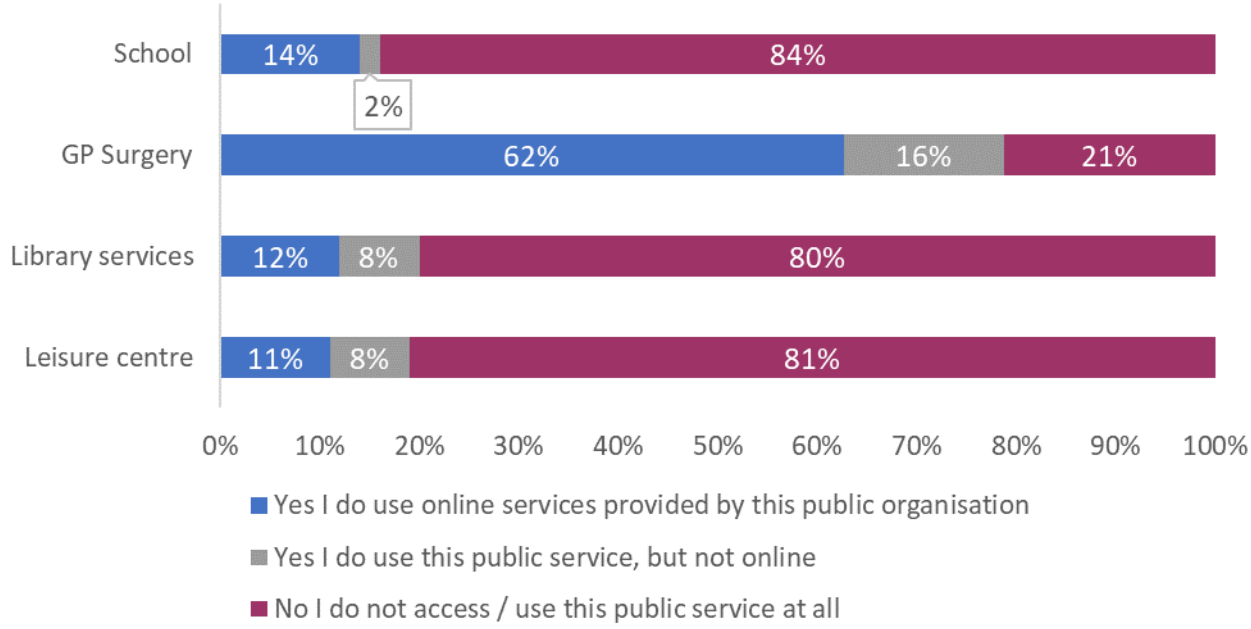
Anecdotal evidence from the qualitative interviews suggests limited promotion and publicity about the Hub upgrades, including some schools not communicating the upgrade to parents for example. However, there were some cases where respondents were aware, either because they had a role associated with the Hub building or because there was a big village / community push to achieve the upgrade.

A large proportion of respondents (62%) use the online services of a GP surgery. This compares to much smaller proportions of residents who use the online services of a school (14%), library (12%) and leisure centre (11%). Notable proportions of residents are using GP surgeries, libraries and leisure centres, but not online. Residents explained that they liked that they could book classes in advance at leisure centres and access information at their own convenience.

"I can book/cancel classes in seconds and have access to timetables."

"The times I've used the website booking system, it has been effective."

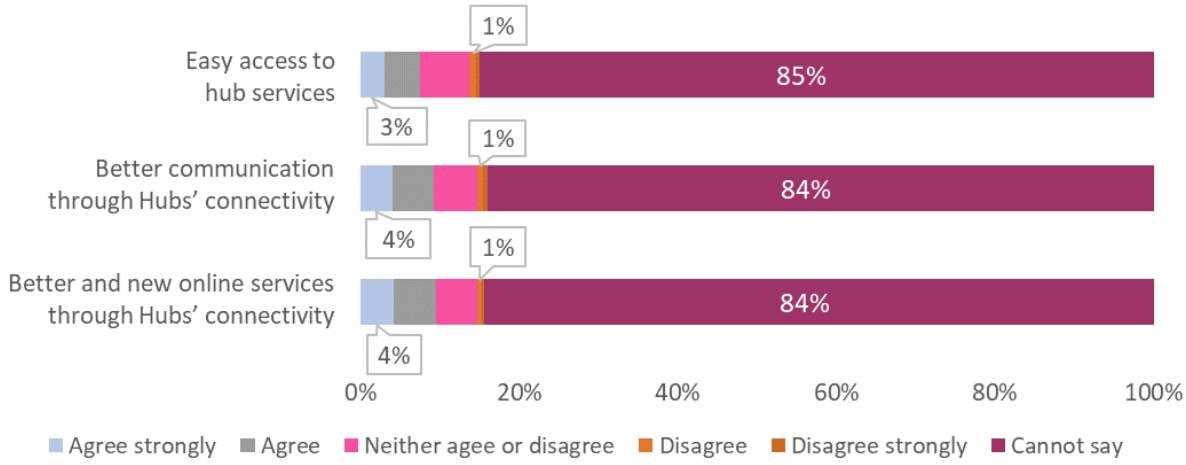
Figure 4.6 Do you access the online services of any of these public organisations? (n=1,518)



In terms of statistically significant differences, users of school and leisure centre online services are more likely to be families with children. Higher proportions of residents using the online services of GP surgeries and libraries are residents over the age of 65.

All residents were asked for their views on whether the Hub was making use of its upgraded connection by enhancing online services. Most respondents felt they were not able to say. Questions were worded so this response was correlated with respondents not using the public service. Where respondents were able to say, roughly half of these agreed that the Hub's services were easier to access, the Hub uses its connectivity to communicate better, and the Hub offers new and better online services – although it should be noted that this is a small proportion (less than 10%) of all residents that responded to the survey.

Figure 4.7 Residents views on the Hub's use of its upgraded connection (n=1,518)



Source: Survey of Residential Voucher Beneficiaries

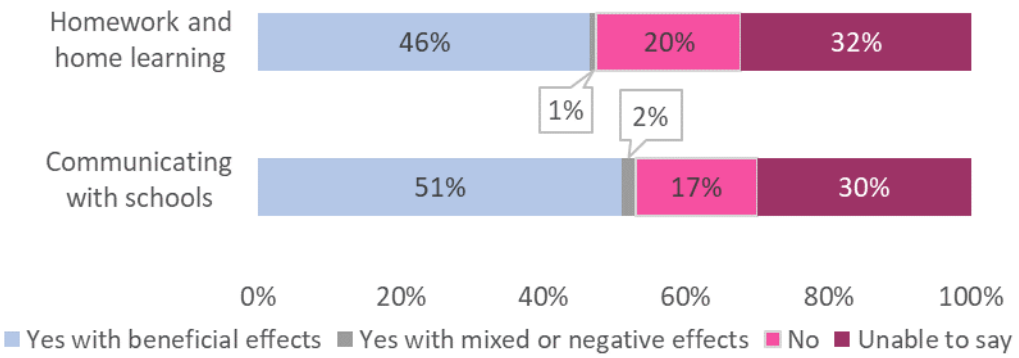
A relatively small proportion of residents (7%) said they had noticed changes in the services offered by their Hub. Of these (n=99), approximately 40% of these have used the online services.

Effects of the Hub

A small number of respondents said that their children go to a school that received the Hub upgrade. Roughly half of these said that they had seen beneficial effects at the school on homework and learning, as well as in interacting / communicating with the school such as through digital correspondence, forms and payment systems.

Respondents whose Hub is a school (n=1,373) were asked whether any of their household attend the school, and 5% said yes. Approximately half of this group of residents said that they had seen changes in the way the school communicates; for example, through digital correspondence, forms, and payment systems (53%) and just under half (47%) had seen changes to homework and learning. Of those that had noticed changes, the vast majority of these felt the effects of the changes made by the school were beneficial.

Figure 4.8 Residents views on whether they have seen improvements in the online services provided by their school Hub (n=69)

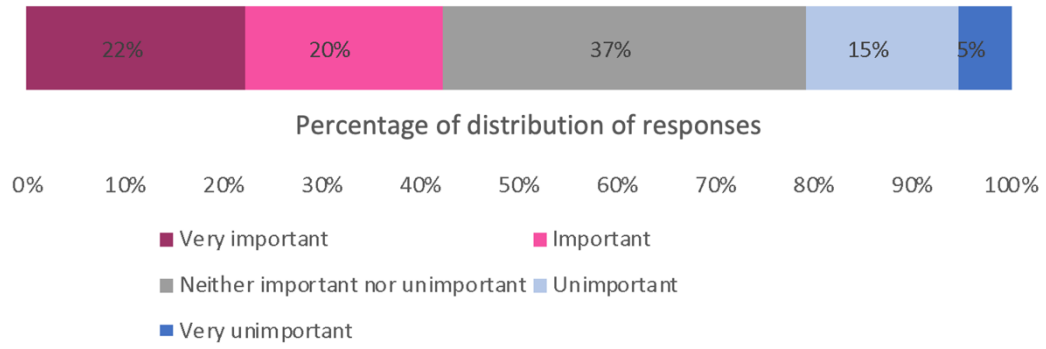


Source: Survey of Residential Voucher Beneficiaries

There is also some qualitative evidence from interviews with residents who are a parent of a child at the school or have a role at the school (e.g. school Governor), that in some schools teachers are delivering higher quality lessons by accessing online videos and materials. Some have also observed that the school has made systems more digital and for schools that are part of a group, they have been able to integrate / communicate better. The effects of connection improvements on schools is the focus of the next chapter.

Qualitative evidence further supports the finding that Hubs have positive effects on the local areas, in terms of resident's ability to work from home, the setting up and running of community groups, and some more ad hoc uses of the Hubs such as providing warm public spaces in cold spells and supporting the distribution of food to those in need. Respondents view the improved broadband connectivity to have enabled online participation and volunteer management in these community efforts.

Figure 4.9 How important is a fast broadband connection in the Hub to you and your household? (n=145)



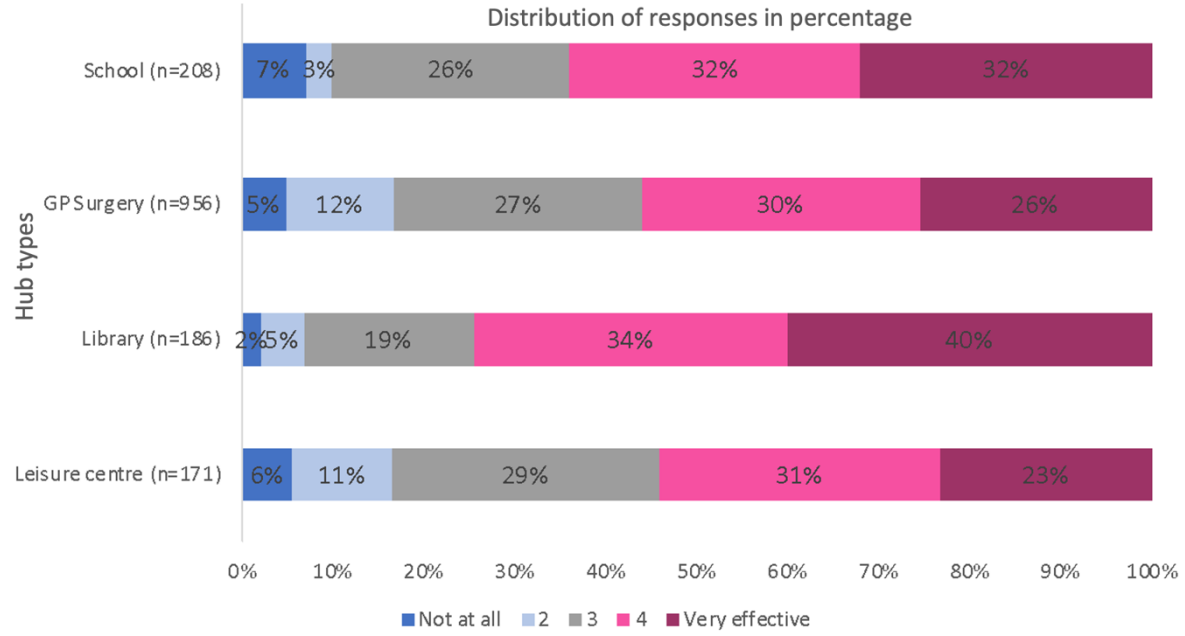
Source: Survey of Residential Voucher Beneficiaries

Almost half of residents (44%) that said that they were aware that the upgrade to the Hub had enabled their own upgraded connection (n=145) view the Hub's connection as important or very important. Residents were not asked to explain the reasons for their response.

Internet and public service use

Residents that had said they used a public service (in general, not specific to a Hub that was upgraded) were asked to rate the effectiveness of the online services provided by them. Just over half of the users of GP surgeries (56%) and leisure centres (54%) rated the effectiveness of the online services provided as 4 or 5 out of 5. Even higher proportions of users of schools (64%) and libraries (74%) rated their online services as effective (4 or 5 out of 5).

Figure 5 Residents views on the effectiveness of the online services provided by local public services



Source: Survey of Residential Voucher Beneficiaries

No statistically significant differences were found between different demographic groups or by voucher type. However, analysis of text answers provided by respondents in the survey shows key themes in why residents think the online services of public services are effective or ineffective. Views of service effectiveness are affected by a number of factors such as, the internet connection at the public service and the respondent's own internet connection to access services and can be affected by the overall design of the public service and the public service's capacity and capability to make the most of an upgraded connection.

These factors are evident in the views expressed on the effectiveness of GP surgery online services. Some residents were positive about the effectiveness of their GP's online services, with some noticing that their GP surgery had expanded their online services, for example offering the ability to order repeat prescriptions online, making appointments online, and communicating with the Doctor online. Residents explained that this was quicker and easier than using the telephone line and suspected that it was also more efficient for the GP.

> *"It enables ordering repeat prescriptions more easily and making appointments."*

> *"I use ASKMYGP which is an excellent service for answering queries, obtaining appointments, gaining information without needing to 'clog up' the surgery phone lines."*

However, some residents had experienced issues in accessing GP online services or did not think the GP surgery was doing as much online as they could be.

> *"It is often not possible to carry out the required activity e.g., book an appointment. This is not a function of the connection; it is a function of the capabilities of the local medical centre."*

"Most of the time you can't do anything with our local doctor's website. It simply doesn't allow you to do so. We hope they get it sorted out."

"The migration to online has not resulted in a more efficient and speedy consultation service."

Other public services that resident survey respondents commented on included library online services. For residents that were positive about their library's online services, this was because they were able to access books and other materials online, as well order items for collection increasing convenience and reducing travel.

"I can get all the magazines and books downloaded, really easy, without having to make a physical trip to the library."

"I find it such a joy to be able to browse the county library online and order books. At 84 reading is a big part of my life."

"I can download all my library e-books and talking books online quickly and easily and then read them on my tablet or listen to them in my car from my phone. Never need to go into the library."

Where residents viewed their library services as less effective, the key issue experienced is not being able to access and navigate the library website. Whilst some residents found this task too complicated, others suggested that it was because the website was out of date.

The users of the online services of a leisure centre had found them effective, and residents explained that they liked that they could book classes in advance and access information at their own convenience. Where residents rated the leisure centre online services as less effective, comments made by residents suggest that this is either because the web site or wider online services do not work well.

Effects reported by business voucher beneficiaries

The profile of businesses close to a Hub is broadly similar to businesses in the wider sample selected for comparison (rural businesses from the earlier evaluation survey of business voucher recipients). The main difference between the two groups is the type of premises upgraded; with a much higher proportion of businesses close to a Hub saying that a private residence was upgraded suggesting a higher proportion of home-based businesses.

Internet use

Businesses were asked questions in relation to what their business uses the internet for, and whether they are making greater use of the internet following their upgrade. They were also asked about the importance of the upgrade on using the internet.

There are no differences in how businesses close to a Hub are making use of the internet compared to businesses in the wider voucher sample. Rates are high in both groups with 95% of businesses making greater use of at least one digital application prompted in the survey, such as rich media websites, supply chain or customer management tools, cloud storage and file sharing, video conferencing/VOIP, advanced digital product service design, HR management tools, staff training, digital banking and accounting services.

How businesses heard about the voucher and why they signed up

Compared to the 2022 survey, no differences were found in how businesses heard about the voucher, their motivations for signing up to the voucher or why they had not upgraded before. Businesses that participated in a qualitative interview went on to explain how they had heard about the upgrade to the Hub – in each case this was a local primary school. It appears that for those that were aware that the school had been upgraded, they had been involved as part of a local community effort. In some cases, there had been information about the upgrade in the local press.

> *"I was aware of the investment in the public building, the chairman of the local parish council worked beside me and told me about it. We were all asking when we were getting the broadband and he worked amongst others for about two years to get it done."*

> *"I am aware because it was part of the village effort. There was a flyer drop and mass email of businesses about this."*

> *"Yes, I knew that the primary school was connected to the upgraded broadband through the local press."*

Some businesses were not specifically aware about the upgrade to the school but were more generally aware that there was investment going in to upgrade the local area.

> *"I was not aware they were part of it. I guess because the whole village was done, I am not surprised. Over 1,000 houses and over 100 businesses upgraded. East Horsely was the biggest rural broadband roll out under the scheme. The parish council and private roads got behind it, so within 24 hours of it going live, we already had the numbers to justify this."*

> *"I did not know about primary school, but I did know that other public buildings were being connected as part of the infrastructure."*

Respondents that were less aware of the investments into upgrading the area tend to explain that their Hub was not in their own village. It appears that this type of business would be more likely to be located on the outskirts of the 5km radius in which the sample was drawn from.

One in ten businesses are aware that the provision of fast connection in their area has included connecting a public building. A small proportion (2%) said that they also understood that the upgrade to the public building had enabled their own connection.

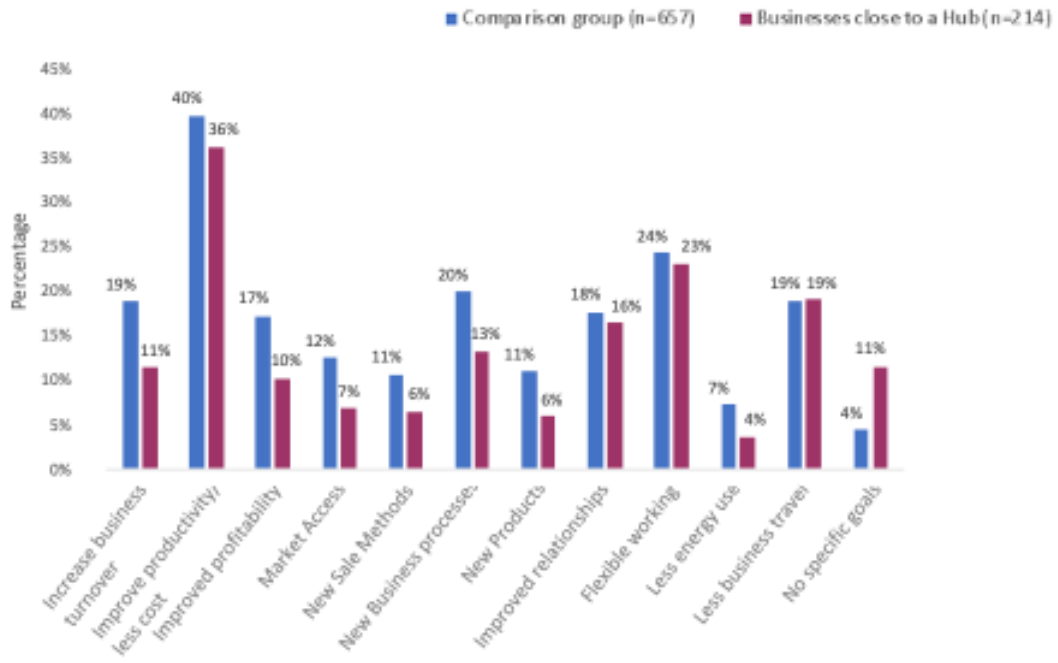
Business benefits

There is some evidence to suggest that businesses close to a Hub were less ambitious in what they wanted to achieve through their upgrade, although it is important to note that the differences found were not statistically significant.

Businesses were asked what their wider business goals were in relation to their upgrade and were provided with a prompted list of options to select from. Fewer businesses close to a Hub selected each business goal, compared to the businesses in the wider voucher sample. These include goals such as increase business turnover, improve productivity, improve profitability, access new markets, implement new business processes, develop new products and services. The lower levels of ambition

amongst businesses close to a Hub could be affected by the large proportion that are home based businesses, and therefore smaller in scale.

Figure 4.10 What were our wider business goals that you hoped to achieve through the new / upgraded broadband connection?



Source: Survey of Businesses Voucher Beneficiaries Close to the Hub

Similar to the findings for residents, the group of businesses close to a Hub appear to be more satisfied as a whole with their connection before the Hub, compared to businesses in the wider vouchers sample. Satisfaction levels after the upgrade are also higher amongst businesses close to a Hub, and fewer report to be dissatisfied. This suggests that fewer businesses close to a hub experienced issues with their connection subsequent to the upgrade. This finding could be affected by businesses close to a Hub being surveyed at a later date.

Businesses close to a Hub have experienced a wide range of business benefits, just like their counterparts in the wider voucher sample, such as entering new markets, adopting new sales methods and channels, and fostering new relationships; however, the proportion reporting each benefit is lower in the group of businesses close to a Hub compared to the wider sample (these differences were not seen to be statistically significant).

Fewer businesses close to a Hub have experienced business benefits such as implementing new business processes, outsourcing functions or activities to other sites or locations, and recruiting more widely and / or diversify the workforce (these differences were statistically significant). This finding could be affected by a number of factors; the businesses close to a hub being less ambitious in what they wanted to achieve from the upgrade, more businesses being home-based, or because of receiving the voucher and upgrade later than businesses in the wider sample and having had less time to see benefits as a result.

A few respondents had noticed positive effects on local businesses since the upgrade, with some going on to emphasise the importance of the upgrade to the local economy:

"Neighbours who run their business from home say it is a lot better now, plus it is also in the village hall where there was none previously. Hopefully it is more appealing to rent it out and for the general community, and also hopefully the community can now get more use out of it."

The availability of good connectivity has then allowed digital technology adoption, with this tying into business performance and then the wider impacts of businesses doing well.

"Businesses have more social media presence."

"They're all much more upbeat and confident so I presume they're doing better- because of the broadband upgrade. People seem to be very pleased they're able to do their business better. It is really important for the wider economy."

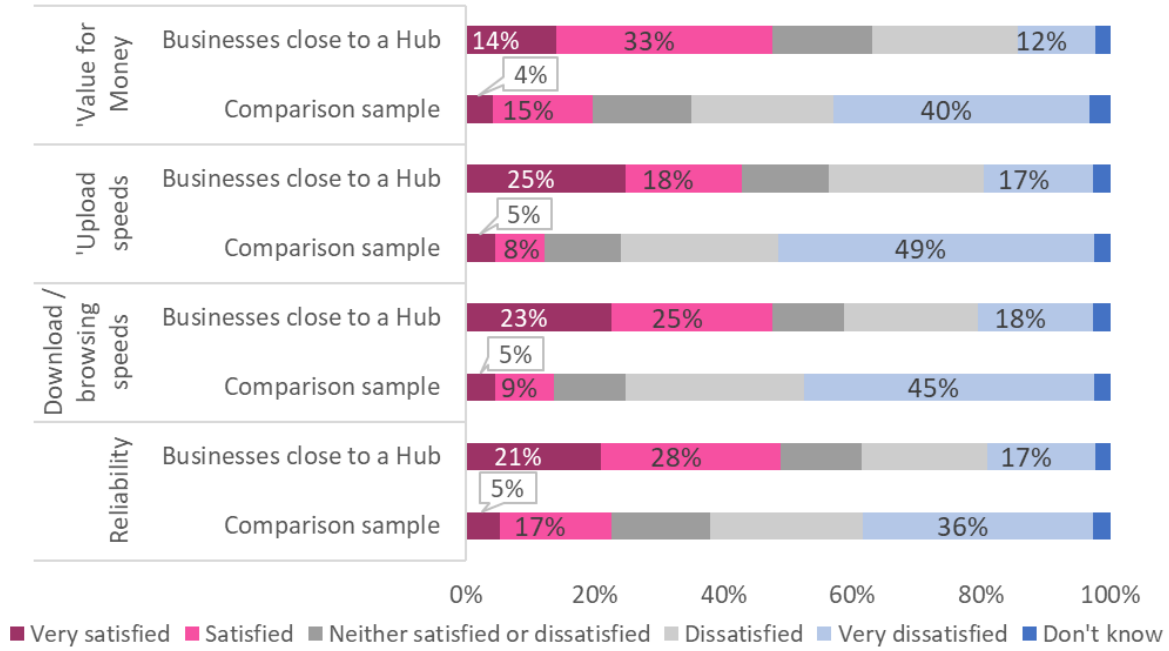
"There are firms up here that use it heavily and it makes a difference to them. I'm pleased to support a local firm; it's kept a lot of people employed."

Awareness and effects of the Hub

One in ten businesses were aware of the upgrade to the public building as a Hub. A very small proportion (2%) understood that the Hub upgrade has enabled their own connection. Whilst some had heard about it through local press or through local connections, other business respondents said that whilst they weren't aware of the specific upgrade to the Hub building, they were aware of the wider upgrade and investment in the local area.

It appears that businesses closer to a Hub were more satisfied with their broadband connection before the upgrade compared to businesses in the comparison sample. For example, half of businesses close to a Hub (49%) were satisfied or very satisfied with the reliability of their connection before, compared to 22% of businesses in the comparison group. The responses regarding other aspects of their connection – download speeds, upload speeds and value for money – are also similar in profile.

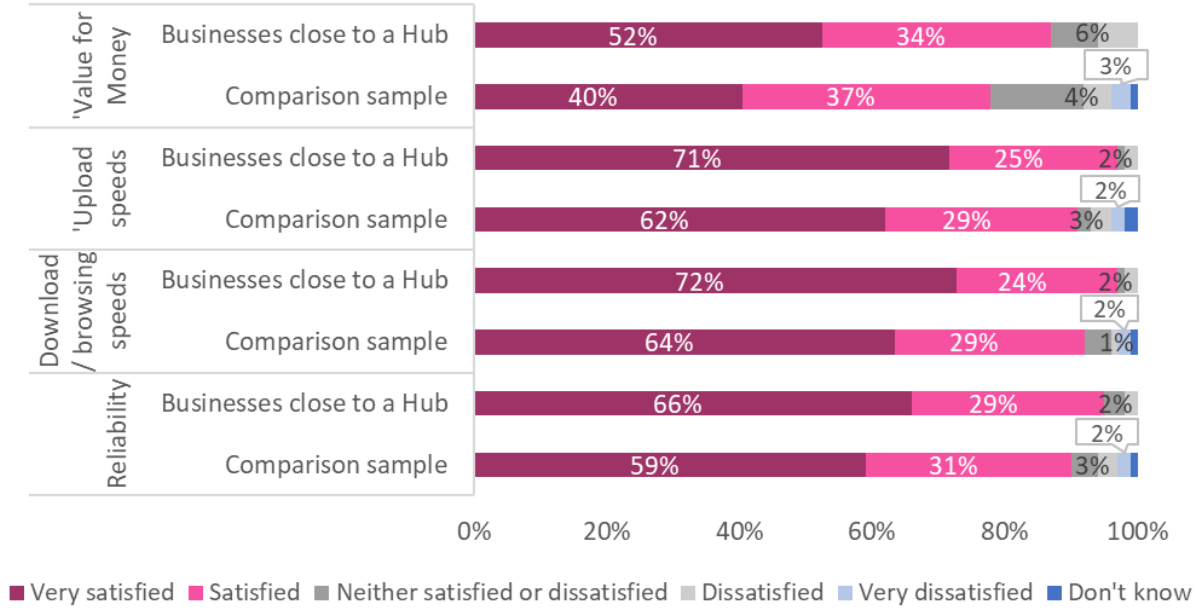
Figure 4.11 Satisfaction with the connection BEFORE the upgrade (Businesses close to a Hub n=214; Comparison sample n=657)



Source: Survey of Businesses Voucher Beneficiaries Close to the Hub

Satisfaction levels amongst businesses close to a Hub remain higher after the upgrade, with fewer businesses close to a Hub reporting to be dissatisfied or very dissatisfied after their upgrade; this is shown in the chart below. This suggests that businesses close to a Hub have perhaps experienced few issues compared to those in the comparison sample, although the numbers that are dissatisfied are relatively small in both groups.

Figure 4.12 Satisfaction with the connection after the upgrade (Businesses close to a Hub n=214; Comparison sample n==657)



Source: Survey of Businesses Voucher Beneficiaries Close to the Hub

Community level effects

A small proportion of residents overall (3%) said that the connecting of the Hub had had effects on the local area. A common observation is the shift of local people working from home, with some suggesting that this wouldn't have been possible without an upgrade:

> *"Most of the people who had the opportunity to work from home in the pandemic, those who had the broadband were able to do this successfully and those that didn't had a major struggle. My neighbour had to rent a flat somewhere else as he didn't have the broadband."*

> *"I know a lot of people in the village work from home post Covid and it has made it easier for those who have taken the upgrade up."*

> *"It probably encourages people to want to move here as well if you have the ability to work from home with a reliable high-speed connection."*

Other positive impacts of the Hub upgrade on the local community were also mentioned by residents in the qualitative interviews, including the setting up of and better promotion of community and social groups, and promotion of local events; "There are drama groups, computer groups, lots of different groups that have cropped up in the last six months, and some that were already there and poorly attended are now better promoted online" and "The Christmas fair is promoted online now".

> *"It has been hugely beneficial for the school and the village in its widest possible sense. I think everyone realised with the pandemic how crucial the internet was to be connected for people to be able to continue to work and to be entertained with all the streaming services going online and being provided*

over the internet. It is hugely beneficial. The pub is community owned; they have ultra-fast fibre; they are also a warm Hub and they are encouraging people to work from there so they don't have to heat their homes If they don't need to. It has given people options that they didn't have before, because they can work with a laptop and a headset and be warm*."*

Hub impacts included supporting locals through the cost-of-living situation, such as the setting up of warm Hubs or assisting with the distribution of low-cost food and supporting the community to set up a community led pub.

> *"They have put broadband into the village hall so groups can meet there and use the connectivity, as well as the warm Hub."*
>
> *"There are significant things in the village that are actively promoted online, for example there is something that promotes cheap food being sold by local supermarkets."*
>
> *"The local pub's till services all run over the broadband – they need it to operate and take money. It is quite important for the commerce of that community pub as that is how they make their money."*

Some businesses had observed changes in the local community either in terms of social groups forming and interacting and increasing the use of local buildings both for income raising purposes but also charitable purposes, like the creation of a warm Hub during the cost-of-living situation.

> *"I think that the parish council and the local networking in terms of the way that our local residents committee and the WhatsApp group has been set up – it's that connectivity between people. There's a lot more very specific community-based groups and societies. My wife's a member of the gardening society and she does a lot more online in terms of messaging and all of that."*
>
> *"I am a trustee on the charity of the village, it's made the lady who does websites, made it easy for her to upload. The charity, we're buying the church, an abandoned church and hoping to use it as a community Hub and offer a warm space and offer use of office space, and without a fast broadband connection that wouldn't have been viable. Now there is more scope to rent it out and make more money for the charity."*
>
> *"Yes, as we have a village hall, which is a registered charity, and are now looking at getting broadband in the village hall. This was not possible to consider before the upgrade. Now they can get it for free as a registered charity. This means they can advertise on Facebook and their own webpage. Previously, people did not want to rent out that room before the upgrade because it did not have wifi, so people could not play music or host parties. Now they can. This makes this hall more accessible to others and people in our village, which is amazing and exactly what we needed. It made our business much better too."*

There is evidence that the way residential voucher beneficiaries heard about the availability of vouchers in their area was more likely to be through local networks the more remote the area, Box 4.1 indicates how the survey evidence is analysed to understand this driver.

BOX 4.1: Households in remote areas and broadband connectivity

Survey results could be analysed in terms of the remoteness of the residential properties connected using vouchers. Of the 1,518 residential beneficiaries of vouchers, 984 are in properties where connections would not be possible on a commercial basis according to BDUK modelling. The survey finds they differ somewhat from the other connected properties.

The respondents were more likely to have heard about the voucher scheme through local community groups, with 54% hearing through this route. In commercial areas, 59% of beneficiaries heard about the voucher scheme through their supplier. They were then more likely to have not considered an upgrade to their connection in the past because it was not available to them, with 81% citing this reason while the rate was 71% in commercial areas. In the non-commercial areas, respondents also reported a higher level of satisfaction with their pre-connection broadband,

Generally, people's awareness of the connection being connected to the Hub investments into nearby public buildings was low (at 9%). However, this knowledge was more common in the remote, non-commercial properties at 12%, being 6% in the commercial areas

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The marketing of vouchers to residential broadband users is primarily through suppliers, who would then provide the connection and draw the voucher funding. When asked about how beneficiaries heard about the voucher scheme, generally the response that this was from the supplier was high. However, in remote areas in terms of the modelled cost of connecting residences, the households close to a Hub reported hearing about the voucher support through the community over half the time. They were also relatively unaware of the possibility of having a fast connection, assuming they were too remote. The survey also reveals a marginally higher knowledge of the Hub investment in this subsample.

Conclusions

This chapter presents the results of a survey of residential and business voucher beneficiaries where the connection was near (within a 5km radius) to a Hub. The analysis uses a set of questions that were asked recently in a large survey conducted to evaluate vouchers more generally, and results from that survey provides the potential effect of the Hubs in terms of a comparator.

- **Residential survey had 1,518 respondents with 33 follow-up interviews.** Residents that live close to a Hub are similar in profile to residents in the comparison sample in terms of age, employment status, household size and income. There were some statistically significant differences between the two groups regarding household type, housing tenure, and occupation. The comparator survey had 1,356 respondents.
- **Use of internet similar to non-Hub voucher beneficiaries.** The comparison group and the Hubs sample are making greater use of the internet for personal, education and professional purposes. Some small statistically significant differences were found in the data – a slightly lower proportion of residents in the Hubs sample are making greater use of streaming entertainment services and keeping in touch with family and friends.
- **There are community-level networks.** Residents close to a Hub were more likely to have heard about the voucher through a local community initiative, and it was less likely to be through a broadband supplier, compared to residents in the voucher sample. Being part of a community initiative appears to be a key motivation for many residents (45%) close to a Hub in terms of upgrading their internet.
- **Less satisfied than non-Hub sample with connection but higher life satisfaction**. Residents close to a Hub are less satisfied with their connection, compared to residents in

the wider vouchers sample., but a higher proportion of residents close to a Hub reported an increase in their life satisfaction, due to the upgrade. The main reason provided by residents regarding this is the ability to work from home.

- **Awareness of the Hub is relatively low amongst residents**. A very small proportion say they use the Hub (2%) and that they understood the upgrade to the Hub enabled their own connection. Where respondents were able to say, roughly half of these agreed that the Hub's services were easier to access, the Hub uses its connectivity to communicate better, and the Hub offers new and better online services – although it should be noted that this is a small proportion (less than 10%) of all residents that responded to the survey.
- **Business survey sample.** There were 219 respondents to the business survey, all within 5km of a Hub. A separate, comparator survey of 214 responses was also used in the analysis. There were in-depth 30 follow-up interviews with respondents near to Hubs.
- **Businesses close to a Hub have experienced a wide range of business benefits.** Like counterparts in the wider voucher sample, entering new markets, adopting new sales methods and channels, and fostering new relationships was cited. Satisfaction levels amongst businesses close to a Hub remain high after the upgrade, with fewer businesses close to a Hub reporting to be dissatisfied or very dissatisfied after their upgrade.

5. Public service delivery outcomes in education

The Hubs product has focused on investing in fast connections in schools. There have been 605 schools out of the 1,021 Hubs and earlier analysis has investigated whether the schools have benefitted from additional broadband uptake, identifying that some portion of the improved broadband connectivity in supported schools did not take place in comparable matched schools.

A part of the collaborative effort to encourage rural schools, particularly primary schools, was working with the Department for Education (DfE) to identify English schools to prioritise a connection. As the Hub product was rolled out, Building Digital UK (BDUK) worked with DfE to survey the Hubs prior to their connection. Following connection, a follow up survey was conducted, and this chapter explores the findings of that survey. It details the follow-on effects of improved connections in the schools, comparing this with other surveys.

Key findings:

- Hub investments lead to additional broadband speed improvements. These reflect 35.7% of the changes seen in broadband speed, with the rest being estimated would have occurred without the support. In addition, the survey found high levels of satisfaction with internet speed.
- The policy objective was to achieve equitable broadband performance in schools, aiming to establish connectivity standards in rural regions that match the best available. Simultaneously, there was a motivation to prevent hindrances to the advancement of policies dependent on robust connections, such as widespread integration of educational technologies and the implementation of online assessments. Strong broadband connectivity was seen as a prerequisite for these educational initiatives.
- Schools reported implementing innovative teaching practices, such as blended learning, and in the use of the internet in conducting formative and summative assessments. Also, workloads are reported as lessening due to technology. In 93 responses, 60% have seen workloads reduced already or are expecting this as technologies are adopted. This question replicated one in a national survey (DfE, 2021, p. 34), which found that 50% had this view. Lastly, cloud storage use is growing after connection.

Attributing improved school connectivity to Hub investments

Earlier analysis looked at whether the areas where schools were supported using Hub investments outperformed comparable areas that also had primary schools. Table 5.1 indicates the main results when the postcode level data about average download speed and gigabit availability is analysed for the supported areas and compared with counterfactual areas. It indicates that the Hub effects are additional at the level of the postcode of the schools.

Table 5.1: Broadband uptake effects at postcode level

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	528 postcodes in treated and matched				
Average download speed (Mbps, logged)	0.28	6 out of 9	0.10*	0.06 to 0.2***	35.7%
Gigabit availability (% premises, logged)	0.32	9 out of 9	0.21***	0.18** to 0.26***	64.3%

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

The approach taken has been careful to identify the counterfactual. Data was compiled about both the output areas and the schools in each area. A focus has been primary schools as, under the DfE's digital standards, secondary schools, all-through schools, and further education colleges should have a connection with the capacity to deliver 1Gbps download and upload speed[5].

Selection modelling could then match both on the fact of an area having a primary school and then also on the characteristics of the school and the area that it is in. Table 5.2 indicates how the schools supported with Hub investments were generally smaller than other English primary schools with 144 pupils, half the English average. The schools also had fewer pupils eligible for free school meals.

By matching, the table also indicates how the counterfactual schools more closely replicated the supported ones. They are rural and, associated with this, the low population density, high F20 score and high distance from the school to the closest telephone exchange.

[5] See , https://www.gov.uk/guidance/meeting-digital-and-technology-standards-in-schools-and-colleges/broadband-internet-standards-for-schools-and-colleges. The DfE school Hubs were primary schools, but where secondary schools without access to gigabit capable connectivity were identified, their inclusion was considered. As a result, four secondary schools have been connected through the RGC Hubs product.

Table 5.2: Characterising OAs before and after matching

VARIABLE	OAs with Schools	All OAs with schools	Matched OAs (Mod V)
Proportion rural (%)	95.8	29.5***	96.6
Employment in LSOA	492	436***	499
Population density LSOA	103	1135***	88**
Employment in digital businesses, 2019 (%)	61.9	45.5***	63.1
Distance to exchange (km)	1.8	1.4***	1.9
F20 Score	0.8	0.6***	0.8
Variables about broadband outcomes prior to support			
Value of vouchers in OA (£)	£1280	£197***	£649
Count of Vouchers	0.6	0.1***	0.4
Change in download speed	6.46	10.60***	6.03
Premises passed by BDUK funded projects	3.12	0.57***	4.13
% premises Full Fibre available	14.0	37.0***	22.2***
Average download speed, 2021 (Mbps)	48.0	82.9***	62.5***
No of connections >=30 Mbps	87.2	101.9***	90.9
Variables used about schools where OA is in England and has a primary school			
Pupils in school	144.6	290.0***	136.3
Proportion entitled to free school meal (%)	13.3	19.6****	12.4
Observations	528	42934	528

Note: Significance levels are 1% (***), 5% (**) and 10% (*) with testing whether difference from the supported Oas. All Oas estimates for stacked dataset.

The table indicates the broadband outcomes prior to support. The different models used in section modelling varied whether and which pre-support outcome was introduced in the selection. Model V, presented in the table, included the past voucher support and the change in download speed, and there is then a good balance on these variables after the matching. Other models included the level of broadband speed, which remains imbalanced in this modelling.

The analysis has matched on output areas – for which data about most variables are available – and then retrieved the postcodes of the Hubs and the matched schools in each of the output areas. This then can be linked to postcode level Connected Nations data, allowing the download speed and gigabit availability to be measured after support for the supported and comparators. Overall, the

effects of the Hub investments lead to additional broadband speed improvements, and these reflect 35.7% of the changes seen in broadband speed, with the rest being estimated would have occurred without the support.

Rural schools and Hub investments

Hub investments lead to improved broadband reliability and performance in the schools, and – where these are additional – they can then lead to further educational outcomes. The effect on teaching of a lack of connectivity included an inability to access commonly used resources such as streaming a programme on BBC iPlayer or connecting a whole class to the internet on Chrome books in a timely manner without disruption to the pace or learning outcomes.

Schools also viewed it as unrealistic for them to improve broadband speeds further. Steps to maximise the performance in school sites had reached the limits of what is possible given the connection levels in the local area. The schools saw the Hubs programme as too good an opportunity to turn down, in terms of funding the bringing of gigabit connectivity infrastructure to the school.

Within school trusts, where groups of schools were operated by a trust, a motivation to connect individual schools appeared to have come from plans for common data storage and access arrangements, as well as IT support, across all the primary schools within the Trust. Schools operating within groups saw broadband connectivity as facilitating their operating models, whereby schools might share resources more easily due to connectivity and benefit from scale returns.

Connecting Schools

There were a mix of issues reported in delivering Hub connections. Most schools were generally happy with the application and installation process, recalling that most of the connection activity took place off-site. The issues emerging included delays in connections, sometimes exacerbated by poor communication about reasons for delay by the supplier. Also, issues arose about where new lines were routed within the school; in one connection, services lost to a neighbouring property appeared to be linked to the works.

Interviews at LA level confirmed that – where provision was co-ordinated across schools by the LA and so could be viewed from a top-down perspective – there were difficulties in timely delivery of broadband to the schools. Officials observed complaints from individual Hubs as suppliers missed contracted timings.

The new connections to schools were accompanied with other investments, with English school Hubs also participating in the DfE Connect the Classroom (CTC)programme. Interviewees recognised the Hub as the enabler for this and understood how the two programmes complement each other. For instance, one respondent reported that the "...Connect the Classroom project which happened very much off the back of the rural connectivity [Hubs] programme. This would not have been possible without upgrading our internet cable to fibre." In two Hubs, interviewees were positive about the connection experience and mentioned that the contact at the DfE had been helpful.

Broadband speeds have improved. Respondents noted that "the new connection has been very reliable with no issues at all. The speed has improved, and we find the connection no longer dips in and out. We rarely have any issues, whereas before we often had to reset our router". All of the schools cited this, and greater bandwidth for carrying out their day-to-day tasks. There were mixed

views on the scale of the improvement. Some expressed dissatisfaction that the line was still unable to deliver more than 150 Mbps, after recognising that this was a significant increase from 5-6 Mbps before the upgrade.

Hubs were also taking steps to optimise broadband performance, diagnosing and beginning to tackle school-level issues such as onsite settings reducing performance. Schools were working with IT suppliers, sometimes noting central government support in this.

Surveying schools about the effects of Hub investments

English schools that have benefited from a Hubs investment have been surveyed before the connection (the baseline survey) and more recently, after the improved connection. The baseline survey was online, sent to all 474 DfE Schools Hubs that were to be connected by funding from RGC. Conducted in 2020, there were responses from 261 schools, with surveys completed by a mixture of school staff but broadly split between responses from headteachers, support staff and others (such as teachers and governors). The questionnaire covered the schools' connectivity and use at the time and then explored the use of the internet in teaching and the barriers experienced. As the connection was imminent, the questions also covered the preparations made by the school.

This section uses results from the recent follow up survey, also online, that aimed to collect post connection evidence about changes seen in the RGC school Hubs. For the survey, an online survey was sent to 507 schools drawn from DfE/BDUK Hubs list. The survey was completed in October and November 2022, after the Hubs connection. There were 148 responses, of which 112 were complete, with the remaining being partially completed. The surveyed schools were upgraded during 2021/22 online and the survey could cover:

- Connectivity and satisfaction with performance.
- Before-after connection use of internet.
- Impacts on learning and staff workloads.
- Barriers to technology use.

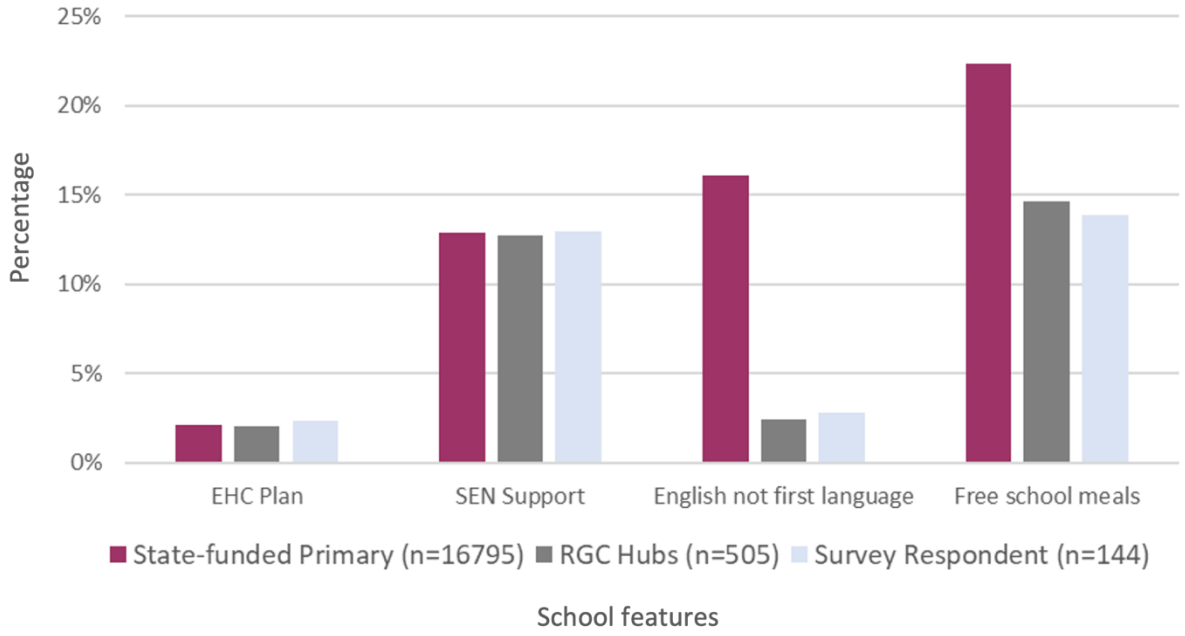
Analysis aims to determine the current position of the school's use of the internet, and then explore the changes using both categorical and textual responses. Key to this has been that the design of the 2022 survey uses baseline questions from the 2020 survey and, while record linkage over the schools across the two waves was not possible, the average change between the surveys offers insight about changes seen in schools. Further, the Education Technology Survey conducted by DfE in 2021 offers some further comparable insight about school use of EdTech.

Surveyed schools

The 2022 RGC School Benefit Survey was sent to 507 schools from which 148 Schools responded. The school unique reference number of the schools was linked to educational statistics for academic year 2021/22. Broadband speeds at OA and LSOA level were then also linked using Connected Nations small area data.

The schools were rural, with all but two respondents from schools in rural areas, and all were primary schools. The regional mix was towards the Northwest, East Midlands, Southeast and Southwest. Other regions of England, except London, were also represented. The measured broadband speeds were 111 Mbps at schools, about double local speeds.

Figure 5.1: Composition of surveyed schools compared to wider population



Source: Survey of School Hubs

By linking to the DfE schools' data, the average size of the surveyed schools (139) was found and was similar to that of all schools funded by Hubs (137). The wider state-funded schools are larger, with 277 pupils. Figure 5.1 also indicates how other features compare with the wider schools population and with the Hub schools that did not respond to the survey. Most notably, state-funded primary schools are more likely to have children whose first language is not English and who are eligible for free school meals. For the share of children that require an education, health and care (EHC) plan and then support for special educational needs, the supported schools look similar to the national average.

Findings from the impact survey

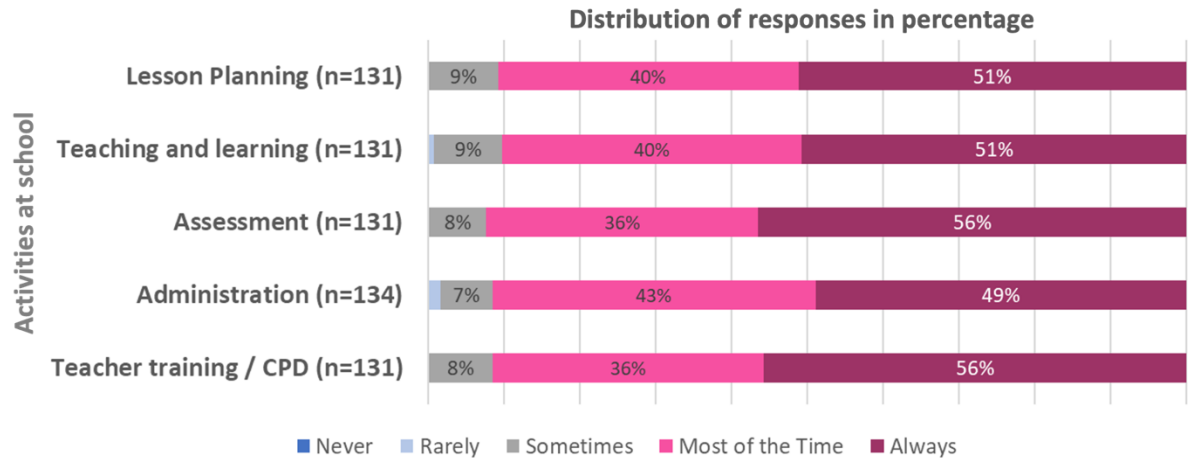
The survey covered the schools' satisfaction with broadband in terms of meeting school needs. This was then enlarged upon by looking at the effects of the improved connection on technology use in teaching, teacher workloads and the administrative use of the internet. This section summarises the findings.

Satisfaction with broadband connection and meeting needs

Schools were asked about their satisfaction with internet connection in terms of speed and reliability and overall value for money. The survey found high levels of satisfaction, with 88% of 138 responses reporting fairly or highly satisfied with the speed of connection, and 82% categorising reliability similarly. In the survey, 71% of 135 responses were very or fairly satisfied with the value for money of the connection.

This high level of satisfaction could be contrasted with the relatively low levels found at the baseline. Then, 45% of responses rated their connection "okay", with 50% viewing it as poor or very poor. The contrast then carries over into the extent to which the broadband meets schools' needs.

Figure 5.2: Extent internet connection meeting schools' needs, 2022

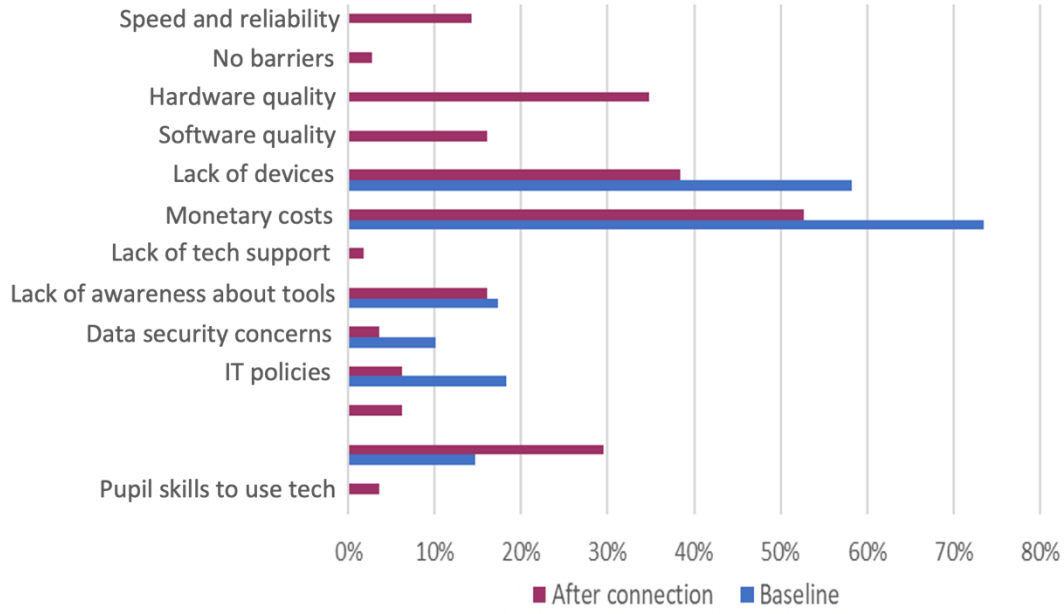


Source: Survey of School Hubs

Figure 5.2 presents results from the survey about five needs and whether these are always met by the connection. By 2022 of 131 respondents, 91% felt connection was meeting lesson planning and other needs most or all the time. In the 2020 baseline, 45% rated the connection Okay, 50% Poor or Very Poor, with the highest being the assessment use (60% regarded it as okay for that need). In 2020, before the connection, schools however said the internet connection was poor or very poor in supporting efficiency (49%), teacher training and CPD (46%), and teaching and learning (46%).

The survey also asked about the barriers to using the internet effectively. Fewer schools report barriers after connection than in the baseline, with Figure 5.3 highlighting how in the barriers that were asked across the two surveys – lack of devices, cost of hardware/software especially – the number mentioning this generally has fallen since the connection. However, there remain barriers, and the survey reports teachers' skills and confidence to incorporate the technology into teaching as a barrier. Qualitative evidence also highlighted concerns about hardware/software complementing connection is noted.

Figure 5.3: Barriers to using the internet effectively



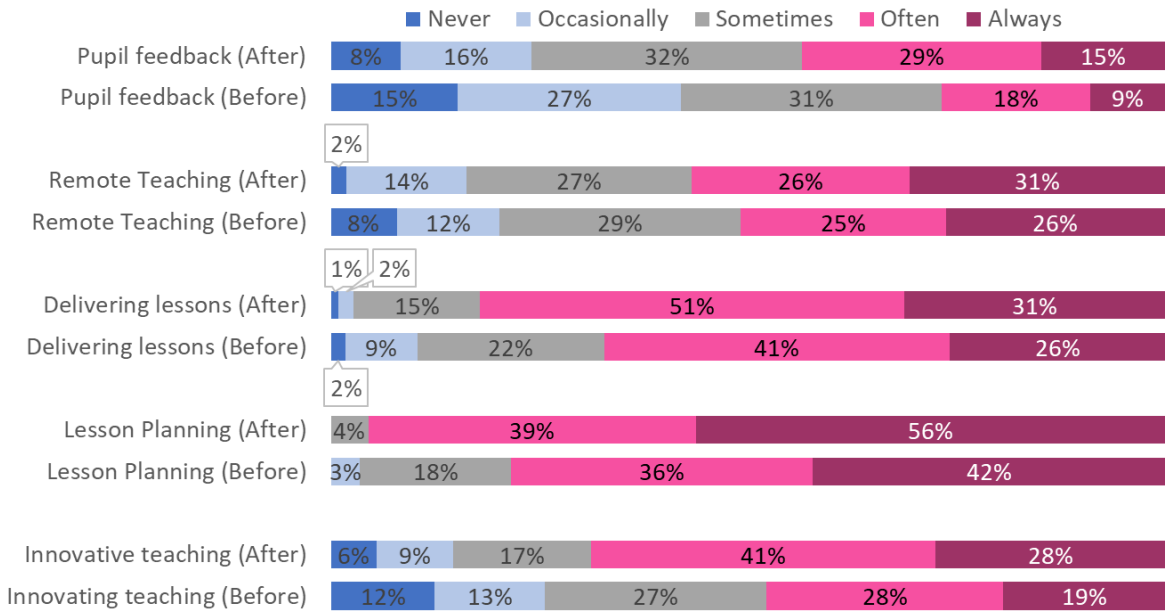
Source: Survey of School Hubs

Technology and effects on teaching/learning

The survey asked about technology use in teaching/learning, exploring whether respondents saw it as changing educational attainment. Schools expect a positive educational/learning outcome. Survey respondents expect that the use of technology will be highly beneficial with 95% of the 88 responses being positive about technology and attainment. Responses to the national EdTech survey are lower, at 64%, suggesting the schools may be more positive on this aspect than the wider set of schools, (though some part of the difference may be explained by the EdTech survey being conducted two years earlier).

The before/after questions about use of the internet in teaching activities asked respondents to rate their use from never in five categories. The largest changes were seen in implementing innovative teaching practices, such as blended learning, and in the use of the internet in conducting formative and summative assessments. In the first, internet use being more than occasional was reported as 47% before the connection rising 22% to 69% amongst the 112 respondents after the connection (Figure 5.4). A rise of 26% is observed in the use of the internet for assessments.

Figure 5.4 How much did you use the internet for these teaching activities before and after the connection?

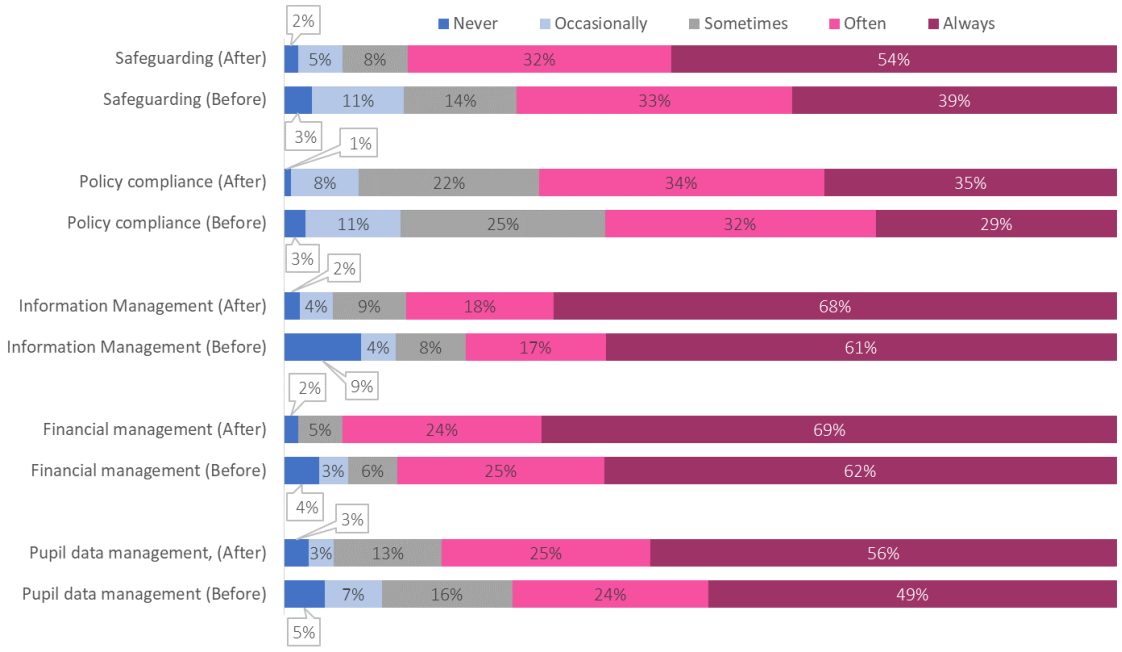


Source: Survey of School Hubs

Technology, Workloads and Administrative Uses

The survey asked about administrative uses before and after connections. Schools reported that the connectivity was used more often in a range of admin tasks (finance, pupil data management etc) than prior to the Hubs investment. Also, workloads are reported as lessening due to technology. In 93 responses, 60% have seen workloads reduced already or are expecting this as technologies are adopted. This question replicated one in a national survey (DfE, 2021), which found that 50% had this view in the DfE EdTech Survey 2021. Again, this difference may, in part, be explained by the EdTech surveying schools earlier.

Figure 5.5 How much did you use the internet for these admin activities before and after the connection?



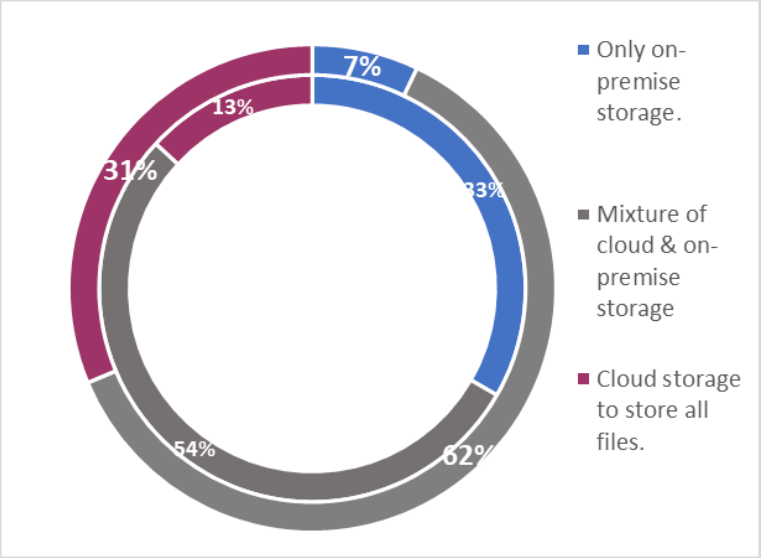
Source: Survey of School Hubs

The improvement of the schools' broadband speed may enable technology adoption. Questions asked about individual activities and the extent to which the internet was either sometimes, often, or always used in the activities. The responses in these categories have changed before and after the Hubs connection. The proportion responding in the positive categories rises across the uses.

Whereas 72-78% of schools were using the internet for administrative purposes in safeguarding, pupil attendance management, finances, and management information before the connection, this had risen by 8-16% in the four activities. The highest change was in response to whether the internet is used in policy compliance related activities, where 51% of schools reported its use sometimes through to always before the connection, rising by 18% to 69% by the time of the survey.

A specific technology – cloud storage of documents – highlights how schools are adopting internet technologies. Figure 5.6 shows the before/after picture with regard to where documents were stored prior to the connection and changes since the investment.

Figure 5.6: Adoption of cloud storage



A school is "currently looking at improving parental communication. Previously, we would avoid any tech-based solutions as everything was so unreliable, but we are slowly changing our outlook on these."

Cloud storage use is growing after connection with – in 99 responses – the share using only cloud storage 31%, higher than baseline 13%. The DfE EdTech Survey 2021 reports 12% of primary schools. Schools report moving to cloud-based solutions and ensuring technology is fully integrated into lessons. They are also introducing changes in administration, such as digital sign in systems, and a digital safeguarding system.

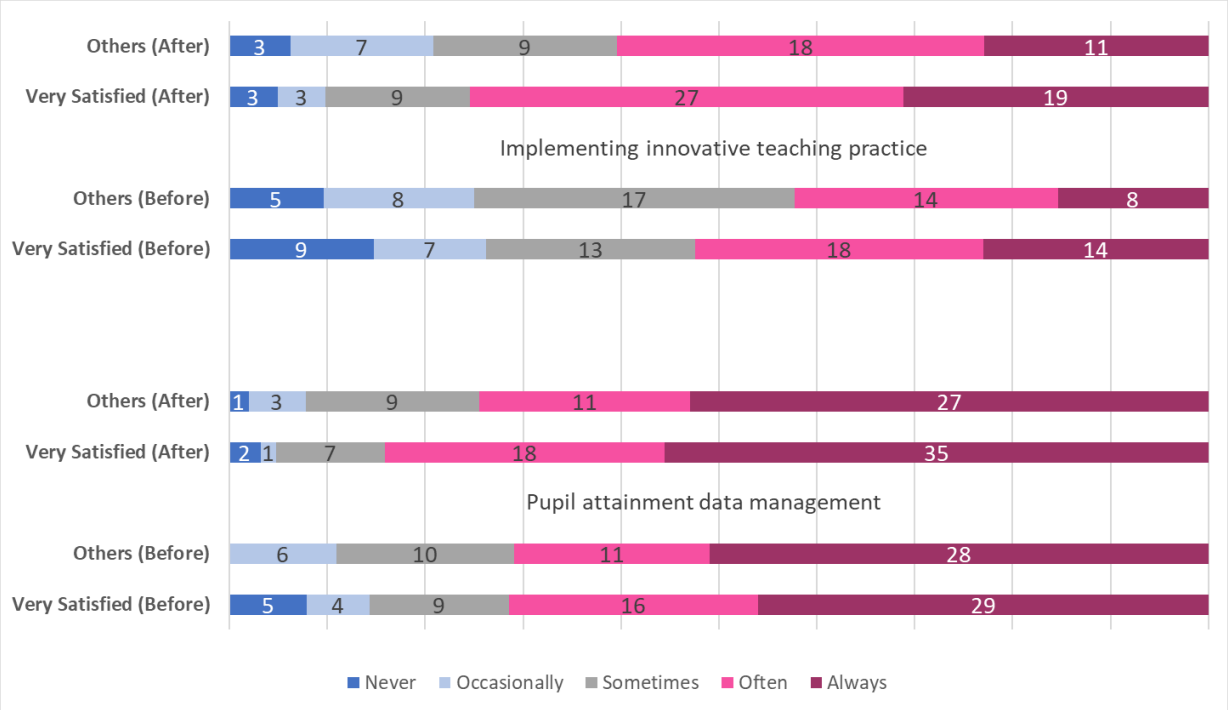
The survey asked about administrative uses before and after connections. Schools reported that the connectivity was used more often in a range of admin tasks (finance, pupil data management etc) than prior to the Hubs investment. Also, workloads are reported as lessening due to technology. In 93 responses, 60% have seen workloads reduced already or are expecting this as technologies are adopted. This question replicated one in a national survey (DfE, 2021, p. 34), which finds that 50% had this view in the DfE EdTech Survey 2021.

Relating internet satisfaction to uses

The respondents to the survey, at the outset, were asked about their satisfaction with the connection. Most respondents stated that they were very satisfied, with many responding that they were satisfied and very few, 12%, falling into the three lowest categories of very dissatisfied to neither satisfied nor dissatisfied.

Figure 5.7 considers two aspects of the changes in the use of the internet differentiating between those that were highly satisfied and the rest. Given the generally high level of satisfaction, the figure does not indicate where different levels of change in the implementation of innovative teaching practices or the use of the internet in managing pupil attainment data. However, on both measures the changes are positive with both sets more likely to be using the internet after the connection.

Figure 5.7: Before/after connection use of the internet by satisfaction levels



Conclusions

The Hubs product has focused on investing in fast connections in schools. There have been 605 schools out of the 1,021 Hubs and earlier analysis has investigated whether the schools have benefitted from additional broadband uptake, identifying that some portion of the improved broadband connectivity in supported schools did not take place in comparable matched schools. An online survey was sent to 507 English schools drawn from the Hubs list. The survey was completed in October and November 2022, after the Hubs connection and there were 148 responses, of which 112 were complete.

- **Hub investments lead to additional broadband speed improvements.** These reflect 35.7% of the changes seen in broadband speed, with the rest being estimated would have occurred without the support.
- **Policy aim was equalising broadband performance in schools to attain standards of connectivity in remote areas comparable to the best.** Paralleling this, was a desire to avoid blocking the development of policies reliant on connections, such as widespread use of educational technologies or use of online assessments, with good broadband connectivity a pre-cursor to these educational policies.
- **Survey found high levels of satisfaction with the speed of connection**. 88% of 138 responses reporting fairly or highly satisfied, and 82% categorising reliability similarly. In the survey, 71% of 135 responses were very or fairly satisfied with the value for money of the connection.
- **Use of the internet in teaching activities increased**. Schools reported implementing innovative teaching practices, such as blended learning, and in the use of the internet in conducting formative and summative assessments. In the first, internet use being more than occasional was reported as 47% before the connection rising 22% to 69% amongst the 112

respondents after the connection. A rise of 26% is observed in the use of the internet for assessments.

- **Connectivity was used more often in a range of admin tasks (finance, pupil data management etc) than prior to the Hubs investment.** Also, workloads are reported as lessening due to technology. In 93 responses, 60% have seen workloads reduced already or are expecting this as technologies are adopted. This question replicated one in a national survey (DfE, 2021, p. 34), which finds that 50% had this view.
- **Cloud storage use is growing after connection.** Share using only cloud storage 31%, higher than baseline 13%. The DfE EdTech Survey 2021 reports 12% of primary schools.

6. Effects of Hubs in local areas

The Hubs product has focused on investing in fast connections in public buildings in otherwise hard-to-reach areas. The logic of the intervention then expected further connections and increased fast broadband take up in the vicinity of the public building. These wider area effects are expected because the Hub investment has brought gigabit capable infrastructure closer to properties that otherwise would be too expensive to connect.

This chapter presents results about this area level effects. It first looks at the quantifiable changes to broadband availability and take up in the vicinity of a Hub, then looking at these effects in two areas of England – Cornwall and South Oxfordshire. Evidence about the school Hubs in two areas is then considered.

Key findings:

- The areas surrounding the Hubs are witnessing a notable increase in the availability of gigabit-capable broadband. Specifically, within a 1km radius of the Hubs, there's been a rise in premises passed by fibre, and the expansion of gigabit availability is occurring more rapidly compared to comparable areas selected through statistical matching.
- However, despite the increased availability, the adoption of gigabit services in nearby areas remains relatively low. There's a lack of observable evidence indicating a significant uptake of the faster broadband options offered in these areas. This lack of uptake could potentially be attributed to the relatively short period of analysis, as it takes time for the deployment of gigabit infrastructure to translate into new connections for residences and businesses.
- Furthermore, Hub investments have been linked to other investments in local schools. Schools in the local authorities are connecting the enhanced broadband connectivity to the utilization of other funding, such as Department for Education, called "Connect the Classroom," and the resulting technological advancements.
- Lastly, the information provided by schools does not strongly identify any effects beyond the school premises or their immediate local areas.

Broadband availability and uptake in the vicinity of Hubs

Hubs are delivering gigabit capable connections to public buildings, and through the improved quality of connection, it is anticipated that public services would be delivered more effectively for local residents. Past DCMS evaluations (e.g. the Local Full Fibre Network Evaluation, DCMS, 2021) sets out the expected outcomes and impacts. There are public service delivery effects, but then also further effects on local connectivity, downstream economic effects, and wider social and environmental effects.

The connectivity outcomes arise as the anchor public building reduces the marginal cost of further fibre investment, meaning nearby areas becoming commercially viable for suppliers. The expectation is that suppliers are encouraged to make additional investments in fibre connectivity, increasing the size of the network in the medium and long term. The local broadband users would be closer to

gigabit connectivity and gigabit availability indicators would rise. As uptake occurs, users would experience improved speed and reliability in their service.

This section explores whether this is observed in the local areas around Hubs. The analysis looks at the output areas (OAs) that are supported through having a Hub investment but then also looks at the availability and broadband performance for the output areas around the Hub output area. The analysis focuses on the output areas that are within 400m and, separately, 1km of the Hub (centre of OA to centre of OA). These areas are matched to comparable unsupported areas, using nine different matches.

Broadband availability in the Hub OAs and the surrounding areas

Table 6.1 focuses on the output areas that contain a Hub plus areas in a circle around the Hub within 400m of the Hub[6]. This alternative definition of treatment views the Hub product as a means to bring connectivity to a wider area than the public building itself.

The table indicates the changes in availability seen in the 2,178 areas and this is generally positive in gross terms, that is before adjusting for what might have occurred anyway due to wider improvements in coverage. The changes are measured from the period before support to the year after. One-year changes are the focus because the Hubs opened relatively recently and there is yet to be data about the more recent changes.

To see whether these changes are additional, differing from wider changes in availability, counterfactual analysis was undertaken. The table summarises nine counterfactuals. Each would provide an estimate of changes seen in comparable but unsupported output areas. The table indicates how many were significantly different and then the difference measured for the median effect across the nine models.

There are 20.38 more premises passed in the year of the Hub opening. This measures the changes in the number of properties that – due to a BDUK project – have gigabit capable infrastructure close enough to them for a connection to be provided at no further infrastructure cost. In comparable areas, there is also a rise in the number of these properties, but the median model suggests that Hub supported areas experience 11.15 more properties passed than the comparable areas, 55% more.

Table 6.1: Availability effects 400m from Hub

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	2178 OAs in treated and matched				
Premises passed by BDUK funded projects	20.28	9 out of 9	11.15***	8.20*** to 14.57***	55.0%
Gigabit availability (% premises)	11.27	8 out of 9	-2.11***	-2.84*** to -0.59	-18.8%

[6] The focus on 400m and 1km circles followed after a series of models were run to look at different distances. Distances below 200m did not increase the number of output areas much, as this is similar to the size of a typical output area in rural parts of the UK. So, the results would look very similar to results in previous chapters focusing on the Hub OAs.

Gigabit availability (% premises, logged)	0.52	9 out of 9	0.19***	0.12*** to 0.24***	37.4%
UFBB availability (% premises)	10.26	2 out of 9	-0.04	-2.05*** to 1.60**	-0.4%
% of premises unable to receive 30Mbit/s	-1.22	9 out of 9	0.67***	0.36 to 1.46***	-54.4%

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

Overall, these positive results have to be viewed in the context of the table conveying a mixed picture about whether the changes seen differ significantly from the change seen in comparable unsupported areas. The number of premises passed in these areas by BDUK funded projects is significantly higher than in comparable areas. The table indicates that of the 44,170 premises that have been passed in the 2178 areas, 24,290 are additional, not occurring in comparable areas.

The growth in gigabit availability is additional as well but only when looking at changes in the logged rates of availability. In all models, the logged changes in gigabit availability grows significantly faster in the output areas that are less than 400m from a Hub than comparable unsupported areas, and 37.4% of the log growth is additional. However, because the share of premises is quite low in these areas in the year before the Hub opens, the 11.27% change in the share measure is lower than all the modelled comparators, and this is generally significantly lower.

To some extent, this justifies focusing on the logged changes, with share of premises measures (the gigabit share, as well as the tabulated changes in UFBB and slow broadband shares) being affected by the starting levels being quite low. So, the 11.27% share increase in gigabit availability is proportionately higher than the control areas but is lower in level terms.

Table 6.2: Availability effects up to 1km from Hub

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	5049 OAs in treated and matched				
Premises passed by BDUK funded projects	17.37	9 out of 9	10.80***	7.76*** to 12.00***	62.2%
Gigabit availability (% premises)	10.50	9 out of 9	-4.00***	-5.0*** to -3.2***	-38.1%
Gigabit availability (% premises, logged)	0.41	7 out of 9	0.07***	0.00 to 0.14***	18.1%
UFBB availability (% premises)	9.61	5 out of 9	-0.74	-2.28*** to 0.94**	-7.7%
% of premises unable to receive 30Mbit/s	-0.93	9 out of 9	0.57***	0.32** to 1.04***	-61.1%

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

Table 6.2 widens the circle around the Hub to 1km and this indicates similar results to the smaller circle. There is again a mixed picture, with some findings consistent with a significant and positive effect on availability. Looking at a larger number of output areas leads to a doubling of the additional premises passed by the projects.

Effects on broadband uptake in supported areas with schools

The availability of gigabit capable broadband will then translate into connections. This section considers the evidence about take up of fast connections in the year a Hub opens and focusing on the areas near to the Hubs.

Table 6.3 summarises results about the 2,178 output areas that are within 400m of a Hub for uptake measures. There is a small increase in the number of vouchers that are received by businesses and residences in the output areas around where Hubs have opened. The differences are insignificant however, from that seen in comparable areas in all the models. The monetary value of the vouchers also is not changing in a manner that differs from comparable areas. Both these measures are growing in the period from before support, but at rates similar to comparable areas.

Arguably, as noted in previous similar analysis, the comparability of the supported areas to the counterfactual in these measures could support a belief that the propensity score matching has found areas that are as likely to be beneficiaries of voucher support as the Hub areas. This may mean they are more suitable as a comparator, in that had the areas benefited from proportionally more vouchers, then any effects may be attributed to this rather than the Hub.

Table 6.3: Broadband uptake effects up to 400m from Hub

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	2,178 OAs in treated and matched				
Number of vouchers in OA	0.13	0 out of 9	0.01	-0.18 to 0.15	8.0%
Value of vouchers in OA (£)	216.50	0 out of 9 5	-11.28	-369.51 to 269.22	-5.2%
Number of connections >=30Mbit/s (number of lines)	6.13	0 out of 9	-0.04	-0.23 to 0.46	-0.7%
Average download speed (Mbit/s, logged)	0.18	6 out of 9	-0.02**	-0.04*** to -0.01	-10.3%

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

Overall, the picture around uptake is that this is not observed to a significant degree in the areas close to Hubs, despite the significantly higher availability of gigabit capable broadband. The only significant difference in the table is that broadband speeds, while increasing at around 18% per annum, this rise is somewhat slower than comparable areas.

Table 6.4: Broadband uptake effects 1km from Hub

EFFECT	Gross change	Models Significant	Median additional change	Range of additional change	Median add'ality
	5049 OAs in treated and matched				
Number of vouchers in OA	0.02	7 out of 9	-0.11*	-0.30*** to -0.09	-617.5%
Value of vouchers in OA (£)	-1.38	8 out of 9	-258.98*	-539.9*** to -176.8	n.a.
Number of connections >=30Mbit/s (number of lines)	6.00	2 out of 9	0.17	-0.22 to 0.38	2.8%
Average download speed (Mbit/s, logged)	0.18	8 out of 9	-0.02***	-0.03*** to 0.00	-10.8%

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

Table 6.4 widens the area deemed as affected by the Hub investment to a circle of 1km, exploring the take up of broadband in the 5,049 output areas. In the year after the Hub opening, there is a different picture emerging for voucher uptake. The voucher funded connections are growing more slowly than comparable areas, and the value of the vouchers is flat in the areas less than 1km from a Hub while it is rising in comparable areas.

Similar to the areas in the 400m circle, the number of fast connections and broadband speeds is improving but this is slower than the comparable areas suggesting uptake is not significant.

This uptake story may be due to the relatively short period of time after the Hub connection for which data has been made available.

Mapping availability and uptake in Cornwall and South Oxfordshire

This section explores broadband availability and performance in two local authority areas. The availability of broadband in both local authority areas has been poor. In Cornwall, the digital infrastructure remains behind the rest of England having one of the lowest proportion of premises with superfast broadband availability. As of December 2022, the county of Cornwall has 46 percent gigabit capable coverage, compared to a UK national level of 66 percent. In South Oxfordshire, accessibility is more mixed with some areas being well-connected especially in areas near the urban centres, but large tracts of the local authority area have poor access, and the average of gigabit capable coverage is lower than Cornwall.

The next sections map this, seeing whether changes observed in availability and uptake are near to the Hub investments.

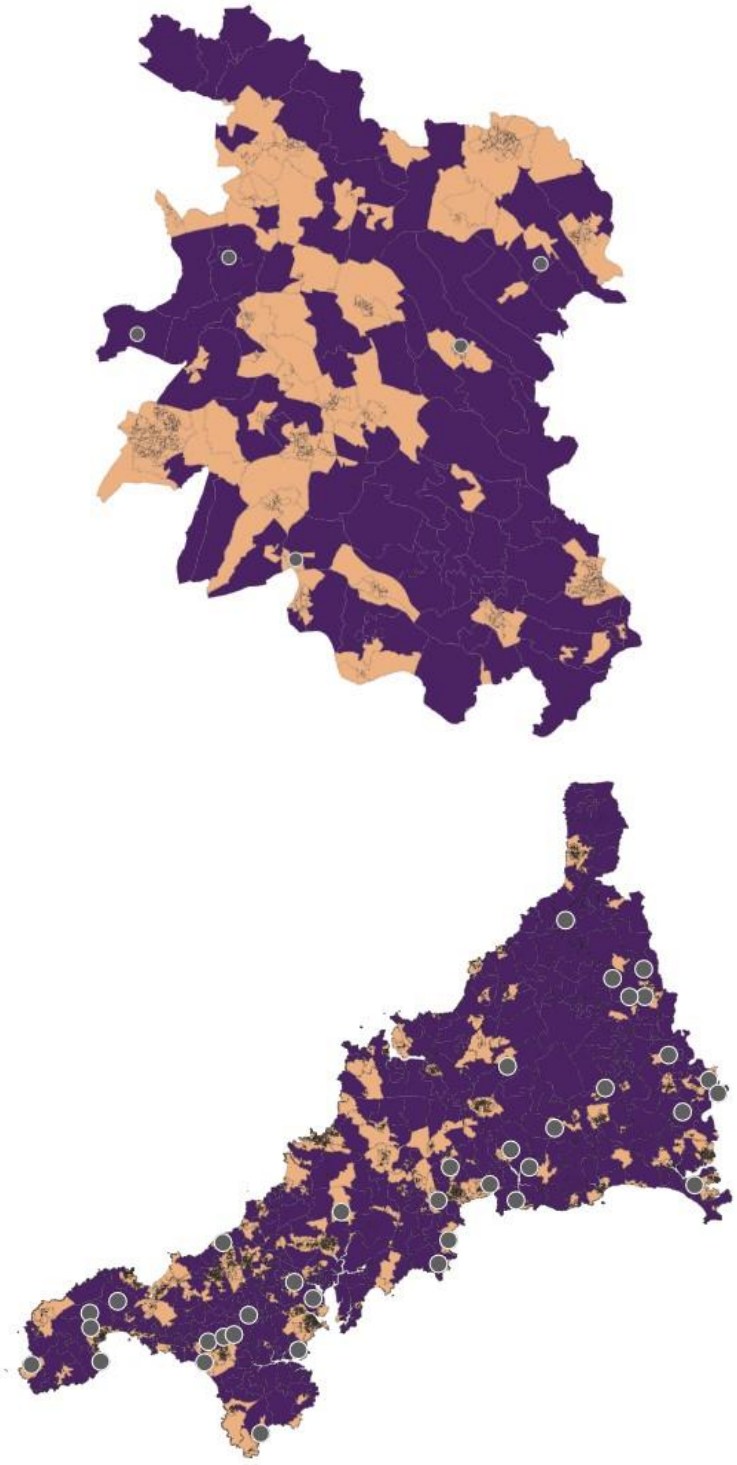
Modelled costs of connecting areas

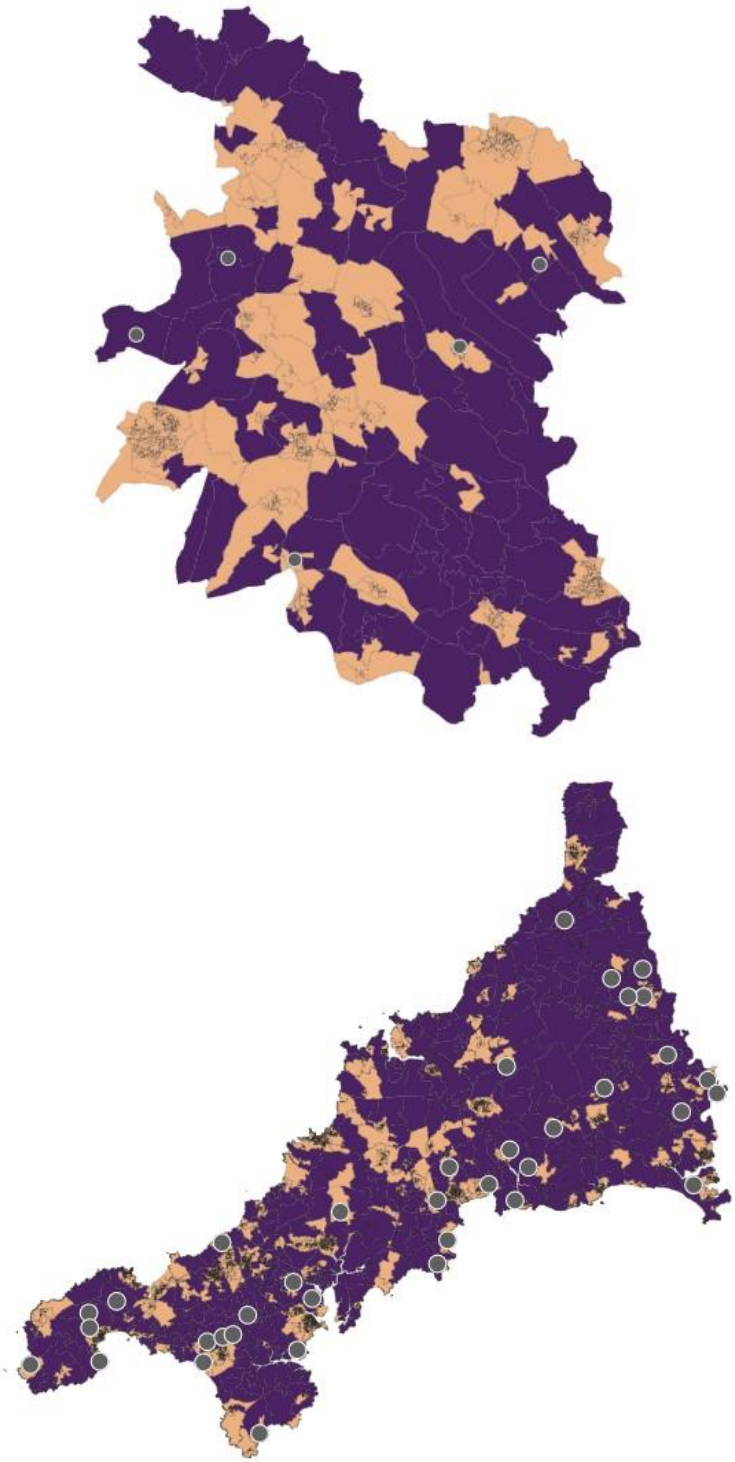
Figure 6.1 maps two local authority areas in England that the rest of the chapter focuses on: South Oxfordshire and Cornwall. There are five Hubs in the South Oxfordshire local authority and 37 in Cornwall, marked with circles

The maps represent in a dark colour the output area where the median property, by cost of connection to gigabit capability, is deemed too high for connection on a commercial basis. The maps demonstrate how substantial portions of each area are non-commercial, with the Hubs located in these areas.

Dark areas are dominated by non-commercial properties, with connection costs for the median property in an OA higher than a cut-off set at a level reflecting broadband provision on a commercial basis.

Figure 6.1: South Oxfordshire and Cornwall F20 cost and Hubs



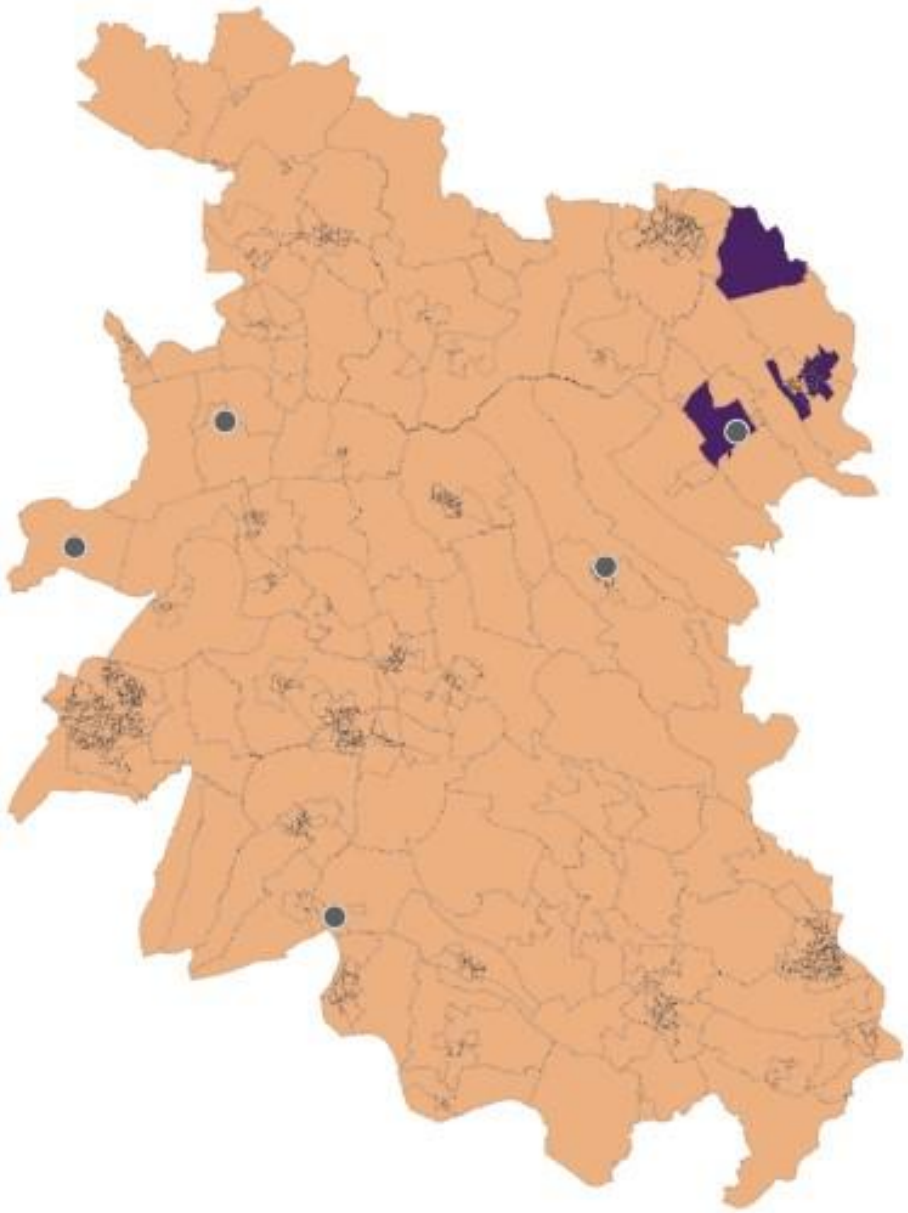


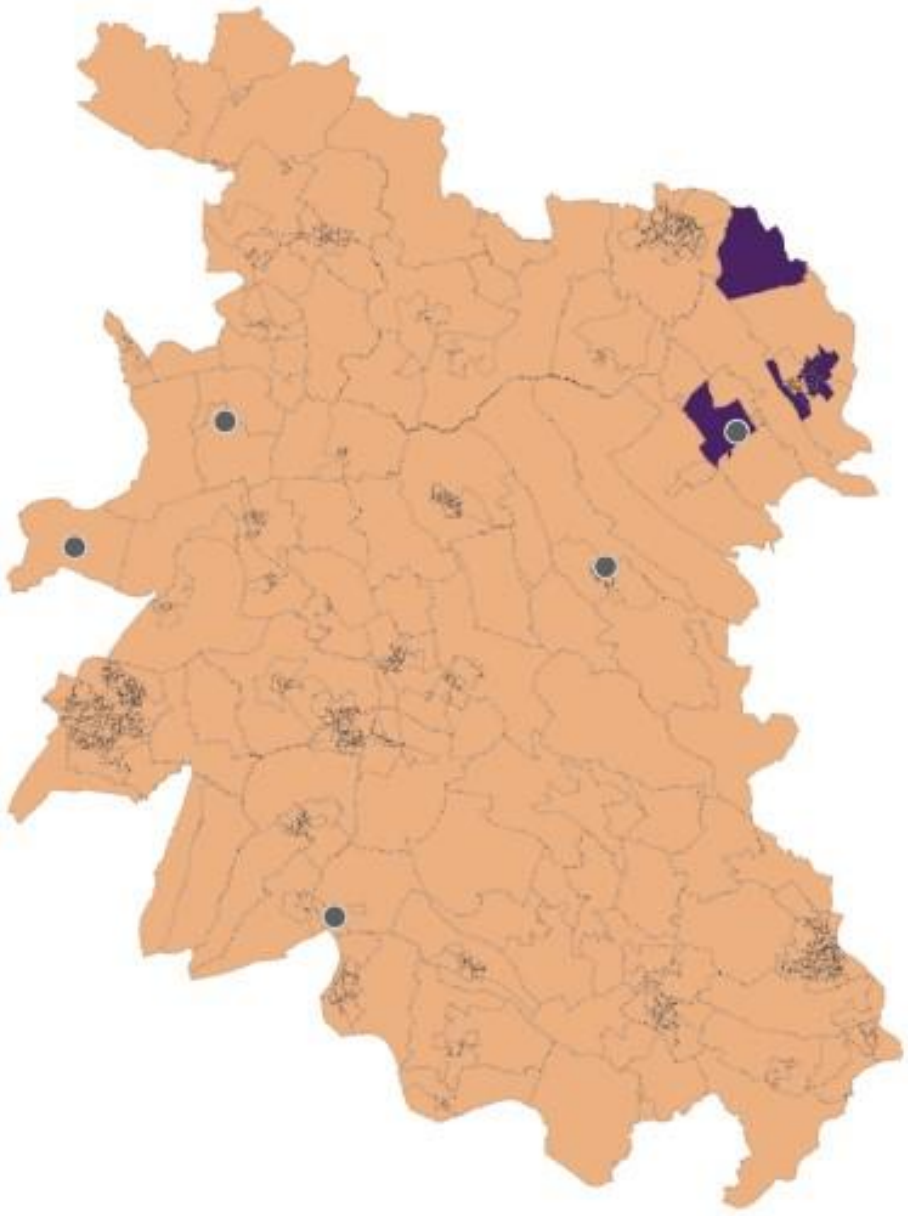
Source: Belmana analysis of Connected Nations data

The next maps indicate what occurs in each of these local authorities after the Hub investments. Figure 6.2 focuses on South Oxfordshire looking at the areas in terms of whether there is a rise in the premises passed. As BDUK has funded connections through the voucher product, and where these projects connect groups of buildings and premises, the suppliers have reported the individual properties that are thereby closer to broadband, passed by the infrastructure. These premises

would not be the connected voucher beneficiaries but are the further properties that can be connected at zero or very low cost.

Figure 6.2: South Oxfordshire change in premises passed and Hubs





Source: Belmana analysis of Connected Nations data

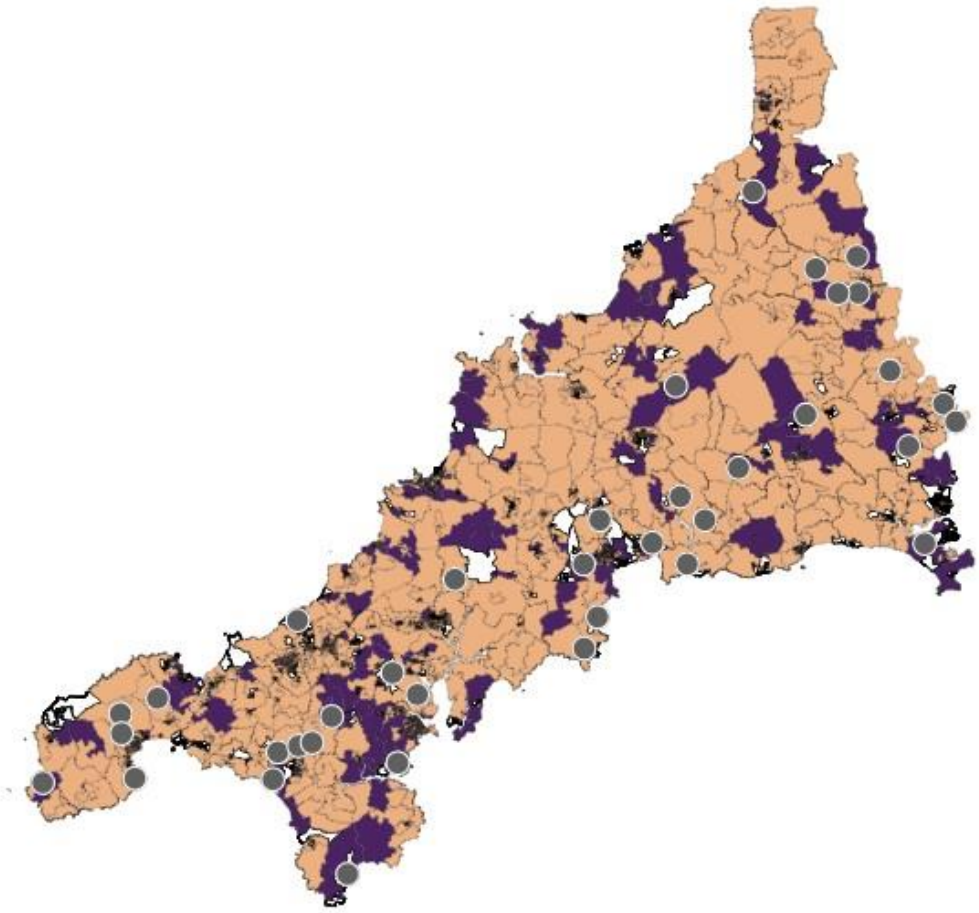
The map considers the counts of these properties in the year after the first Hubs open, that is the period 2020-2021. Generally, bringing broadband closer to poorly connected areas through projects is somewhat correlated with Hub investments. However, as the projects are generally quite discrete interventions, there are many Hubs that are distant from projects, too far to be complementary interventions.

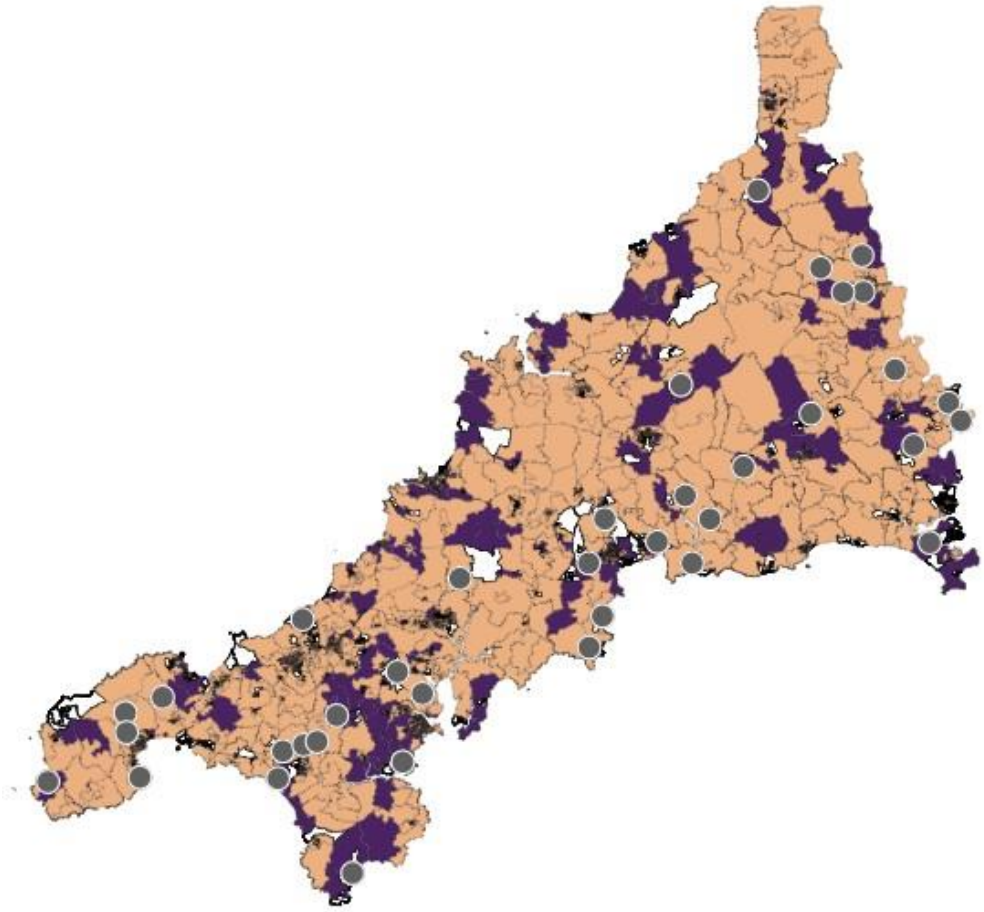
In Cornwall, projects are recording significant changes in the premises passed in less than thirty of the 1,791 output areas, so the picture is similarly sparse to South Oxfordshire. This is annexed.

Figure 6.3 maps out – for Cornwall – a further measure of the availability of gigabit broadband. Darker areas are ones where the changes in the growth of coverage is high. Growth in these areas is more than 5% in the years after Hubs opened in Cornwall. The other areas in the county have generally also experienced a rise in coverage, but the cut-off has been set to pick out, in a light colour, ones where it is not high.

Like other maps of broadband metrics, the correlation between the location of the Hubs and an improvement in coverage can be seen, but it is probably more in showing that areas distant from the Hubs are almost always in the light areas, with low coverage growth.

Figure 6.3: Cornwall gigabit coverage rise and Hubs



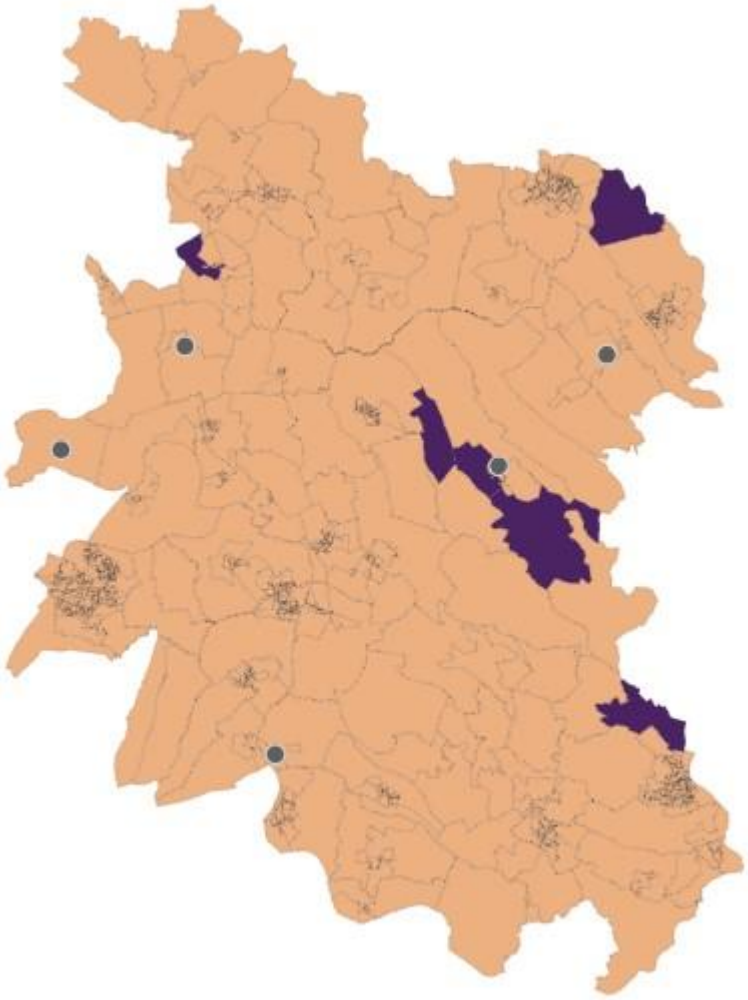


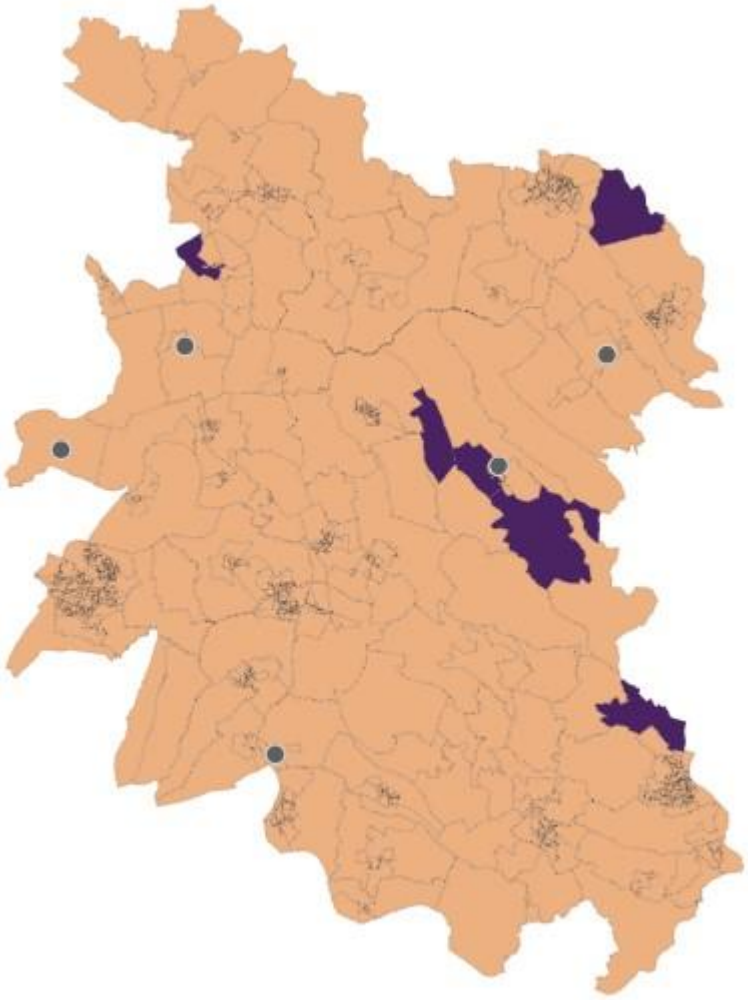
Source: Belmana analysis of Connected Nations data

The picture for South Oxfordshire is annexed. There, a number of OAs have missing data, as the coverage of gigabit was zero in many output areas in 2020, the base year for the growth, and the logged growth from that base is then not defined. However, four of the six Hubs are in areas where gigabit availability growth is high.

Figures 6.4 and 6.5 look at the take up of gigabit connections. As with the econometric analysis, while there is some evidence of availability improvements being correlated with Hub investments, the changes in uptake of fast gigabit connectivity by residents and businesses is less correlated with the Hubs. The first figure looks at connections supported by vouchers, where the level of the value of vouchers (and not the change) is mapped. The areas in the dark colour, where there is a high level of voucher support, appear distant from all but one Hub.

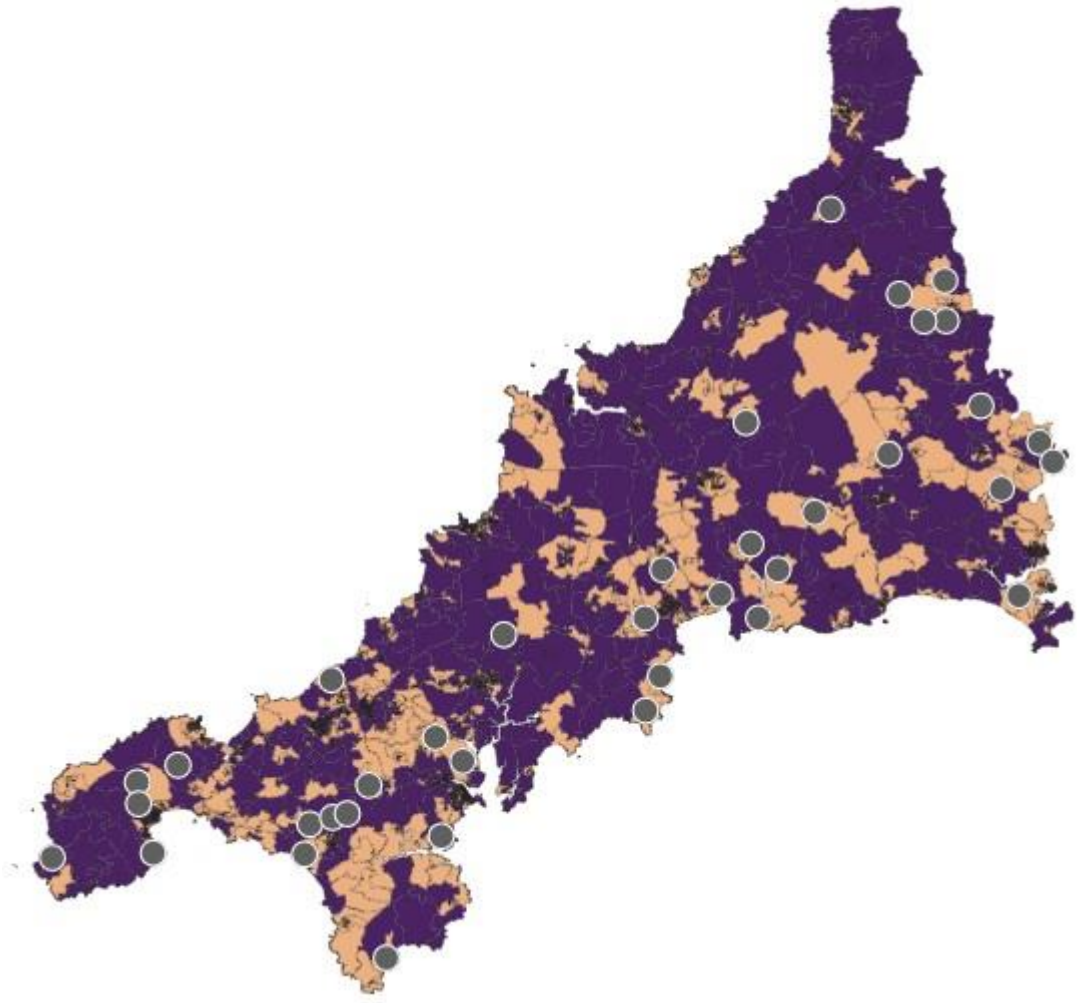
Figure 6.4: South Oxfordshire voucher value and Hubs





Source: Belmana analysis of Connected Nations data

Figure 6.5: Cornwall download speed rise and Hubs



Source: Belmana analysis of Connected Nations data

In Figure 6.5, the dark areas are ones where the speed of broadband increased by more than 10 Mbps. This does occur in Hub areas but is also occurring in areas without Hubs. There are also many Hubs located in the areas that have had modest speed improvements.

There is a consistency between these mapped effects and the econometric modelling of the last section. There are some correlations in the two local authorities between Hub investments and availability of gigabit capable broadband but the story for the uptake of connections is not present. This could be because the Hub investments are relatively recent, and it is too early to then expect for businesses and residential users to have taken up connections.

Hub investments in Cornwall and South Oxfordshire

This section explores qualitative evidence of the effects of the Hubs in the two local authorities. The fieldwork for the study involved in-depth interviews in schools in Cornwall and South Oxfordshire, focusing on small schools with around 120 students. As with other such interviews, these were semi-structured. The interviewees were either with school IT staff (occasionally operating in multiple schools), teachers with an IT role or the head teachers.

In Cornwall, the interviews were conducted in four rural primary schools ranging in size from 105 to 458 students. The schools were connected between June 2020 and August 2021, and – with the interviews taking place in late 2022 – one school was reflecting on over two academic years with the connection, and the other schools having at least one academic year. Three of the Cornwall schools were part of Multiple-Academy Trusts, so were part of organisations running between nine and 31 schools. The schools ranged in terms of their characteristics, so that the schools had between 10-33% students eligible for free school meals, with an average comparable to the English average.

There were four rural primary schools ranging between the sizes of 76 to 208 students and one large all-years school with 982 students in South Oxfordshire. Three connections were for the academic year 2020/21 and one for 2021/22. The large school differed in providing both middle years and International Baccalaureate provision, alongside kindergarten and primary schooling. Across the schools, the eligibility for free school meals was lower than English schools' average levels.

Table 6.4 highlights the main findings about the effects of the broadband investments identified during interviews at schools. They mirror the effects seen in earlier chapters.

Overall, there was positive impact, with respondents being able to complete teaching and administration tasks more quickly and efficiently, to progress more engaging teaching activities, and leading to greater collaboration and uniformity in approaches to teaching, training, and information management. These effects are attributed to faster and more reliable internet connections, alongside the other complementary investments made by the schools. There is evidence of cost savings, with reductions in administration costs, alongside time savings for teachers and parents as operations move online.

Table 6.4: Summary of interview findings

	Cornwall schools	South Oxfordshire Schools
Connectivity before and after Hub investment	Connections before the investments with low speeds – less than 10mbps - and unreliable connections Poor connections caused issues with creating engaging lessons and learning content for pupils Hindered the schools in Trusts achieving greater uniformity in what they deliver to pupils	Poor internet connections before investments Had reached limits of connection speed improvements Schools note various EdTech
Aims and expectations	Across a Trust, move towards better use of the cloud for data management and efficient remote access	Future-proofing systems to keep up with latest IT developments Cautious about future financial burden of keeping up with IT hardware
Outcomes on operations	Large speed and reliability increases, to over 100mbps Reduced IT support and school administration costs with time savings as easier access to pupil records etc; Enables cloud first approach across a Trust Online meetings between teachers, parent-teacher more widely used and improved quality Completion of staff training online	Significant purchases of IT equipment enabled by Hub and funded with Connect the Classroom. Widening use of cloud-based systems Communications using platforms such as Teams or Google Meet, although external communication with parents and other contacts remains relatively unchanged; procured VOIP phone systems Annual connectivity costs reduced significantly
Adoption of technology	Wider use of streaming sites such as BBC, YouTube, White Rose Maths and Oak Academy Enables Connect the Classroom funding Move to an app-based communication platform, which can allocate work to individual students More year groups accessing IT and more frequently	Investments in interactive whiteboards for all classrooms Enabling students to use laptops and tablets by improved Wi-Fi More active use of technologies already adopted in administrating school

Schools reported having poor internet connections prior to the investments but were not actively looking into ways to increase their broadband speed at the time they received Hub support, with the prevailing view that it was unrealistic for them to be able to address wider infrastructure issues to bring gigabit capable broadband nearer the school. Some schools had explored options, such as satellite broadband but Hub investments were viewed the best means to address the wider local connection issues.

"We had access points, but reliability wasn't great: it would drop out."

"We are a tiny school, if this wasn't offered through a government scheme, we wouldn't be doing it."

The application process was viewed as "very straightforward". Mirroring findings from discussions with suppliers, schools heard about the Hubs programme from DfE inviting the school to apply, as they had been identified as a suitable rural school. IT leads in the schools often were either supporting school heads or progressing applications.

Schools were generally happy with the installation process and recalled that most of the connection activity took place off-site. There were views that it could have been faster, noting that it took over one-year to get the fibre line in: "We got equipment in and running but it took a long time for Openreach to get the line in."

Area level effects

This section considers some of the local effects of the investments. Earlier chapters have explored the direct effects of the investments in schools in then allowing teaching and administrative changes especially by adopting educational technology, but a question is whether there are indirect effects in the nearby areas, or the direct effects are enhanced because of the location of the schools.

Importance of Connect the Classroom

A first spatial effect is that the Hub investment in broadband has enabled further resources being directed to rural schools. English schools are eligible for DfE Connect the Classroom funding, which supports investments in educational technology in the schools. Connect the Classroom is not funding the connection to the school, but schools securing the Hub investment has acted to leverage into local areas the DfE funding.

Hub schools all recognised the Hubs programme as the enabler for this and understood how the two programmes complement each other. Respondents are generally pleased with the improved internet provision usually referring to the combined benefits from the Hubs programme and Connect the Classroom. Most cite better reliability first, and increased speed / capacity second.

"The new connection has been very reliable with no issues at all. The speed has improved, and we find the connection no longer dips in and out. We rarely have any issues, whereas before we often had to reset our router."

Primary schools have made significant purchases of IT equipment since securing Hub funding, such as new interactive whiteboards at one school worth £8,000; and new iPads for pupils at another worth £11,700. Respondents felt these purchases would not have happened without the programme. One of these schools also reported investing in a replacement server, which would not have been possible without Connect the Classroom. There has been an increase in use of tablets and laptops as the fibre broadband backbone has been enhanced.

"Quite a lot of laptops are being used now, we previously didn't have the bandwidth to support this. We are moving towards getting a laptop on every desk. The same with tablets, we are getting more equipment in, using more tablets and laptops for general use. For example, one of the PE teachers is using a laptop to record lessons, one of the requirements for the IB diploma."

However, recognising the speed of internet is much faster now, some schools also reported they were addressing the low performance of site Wi-Fi, using funding from Connect the Classroom.

School effects and rurality

There were effects in the way schools operate that had a spatial dimension, tied into the rurality of the schools and low speed broadband raising the costs of doing things. A headline impact from a Cornwall Trust was reduced workload for IT support, as some IT issues could be resolved online without needing to visit the schools. Travel can be costly, and congestion affected as, in the summer term, the county experiences higher volumes of traffic owing to the tourist season.

Administrative functions are becoming 'cloud first' across this Trust. School information management can be on a cloud-hosted platform that can be used at home by both teachers and admin staff. This was exclusively onsite, so when teachers and classes were 'virtual' due to Covid, they could not take a register. Moving to the cloud meant the school could 'move the whole school online', which was useful during the pandemic, meaning children were able to continue learning whilst at home during the third lockdown, and staff were able to monitor attendance and progress through the online systems.

Other savings of time and efficiency include staff at the schools and across trusts are able to join meetings remotely. This is valued in arranging parent meetings to review the Education Health and Care Plans (EHCPs) of children and conducting remote parents' evenings via an online platform.

Teaching and administration staff are now able to complete some training online without the need for travel. This has become more important since the pandemic with more training being delivered online. With the schools' geographical locations, that would have implied travel costs and whole days out of school which would have to be covered.

Effects beyond the schools

In-depth interviews at Hubs did not reveal respondents being aware of benefits extending beyond their schools. Some respondents recognised that the connection to the school passed by properties, but regarded the numbers as quite small and did not feel able to comment on the take up of broadband related to this. However, there have been some community uses of the school that have then benefited from better broadband in the public building. In one school. An independent company holds breakfast and after-school clubs; the school has also been used for a family targeted support session. Such users did then have access to and use the school's broadband.

Further interviews were also conducted with members from three Parish Councils in Oxfordshire that contained a school Hub. Parish Clerks and Councillors expressed concern that the limited number of connections that could be secured via an RGC Hub had created or exacerbated inequalities in internet access within their parishes:

> *"Well, the Hub at the school is of no bearing to anybody, apart from 11 houses out of 16 in [a particular location] and …[around]…3 houses in [a specific lane]. For anybody else, it may as well not exist… [These addresses] they'll get speeds of up to 900 megs if they want it. Anyone else? Sorry it's not available. It's that close to a postcode lottery*

All three Parishes had copper-wire-based cabling in the village network, on which the connections to individual houses relied after the fibre broadband to the cabinet (FTTC) was connected. Cabinets are often centrally located, and Councillors observed poorer connection speeds and reliability for houses and businesses located further away from the Parish centre.

> *"…one of the problems we have with [our Parish] is that we're a very long and narrow village, so I think we're probably about 3 to 4 miles from one end to the other. But of course, that's just a longer road…with the result that even with fibre to the cabinet, all*

of the cabinets are sort of in the middle, and that's fine for people in the middle of the village, but the extremities tend to be a kilometre or so away from the cabinets…So in some cases get a worse service on FTTC than they did on [A]DSL." (Councillor, Unnamed Parish, Oxfordshire)

Interviewees also noted that these problems become more acute for business parks located in the outskirts of villages and towns.

> *"I think if we wanted a Hub anywhere, we probably want one up here [points the cursor to an area of a map of the Parish which is a business centre]. I think a lot of those companies [currently renting office space at the business centre] aren't reliant on Internet…They [the business centre owners] haven't complained a lot, but I believe it's…preventing new ventures…it's a fairly small group, a set of office spaces, so they're possibly not looking for that much new custom…but I would anticipate that, over time, they might find it harder to attract people there."*

In terms of the resulting speed levels, at extremes in the network, Councillors suggested slow speeds, of 20 or 30 Mbps, are forcing alternatives such as use of mobile broadband or satellite internet. An interview with a parish councillor took place over mobile broadband because the council's office had poor speed and reliability through the fixed network:

> *"So, for me as the Clerk…right now we're talking off a SIM card because we have no broadband to the parish office at all. Which means the signal is patchy, it drops out. We do our best [and] overall it's fine, but I quite often find myself having to retreat home to get a good enough plug-in connection to send out some of the bigger files I have to send."*

> *"Basically, we're genuinely looking at Elon Musk's offering as our only option of broadband... They're only bringing [the Hubs scheme] right to the very middle of the village. There are a lot of [areas in the] village like us, the little bits out on the edges, who are again facing being cut off with no recourse or ability to access what is a modern necessity…*

Interviews revealed a high level of frustration with this aspect, as the rural nature of the parishes meant that economic activity was much more evenly spread and connectivity was brought "to village centres, and it's almost at the expense of the real working world outside of the village centres."

Councillors highlighted a concern was making access in the centre even faster at a time when the businesses and households in the outskirts of the Parish faced losing access to any type of broadband. The Hub connection, often provided by BT Openreach as a one-off installation, could deter the providers willing to serve the edges of villages. The reasoning for this varied by the supplier, but interviews felt properties were losing their connectivity as suppliers withdrew. An issue cited was that some non-Openreach suppliers would like to connect an area in its entirety. Their business model invests expecting to reach a level of scale in connections that justifying the high costs of the first few connections in an area. This may be hampered by the Hub connection being one of those first connections but being provided by another supplier.

Conclusions

The Hub funding targets hard-to-reach public buildings with direct effects on the services provided in the school, GP surgery or other public facility. This chapter has provided first insights about the

spatial effects of the Hub investments beyond those seen in the directly supported area. The approach taken is both quantitative and – with a limited sample size – qualitatively.

The quantitative evidence takes a counterfactual perspective, comparing the changes in broadband availability and uptake levels before and after the Hub investments with comparable areas which did not have the investments. The qualitative evidence is limited because the study had been undertaken after Hub investments. While the Hub respondents have been able to recall the situation before the Hub and so provide evidence about changes in the Hubs, there has been a limit to the extent to which others involved in the Hubs could be engaged in the qualitative evidence gathering. In further work, looking at Hubs as they are connected, there will be a great opportunity to collect evidence from other local stakeholders, such as suppliers, the local authority, government, and community bodies involved in the connection of the Hubs, as well as better gauge wider community stakeholders' views. Any engagement with these stakeholders may also provide an opportunity to validate the empirical evidence. For example, the maps of broadband connectivity could be validated in dialogue with local knowledge.

However, overall evidence in this section presents some findings about the area level effects:

- **Areas around the Hubs experience an increase in the availability of gigabit capable broadband.** The areas within 1km of the Hubs have increases in the premises passed by fibre and the growth of gigabit availability is faster than the comparable areas selected using statistical matching.
- **Despite availability, the take up of gigabit is yet to occur in nearby areas.** There is less evidence of the taking up of the faster broadband on offer in these areas, with no additional broadband speed changes or taking up of voucher-supported connections. However, analysis uses data only a few months after the connection of the Hub, so this could be due to the lag between the bringing of gigabit to an area and this leading to residences and businesses securing new connections.
- **Mapping two local authority areas correlates the increased availability.** There is a correlation between areas that do not see a growth in gigabit availability with distance from a Hub, indicative of the spatial effects. However, this evidence needs validation.
- **Hub investments are associated with other investments into local schools.** A complementary funding stream from the Department for Education – Connect the Classroom – allows schools to invest in educational technology. The schools in the local authorities link the improved broadband connectivity to enabling use of this funding and the consequent technologies.
- **Limited evidence from schools of wider local effects.** The qualitative evidence provided by schools does not identify effects of the Hub investments beyond the school and on the local area.

7. Conclusions

This chapter summarises the findings of the study and provides an indicative analysis of the costs and benefits that can be assessed in monetary terms. There is a range of evidence of impacts from the Hub investments. It covers effects at the Hubs themselves, and the wider broadband networks in areas relatively difficult to service with gigabit capable broadband. The chapter also provides some evidence about value for money. This was not a focus of this stage of the evaluation and the interim findings are partial feeding into future evaluation work. It looks at effects soon after the Hubs have been connected, focusing on the English school Hubs where there is counterfactual impact evaluation evidence. Analysis is in line with the principles of the HM Treasury Green Book but, at this stage, probably can only represent a part of the benefits. Some further benefits are either yet to occur, or yet to be observed in data that can be used to value the benefits.

Key findings:

- Looking only at the changes in spending on educational technologies in school Hubs, there is evidence that benefits are on track to be greater than costs in monetary terms. The Hub schools are spending more on educational ICT than is the case in comparable schools and that switching of resources if maintained for five years will be similar to the cost of the connection. This measure focuses only on one school activity and so would understate effects, not including other effects that the study finds but cannot be valued.
- The more qualitative impact findings correlate with these. The schools report using their fast broadband in a variety of ways, enabling more adoption of education technology, improvements in the way schools are administered and numerous examples of IT being used in school operations and education.
- Where there is less evidence of effects is on the uptake of broadband near to the schools by the wider communities in which the Hub investments were made. This may reflect a timing issue, with the study taking place relatively soon after the Hub connection.

This report covers the initial stage of a multi-staged evaluation. The chapter ends with some of the next steps in the study. Next stages of the evaluation involve wider evidence gathering to capture more of the effects of the Hub product and, as the later stages will benefit from more years of evidence, analyse beyond the short-term effects of the Hub product.

Findings about the impact of the Hub product

This study focuses on the early impacts of the Hub product, answering a research question about how effective the product has been in delivering additional benefits soon after investments. The study mixes quantitative analysis with qualitative evidence to understand these effects.

The study firstly looks at the outcomes enabling public sector efficiencies. There is evidence of additional uptake of fast broadband at the Hub using Connected Nations data. The speed of broadband in postcodes of school Hubs grows faster than comparable postcodes which have primary schools, are equally distant from the broadband network and similar in other characteristics. A third of the speed increases in Hub postcodes are attributable to the Hub products.

The study has found survey evidence that, in schools, faster broadband leads to increased use of the internet in teaching and administration, and there is adoption of educational technology. Attribution to Hubs is complex as there have been considerable complementary public funding of the IT needed to make use of the reliable and faster broadband that would also contribute to the internet use changes seen in schools. However, qualitative evidence suggests the faster broadband at the Hub has enabled the benefits from educational technology investments into schools in remote areas.

There has so far been limited additional take up of broadband in the residential and businesses near to the Hubs. However, availability, i.e., the share of properties passed by the gigabit capable network, has increased faster than comparable areas so that more premises could be connected relatively cheaply and on a commercial basis. As the study is quite soon after the Hubs connection, the businesses' and residences' take up of a connection may be yet to occur.

Households and businesses that have been connected recently using a government-funded voucher were surveyed and analysed, comparing those near Hubs to those not near a Hub. The benefits of the connections near to Hubs are similar to those seen in connected properties distant from Hubs. However, near to Hub areas, voucher recruitment is more likely to result from community networks, rather than supplier marketing. Also, residents close to a Hub are less satisfied with their connection, compared to residents in the wider vouchers sample, but a higher proportion of residents close to a Hub reported an increase in their life satisfaction.

Assessing value for money of Hubs

Analysis of the uptake of broadband in postcodes that contain a Hub school demonstrate the effect of the Hub investments. Looking at the change in speed at this detailed geographical level highlighted that English primary schools benefiting from investments had a significantly higher growth in speeds than comparable postcodes where there is a school. A question then is whether the educational or school administration use of the internet changes as a consequence of the broadband improvement, and whether any changes differ to those seen in schools that did not receive the Hub investments.

Context for assessing value for money

The qualitative evidence from earlier chapters highlights how school Hubs do change their behaviours, with surveys and in-depth interviews of the schools finding that educational technology has been adopted, that there have been changes in the way that schools are administered and that specific activities are making more use of broadband. This is attributed qualitatively to the improvement in the school's broadband by interviewees.

However, there remain some key steps to robustly validate this. It would be useful to have a comparator to understand what might have happened anyway, in similar schools that did not receive Hub funding. Schools are generally investing more in broadband and related educational technologies and so these underlying trends may explain a portion of the changes that have been found in the school Hub surveys and reported by those interviewed at Hubs. In addition, there is likely to be other support provided to public buildings to make more use of digital technology.

The earlier analysis has allowed the first issue to be addressed, by developing a dataset about schools that covers both the Hubs and the schools that are in comparable areas with schools. The approach relies on data that is available across English schools. This section looks at a further such dataset, collected from all schools in England about their income and expenditure, covering the period 2017-18 to 2021-22. The data is the DfE Consistent financial reporting (CFR) framework. It covers Local Authority maintained schools, providing overall costs and income, but also then

breaking this down by CFR expenditure and income codes. These codes cover spending that approximates learning costs associated with the use of educational and information technology. There are also details about ICT equipment spending.

Analysing the resources allocated to technology after a connection

The data is at school level and cover 455 of the English school Hubs, of which 365 have been matched to 165 comparable unsupported schools. This ability to find comparable schools is then used looking at spending measures on a per pupil basis.

Figure 7.1: Total and ICT School Expenditure, £ per pupil, 2019-2023

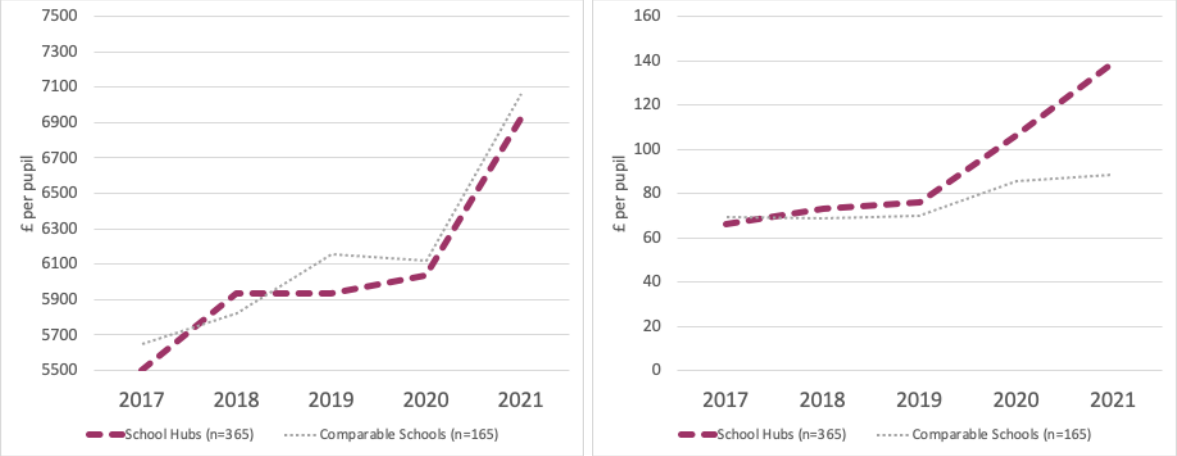


Figure 7.1 indicates the key findings. In the first panel, overall expenditure is plotted for both groups of schools and the changes seen are similar. The annual total expenditure per pupil reported in CFR averaging over Hubs – dashed plum line – tracks that seen in the comparator schools. As with earlier analysis, nine models for the control were tested. They differed by how matching to comparators was modelled and varying the pool from which comparable schools were selected. The grey line indicates the median modelled control of these. There is no significant difference between Hubs and comparable median primary schools in total expenditure and, overall, only 1 in 9 models has a significant difference, and there is no consistency in the sign of the differences.

Turning to ICT expenditure, the right-hand panel indicates the expenditure per pupil on CFR code E20, ICT learning resources for five financial years. Until 2021, around spending is £70 per pupil for both Hub schools and comparable unsupported primary schools. However, there is a pickup seen in Hubs that is significantly higher, at 5% confidence, than in the median model, and this is the case across 8 of the 9 models.

The detailed expenditure records also show how much schools spend on ICT equipment (which is capital expenditure). Hub schools invest £18,700 in ICT equipment (CE04), £8,200 more than comparators, significant at 1% in all models. This is at a whole school level and aggregates across five years, recognising that capital expenditure is more lumpy.

Expenditure changes and value for money

The changes seen in the school Hubs indicate how, following the broadband connection, there is a switch of resources towards educational technology. It also values that switch. As total expenditure is changing in similar ways in the two sets of schools, but there is expenditure moving into

educational technologies, the size of that switch indicates the higher value placed by schools on these expenditures than alternative items of spending.

Where resource switching occurs, there are two effects. A first sees £70 per pupil removed over two financial years 2020/21 and 2021/22 from other spending, lessening the outcomes derived from that alternative spending. However, by reallocating to ICT expenditure, this implies a value of at least £70 per pupil is being place on digital technologies. Further, as switching is occurring, it suggests that there is some further educational value surplus motivating the switch. Determining the scale of that surplus is however difficult to assess. The CFR indicates school size averages of 130 pupils so the expenditure switching is just over £10,000 per school over two years. There has also been a switch of £16,000 in capital spending towards ICT, reflecting the purchase of tablets, screens, networking hardware. These are changes not seen in comparable schools and indicate value for the Hub investments, but to what extent it justifies the cost of the connection needs further work.

Robustness of assessing value for money

The focus of this first stage of the evaluation has been exploring early impacts of the Hub product. Within a wide set of interventions to both increase the availability of gigabit capable broadband and the adoption of digital technologies in public services, the case for Hubs is complex. Bringing the infrastructure needed for fast broadband to remote areas of the UK through connecting a single premise may not then cause the further access to broadband: there are other policies also encouraging connectivity. Equally, with the study focusing on schools, the how general results are may be questioned.

The approach taken has been mixed methods, with individual parts of the impact story being tested qualitatively, quantitatively and with a counterfactual. The evidence for Hubs causing effects does then stem from the counterfactual, survey, and qualitative evidence available for English schools.

This centring on one type of Hub is – at this stage – due to the breadth of methods used only providing a complete picture for these Hubs, and so the findings for this type of Hub are the most robust. Using a counterfactual provides a comparator to what would have happened without Hubs. This provides a set of schools that are as likely to use or not use other subsidy funding, as likely to be close to or far from the gigabit capable network etc. The Hubs' higher take up of broadband and the increased adoption of digital technologies is then partially due to the Hub investment, and the analysis has sought to robustly identify what portion is caused by the Hub investment.

However, the analysis is yet to find evidence of wider uptake of gigabit broadband beyond the Hubs. Further, whether the English schools' effects are replicated in other types of Hubs is not yet evaluated.

Next phases of the Hubs evaluation

The evaluation aims firstly to look at the case for the Hubs product in terms of improvements to the delivery of public services at the Hub site. This aim has been met by the collection of qualitative and quantitative evidence about effects but focusing primarily on schools. Schools have proven to be the most important type of site, and this phase of the study has benefitted from the large number of such Hubs, allowing robust surveys of the schools and enough quantitative evidence to estimate additional effects statistically.

The next phase of the evaluation will seek to widen beyond this type of Hub, considering the other significant Hub types. Applying the approach taken for schools may be possible. Firstly, looking at

area effects by comparing all Hubs to areas matched by being costly to connect to the broadband network and also having a public building would allow analysis of additional broadband uptake and availability effects. Secondly, looking at changes in the use of digital technologies through surveys, financial and activity data may also be possible for some of the Hub types. The surveys can provide a qualitative picture, accompanied by in-depth interviews. The financial and activity data may allow some counterfactual analysis, if, as with schools, the data covers both Hubs and unsupported public buildings.

An aim of this evaluation is also to look at the network effects of the Hub investments. The bringing of gigabit capable broadband to areas distant from the fibre network should then mean nearby properties, both business and residential, could connect at affordable costs. This study has not yet been able to find broadband uptake effects due to the Hubs. The explanation for this may be because the Hub investments are relatively recent, and it can be expected that the further connections are likely to occur with a lag.

There will be a sequencing for these network effects and the evaluation throws up some pathways for these wider uptake effects. Areas near to Hubs are benefitting more from vouchers, not in the number of vouchers but in the higher number of premises that are passed as voucher connections are made. Hubs have generally been connected through Openreach and next steps would involve suppliers delivering connections from the Hub investment. Time will be required to scope and then implement works, as well as the marketing of availability of fast broadband to property owners. For the next stages of the evaluation, various evidence is to be gathered across this sequence of steps, such as looking at the Hubs product processes and the involvement of supplier as they shape connection plans.

If these impacts are observed in the future study, assessing the value of any benefits could use approaches developed for the recent BDUK Gigabit Voucher Study. Hatch (2023) considers productivity impacts in businesses, well-being effects in households and environmental effects. The methods allow valuation of some network effects:

- **Well-being effect of faster broadband.** There are HM Green Book consistent values for increases in measured well-being, with the measures derived from standard questions put to households. Past studies have then correlated the surveyed well-being changes with the roll out of broadband to provide tools to model monetised effects of improvements.
- **Productivity effects of faster broadband.** Hatch (2023) looked at businesses that benefited from a fast connection through a BDUK voucher. The firms' employment after this is tracked in government data made available for research at the Office for National Statistics. A counterfactual approach can be used as ONS has all businesses' employment over time, and the additional employment is linked to wage levels of the jobs to ensure any employment effect is only measured in terms of better jobs (adjusting for the reallocation of employment).
- **Environmental benefits.** The effects of improved broadband on reducing travel is apparent in various parts of the study and could be a significant impact in the more rural areas where travel costs are high. Hatch used survey responses about travel patterns, then valuing the reduced emissions as surveys indicated lower travel-related energy use.

Applying these to the Hubs product would be possible but this would have to be adjusted for how the Hub product differs from the voucher. Most importantly, the voucher directly incentivised businesses and households to take on a gigabit capable connection. However, the impact of the Hub product is directly only on the public building, with any effects on nearby properties being indirect. Any analysis then also has to take account of there probably being BDUK Gigabit Voucher

beneficiaries in the nearby premises and attribution of effects would have to be largely allocated to the voucher.

A third aim of the evaluation is to look at the supplier market for broadband services in the areas with Hubs. The next phase of the evaluation will repeat the qualitative approach taken in this study. The widening of the number of areas studied should improve the robustness of this approach.

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Annex A: Datasets developed

To undertake the impact analysis, characterising the areas served by Hubs is important. The Hubs are being connected in areas that are remote in terms of the broadband network. That provides a start to characterise where Hubs are being delivered, but there are also socioeconomic, broadband coverage/performance and public service delivery drivers for a Hub investment. This annex looks at the data that has been compiled to explore the Hubs connections. Various datasets are linked at an output area (OA) level.

Coverage and performance data: Connected Nations

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 2018 up to 2022. The annual reports track progress, focusing on the availability and performance of fixed broadband and mobile networks, and this is published at a detailed geographical level (postcodes and output areas) which can then be averaged or aggregated at the higher OA level.

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 of the analysis.

Connected Nations relies on data provided by suppliers and cannot be guaranteed to provide full coverage of all fixed networks. 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 2018 to 2022.

Fixed Coverage

Most of the variables on the fixed coverage focus on the percentage of premises that meet certain speed availability cut-offs. The data was collected in September of each year from 2017 to 2022. Table A1 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.

The table does highlight some data gaps. Perhaps notably is that the data about the availability of full fibre is only for the earlier two years and Gigabit is only recorded in the most recent two years. These two series have been merged, based on discussions with BDUK. In these discussions, it emerged that the technologies classified to full fibre and Gigabit – while broadly similar – diverged significantly for Virgin Media and, there is a discontinuity in the time series about coverage associated for areas supplied by the provider. This does not affect the Hubs evaluation as Virgin Media is not found to serve any areas where Hub connections have been made.

However, generally, the coverage is good especially for output area level. An issue with postcode level datasets is the limited availability of counts of properties that are consistent with the shares

data that is published. There are also a significant number of postcodes for which data is unavailable because the count of properties is too low. This causes some reduced sample for the postcodes with Hubs. For output areas, a more complete and detailed dataset is provided giving both the number of properties in the area and the share that are in a particular category.

Table A1: Variables available for Fixed Coverage by Connected Nation Report Year

Variable	Level	18/19	19/20	20/21	21/22
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 (100Mbps) 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 2Mbps, 5Mbps, 10Mbps, 30Mbps	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<2Mbps, 2<5Mbps, 5<10Mbps, 10<30Mbps, 30<300Mbps, >=300Mbps	Both		X	X	X
Number of premises with SFBB availability	OA	X	X	X	X
Number of premises with UFBB (100Mbps) 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 2Mbps, 5Mbps, 10Mbps, 30Mbps	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
Number of premises able to receive SFBB from FWA	OA	X	X		
Number of premises with download speed: 0<2Mbps, 2<5Mbps, 5<10Mbps, 10<30Mbps, 30<300Mbps, >=300Mbps	OA		X	X	X

* For postcodes data only available for 2018. OA= Output Area

Fixed Performance

The variables available for fixed performance are presented in Table A2. 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 A2: Variables available for Fixed Performance by Connected Nation Report Year

Variable	Level	18/19	19/20	20/21	21/22
oa11	OA	X	X	X	X
postcode	Postcode	X	X	X	X
Median upload speed (Mbps)	Both	X	X	X	X
Median download speed (Mbps)	Both	X	X	X	X
Median data usage (GB)	Both		X	X	X
Average upload speed (Mbps) for lines < 10Mbps, 10<30Mbps, 30<300Mbps	Both	X	X	X	X
Average upload speed (Mbps) for SFBB lines, and for UFBB lines	Both	X	X	X	X
Average upload speed (Mbps)	Both	X	X	X	X
Average download speed (Mbps) for lines < 10Mbps, 10<30Mbps, 30<300Mbps	Both*	X	X	X	X
Average download speed (Mbps) for SFBB lines, and for UFBB lines	Both	X	X	X	X
Average download speed (Mbps)	Both	X	X	X	X
Average data usage (GB) for lines < 10Mbps, 10<30Mbps, 30<300Mbps	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 (Mbps)	Both	X	X	X	X
Maximum download speed (Mbps)	Both	X	X	X	X
Number of connections (number of lines) < 2 Mbps, 2<5 Mbps, 5<10 Mbps, 10<30 Mbps, 30<300 Mbps, >=300 Mbps, >=30 Mbps	Both	X	X	X	X
Minimum download speed (Mbps)	Both	X			
Minimum upload speed (Mbps)	Both	X			
Average data usage (GB) for Basic BB lines	Both	X			

Building Digital UK datasets

Building Digital UK (BDUK) provided a range of data for the study. The Hub intervention data related to the 1,021 Hubs supported by mid-2022. Data covered the name, address and type of site, the time of the investment and connection, as well as the funding provided and the supplier that connected the Hub.

BDUK also provided data – the Vouchers Data – covering the timing, supplier, value and location of recent voucher support and whether it was supported under the GBVS or Rural Gigabit Programme 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).

Projects and premises passed

Where the voucher was a project, the individual premises passed by the projects' investments was also made available. This listed all premises that a project passed. The data provided the potential additional premises that could take up gigabit broadband, and for each the unique property reference

number (UPRN) was usually indicated. There were 1.02mil premises listed and these were passed by 1,761 projects. Around 930k UPRNs could then be linked to the register of properties, with unmatched records usually reflecting clearly incorrect UPRNs (too short or not a UPRN). In these, some properties were passed by more than one project and 763k different premises were listed. There were 702k that could be linked to a postcode.

The compilation of this dataset into variables for geographical areas involved linking each project, through the voucher dataset, to the timing of the project. Dating when premises were passed allowed analysis of the timings of when businesses, residential users or others might then secure gigabit connectivity. The vouchers/project link was not perfect with around 300k premises in projects for which voucher data was unavailable. Voucher data for these projects is likely to become available in later data but meant the passing of premises could be associated with the year in which this occurred for 368,722 properties.

Table A1: Premises passed in datasets by year of project

Premises Passed	2018	2019	2020	2021	2022	TOTAL
Excluding projects without date of first connection	1,841	11,444	49,244	131,213	151,878	368,722
All projects: missing connection year is 2022	1,841	11,444	49,244	131,213		

Table A1 indicates the total number of premises passed that were passed where the year this occurred know (in the top row) and where it is assumed to be 2022 for the projects where dates were not known. Using the most recent year is probably correct as – looking at the projects – there is some indication that the premises passed data is not linked to voucher data for more recent projects

Telephone exchanges and their served areas

Each property is connected to an exchange, through cabinets and inter-cabinet infrastructure. While data on the property to exchange is not made available, there are postcode to exchange lookups, such as the SamKnows database, and then the premise to exchange connection has been modelled by BDUK to give the geography of the telecom network. BDUK made this available to the study.

There are 5,583 exchanges and each serves around 5,000 premises. The Hubs can be matched to the exchange serving them and, as the same exchange can serve multiple Hubs, there are 790 exchanges serving the 1,019 Hubs. While there has been substantial investment in rolling out the connections to exchanges by fibre-optic, the exact times and extension over time is not available for this analysis. So, rather than characterising the exchanges, the analysis has constructed variables based only on which exchange serves a Hub.

The exchanges that connected to the Hubs were identified. Also, each output area that was served entirely by a single exchange was determined and the ones where the exchange which connected to a Hub were tagged. This yielded 17,983 output areas.

These output areas – to the level of the exchange – would have the same broadband infrastructure as the Hub. They therefore provide a pool from which a counterfactual can be chosen which shares a major technology characteristic with the Hub. Also, if the Hub connection involved some

improvement to the exchange, then the properties in the OAs that use the exchange may also benefit.

A further variable was derived from the exchange dataset. The postcode of the exchange meant that the distance from each OA to the exchange could be estimated. This would also correlate with the costs of connecting the properties.

F20 Modelling and assessing Connection Costs

The commercial viability of UK locations is modelled by BDUK. The F20 Model provides an estimated relative cost to install fibre to the premise. This has been indexed for the model, but the value is proportionate to cost, so that low values reflect premises that can be connected at modest costs, 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 public subsidy. This distinction approximates to the 20% of premises referred to as being F20 premises in earlier related work (see Hatch, 2023).

The BDUK cost modelling focuses on properties in the UK, estimating the build out costs from a fibre hub, i.e. an exchange or some other location with fibre connectivity. The 2022 model uses a September 2021 dataset about the fibre connectivity status of cabinets and then models costs to connect each property from there. The property list used in the modelling is epoch 91 AddressBase Premium, ABP), with the previous version of the model using Ofcom's premises definition and epoch 70 of ABP.

There are a number of other changes made for the update as well as the significantly larger number of premises in the new run. This single change means is most material, in that the density of properties has increased reducing costs to connect in terms of building distance. Costs are estimated by multiplying the modelled building distance by £35 as the measure of cost per metre and a 35% optimism bias uplift. The analysis has then also provided a categorising of costs, rather than the previous ranking of costs per property, and there are four subsidy categories:

- Commercial premises are those with a build cost below £615.23.
- Hold-up premises begin at a build cost of £615.23.
- Uncommercial premises begin at £930.19.
- Premises beyond the value for money limit begin at £7,000.

Commercial properties represent the vast majority of properties in the dataset with 82% in this category.

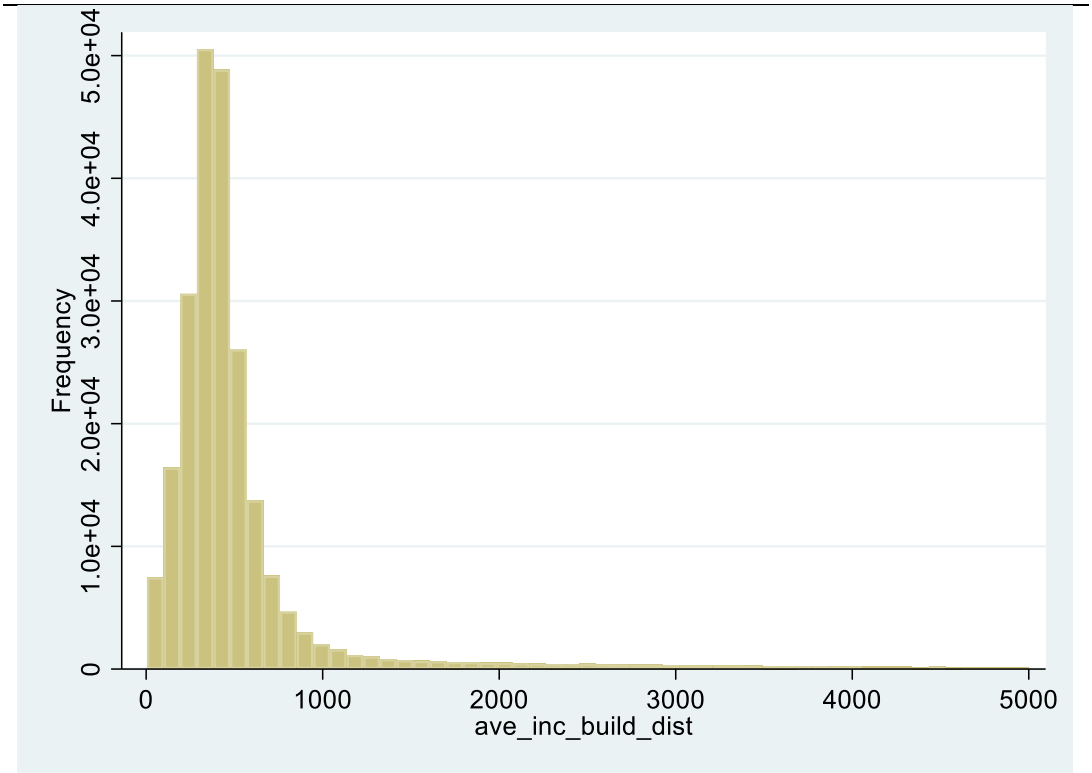
For this analysis, BDUK provided Belmana with a file that contained variables "uprn", the percentile of each property variable "average_percentile', the "average_incremental_build_distance", and "subsidy_category". There were around 33mil records, with each record having the build distance and subsidy category.

The uprn is a property referencing system that can then be linked to property registers to locate each property in terms of postcode and Census output area (OA), at middle and lower layers (MSOA and LSOA). It also places each property in administrative geographies such as local authorities.

There are 231,896 output areas in the database covering the four nations, of which around 175k are in England and Wales which have a wider set of OA level data. Figure A1 plots out the profile of a measures across the UK OAs, the average connection costs. It focuses only on the areas where this

is less than £5,000, removing a very small number of very remote OAs where costs were up to £20k.

Figure A1: OA average build costs up to £5000



The plots are frequencies, indicating about 100,000 are in the left most bars in the graph. The plots therefore are very dense at these low levels. A key cut-off is the £615.23 commercial/non-commercial boundary. There are 44,273 OAs that have costs above this.

Data to characterise Hub areas

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). The equivalent series for Scotland and Northern Ireland were integrated. As well as total employment by LSOA, a variable measuring employment in digital sectors was constructed. For OA level analysis, only LSOA level data is available.

Other area characteristics controls: ONS/NRS/NISRA 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, again only LSOA level data is available. Overall, variables derived from these public datasets are:

- **Population density:** The number of people per square kilometre in Lower Layer Super Output (LSOA) areas in England and Wales, Data Zones (DZ) in Scotland and Small Areas in Northern Ireland.
- **2011 Rural Urban Classification for LSOAs/DZs and Small Areas**: 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:** These datasets provide a directly measured Index of Deprivation across all LSOAs in England and Wales, as at 2015-16, enabling ranking across the two countries. Equivalent analyses for Scotland and Northern Ireland have been added and analysis includes these rankings both with England and Wales and interacted with a dummy for the two Nations to allow for a different scale effect in the compilation of the indices in Scotland and Northern Ireland.
- **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 the LSOA (for England and Wales), Datazone (for Scotland) level and Small Areas for Northern Ireland. The IUC provides 10 unique profiles of neighbourhoods based on a number of characteristics,

Many of the Hubs are primary schools. For English schools, a public dataset provides the location and key characteristics of the schools. This is the Department for Find School Performance data service[7]. Further, the DfE Consistent financial reporting (CFR) framework provides a framework for English schools to collect information about their income and expenditure. Financial year data for 2017-18 to 2021-22 is used for this analysis. The variables drawn from these sources:

- **Number of pupils at the school.** This is used to indicate primary school size, with the Hub schools generally smaller.
- **Pupils' characteristics**. The variables drawn from the dataset are the share of pupils that are eligible for free school meals and the share than receive support for special education needs.
- **Expenditure on ICT learning materials.** Expenditure per pupil CFR code E20, ICT learning resources.
- **Total expenditure per pupil.** Aggregating across staff, materials and consumables used in the school.
- **Investment in ICT.** ICT equipment (CE04) in total across schools.

The variables are linked to the school reference number, and then to the address of the school. The postcode can be linked to the Hubs database so that all English primary schools supported with Hub investments can be characterised in terms the number of students and the pupils' characteristics.

[7] https://www.gov.uk/government/publications/understanding-school-and-college-performance-measures/understanding-school-and-college-performance-measures#overview

Annex B: Identifying counterfactuals and estimating additional effects

A means to estimate impacts of investments into broadband connections in public buildings is to compare Hub supported premises or areas with ones as comparable as possible that had no support. The comparison used in this study is determined statistically focusing not on individual premises but the small areas that include a Hub.

The matching uses propensity score matching (PSM) to identify the comparator small areas. The method generates a score for each of the supported locations, based on its characteristics. The same selection model is then applied to score the unsupported areas and – for each of the Hub areas in the modelling – the methodology identifies the nearest unsupported ones in terms of the score. These are as likely as the recipient group to receive support, based on their observable characteristics. Having identified the counterfactual in this way, the supported areas and the control are tracked in the Connected Nations database plus other linked datasets.

The analysis is undertaken in relation to all Hubs but also then focuses on the primary schools supported in England. For this latter group, the approach to finding a counterfactual has then focused on areas that are unsupported but also have a school that is similar to the supported English schools. Matching on both the area having a school and some of the characteristics of the school provides a different form of counterfactual analysis and the chapter looks at the spatial analysis possible.

The next sections describe some of the selection models and the robustness and quality assurance tests are presented to substantiate the choice of this model. Sections then presents detailed results of the modelling, with these results summarised in earlier chapters.

Outcome variables for small areas

This analysis uses the Connected Nations database and numerous other area-level datasets described in the previous sections. Connected Nations (CN) draws two snapshots each year of the broadband performance and coverage by small areas. It provides measures over time, for all UK locations. The bi-annual updating means CN provides a wide range of variables consistently across areas and over time, particularly around broadband speed, coverage by different types of connection, and the properties that suffer from poor broadband speeds. The most recent year available in the BSD covered financial year 2021/22.

Data linking then has greatly enriched this dataset. Outcome variables that have been added include the premises passed as projects are implemented, and the number and value of broadband vouchers. Overall, the outcome variables are calculated for output areas (OA)[8] with the broadband speed variable also analysed at the postcode level. There are some outcomes that relate to the availability of gigabit-capability:

[8] While this term is used for England, Wales and Northern Ireland, and the similar Data Zones used in Scotland, for brevity, output areas is used throughout.

- **Premises passed**: As suppliers deliver project vouchers – where groups of premises are connected – the premises passed by the investment have been quantified by output area.
- **Gigabit availability:** Percentage of premises that have Gigabit capable services from fixed broadband, with a complimentary measure logging this, **Gigabit availability (% premises, logged),** which when differenced over time focuses on the change from a baseline year making growth differences discernible.
- **UFBB availability:** Percentage of premises that have Ultrafast Broadband (300Mbps or greater) coverage from fixed broadband
- **% of premises unable to receive 30Mbps.** Number of premises that do not have access to services above 30Mbps from fixed broadband

Then, there are outcomes measuring the take up of faster broadband, the first focusing on connecting either residential or business properties using government subsidy:

- **Number of vouchers**: Count of vouchers connected in an output area and the **value of voucher**s in OA (£) totalled.
- **Number of connections >=30Mbps (number of lines).** Number of premises that have Superfast Broadband (30Mbps or greater) coverage from fixed broadband.
- **Average download speed (Mbps, logged).** Average download speed (in Mbps) of all connections.

As seen in tables below, there are around a thousand Hubs and a similar number of OAs that have Hubs in them. While there are more than 200 supported OAs in 2020/21, so that some limited analysis of two-year effects may be possible, around 700 of the investments occurred in financial year 2021. So, the time-series about outcomes after the investments will only be a single year for most Hubs.

A focus on one-year outcomes can be made statistically powerful by stacking the data. Stacking recasts time-series data centring on the year of support, so that for areas supported in 2020, the 2021 data is year 1 data, 2022 is year 2, etc. The different cohorts of support then are aligned not on the calendar year but on how many years before or after support a particular outcome or variable is observed. It means that the year 1 estimates of outcomes can pool the Hubs supported in each of the three financial years (2019, 2020 and 2020) looking at the outcomes a year after support in each. This has meant that samples are for over 900 Hubs for the modelling and over 500 where modelling focuses on English schools.

Defining treatment, match pools and selection models

The Hub is an individual property – such as a school, GP surgery, library, or emergency services building – usually located in terms of its postcode or UPRN. While some analysis can be done at a property or postcode level, the counterfactual impact analysis has used the output area level data to understand the Hub support and then match output areas using PSM. This section firstly looks at the way treated output areas are defined and then considers options for restricting the pool of unsupported areas from which a counterfactual is drawn before turning to the selection modelling used in the analysis.

A first set of OAs are defined as treated if a Hub connection is completed and operational in an output area and then the timing of the support is the financial year when this occurs. The postcodes of all Hub investments and the timings in the intervention dataset provides sufficient information for all the Hubs connected before 31 March 2022, the end of financial year 2021. Table B1 indicates how

this provides 962 treated output areas, with 1,019 Hubs as some Hubs are in the same output areas. The value of these investments is £21.8m.

Table B1 also indicates a second focus of the analysis. This is analysis of Hubs which are primary schools in England. For the subset of Hubs that were English primary schools, the linked datasets available include a range of variables about English schools and as seen later, this allows for some additional modelling as, when selecting a counterfactual, the pool of OAs can be restricted to ones that contain a primary school. However, this also restricts the number of supported areas. There are 550 output areas in this group. They have 553 Hubs and £11.6mil funding, representing 41% of the total support.

Table B1: Areas with Hubs

	All Output Areas (n=231,836)				English Primary School OAs (n=17,696)			
	2019	2020	2021	Total	2019	2020	2021	Total
Value of Hubs	£393k	£6.25mil	£21.8m	£28.1m	£350k	£2.93mil	£8.28m	£11.6mil
Number of Hubs	21	224	774	1,019	19	129	405	553
Number of postcode areas								
Output areas for counterfactual analysis								
Number of OAs with Hubs	20	209	733	962	18	128	404	550
OAs within 400m	30	516	1,632	2,178	-	-	-	-
OAs within 1km	66	1,213	3,764	5,043	-	-	-	-

The effects of the Hub investments – especially bringing of gigabit capable broadband to remote areas – means that the treatment may be beyond the public building to the neighbouring premises. The output area that contains the Hub would be part of that effect, in that analysis of the Hub output area would include outcome measures for the immediately surrounding area.

Table B1 defines some additional treatment variables used in the analysis, using the output area that contains each Hub plus neighbouring OAs that are then deemed treated. The distance between the centroid of the Hub OA and its neighbours is calculated and two treatment variables are created, one for OAs within 400m of the Hub OA and one within 1km of the Hub OA. The table indicated how this more than doubles the number of areas defined as treated.

A second dimension to the selection modelling is to restrict the areas from which matching takes place to OAs that share some feature with the Hub. As well as using all OAs to select the counterfactual from, two sub-samples have been created:

- **Areas connected to the same exchange.** Areas served by the same exchange as a Hub: The telephone exchange that is connected to the Hub will typically connect a further 5,000 premises. The OAs where all premises are linked to an exchange as the Hub can be identified: there are 17,983 OAs that share the same exchange as a Hub. This pool of areas will have exactly the same network technology up to the exchange, meaning that matching to counterfactuals only to these OAs will then ensure the treated and control groups are similar in this regard.
- **Areas at the fringes of supported areas.** A second match pool defined is the OAs that are 4-5km away from all the Hub OAs. At this distance, the OAs are too far from the Hub

to be considered treated but will share the regional and rurality characteristics of the supported areas. There are 11,563 OAs in this fringe around the Hubs.

Table B2 presents the counts for the output areas in total and then these two groups of OAs.

Table B2: Pools from which the counterfactuals are drawn

POOL	Description	Number of Output Areas
All areas	All UK output areas	231,836
Same exchange	Output areas that where all properties are connected to a telephone exchange that also is connected to a Hub	17,983
Fringe	Output areas with centroids 4-5km from the centroid of Hub output areas	11,563
English primary schools	Output areas that contain a primary school in England using the DfE Find School Performance data service	17,696

The table also indicates how many OAs have schools in them in England. This provided the fourth pool from which the comparator areas could be drawn. This pool has an important distinction in that it provides a set of OAs to match from that can be characterised both in terms of the connectivity, socioeconomics, and demography of the areas in terms of the characteristics of a public building in the area. The selection modelling can then incorporate variables about the school.

Selection modelling

Statistical matching was carried out by identifying unsupported areas with similar characteristics to those which had a Hub investment, with the dataset stacked so that it pools across all Hubs in 2019/20, 2020/21 and 2021/22 and matches to a pooled dataset across all three of these datasets. The PSM matches on a one-to-one basis, and the first stage of the modelling involves estimating the drivers for the area into support in terms of the characteristics available in the data.

The selection of the variables used in the modelling is crucial in this and Table B3 indicates how different models use the variables available. The modelling must use variables available about areas before support and these are derived from the data above. Variables available include the number of employees, population density, high digital employment, rurality, index of multiple deprivation, 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.

The selection modelling for this analysis uses a Probit model for the treated in 2019, 2020 and 2021. The stacking of the dataset means that the individual points in the data also include which financial year it is centred on, with two binary variables for 2019 and 2020 with the default representing the data being centred on 2021.

The dependent variable in the Probit takes a value one for the OAs with a Hub. The data about Hub supported areas is in the dataset only once and is not then repeated for the other financial years outside of the year of support. This dependent variable then takes the value zero for the unsupported areas who did not receive any support.

Table B3: Variables used in selection models

VARIABLE	Description	I	II	III	IV	V
Distance to exchange	Distance from the LSOA/OA centre to the exchange serving at least 60% of properties	x	x	x	x	x
Employment (logged)	LSOA level employment for England, Wales and Scotland; NI is larger areas	x	x	x	x	x
Index of Multiple Deprivations	Rank for each country with interaction term for Scotland and Northern Ireland as ranks are separate for two countries	x	x	x	x	x
F20	Modelled score for the cost to connect property, averaged for OAs	x	x	x	x	x
Rurality	Binary variable based on 2011 Census ONS rural/urban classification	x	x	x	x	x
ICT employment	Share of LSOA employment that is in ICT industries	x	x	x	x	x
Population (logged)	LSOA level population estimates from 2011 Census	x	x	x	x	x
Voucher beneficiary	At least one voucher connection in area in year before				x	x
Change in download speed	Connected Nations area level data for annual chance in year before			x		x
Variables used about schools where OA is in England and has a primary school						
Pupils	Number of pupils in the school	x	x	x	x	x
Free school meals	Percentage of pupils in the school eligible for free school meals	x	x	x	x	x
SEN share	Percentage of pupils that receive support for special educational needs	x	x	x	x	x

Table B3 indicates the variables used in the probit selection models then. Most variables were used across the models as these characterised the output areas in terms of their socioeconomics (employment, share of employment in information and communication technologies (ICT), population density and the index of multiple deprivation). There are variables to locate the output area in terms of the broadband infrastructure, primarily the F20 modelled average costs to connect the OA to gigabit capability and the distance between the area and the exchange that serves it.

The table also highlights that – where an English Primary School is located in the area – the DfE data about schools provides some variables about the schools, such as the number of pupils and the share pupils eligible for free school meals and support for special education needs. These variables also then can be calculated for the Hubs that are primary schools in England, and this subset of observations have been modelled restricting to the OAs that have primary schools.

Table B4 presents the modelling for the English primary schools. Output areas are more likely to receive Hub support if they are rural and costly to connect to the gigabit network. The table indicates positive and highly significant co-efficient on the variables. High population density reduces the chance of support, as it is correlated with urban areas.

The modelling mixes some variables about the pre-support broadband performance and support. Receiving Hub investments is correlated with low download speed growth in the period before support. Support is more likely in areas that did not receive voucher support in the period before support. Both are consistent with the logic of the support measure in that it seeks to address poor broadband performance and, as areas are remote from gigabit prior to the Hub, they would have limited potential for voucher-aided connections.

Table B4a: Selection models for Hubs that are primary schools in England

Pool	All OAs with Primary Schools			Primary Schools in same Exchange			Primary Schools in the Fringe		
Model	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**
Dist to Exch	0.00	0.00	0.00	-0.20***	-0.20***	-0.20***	-0.04	-0.04	-0.04
Employment	-0.01	-0.01	-0.01	-0.01	-0.02	-0.01	0.02	0.01	0.02
ICT emp share	-0.05	-0.05	-0.05	0.04	0.04	0.04	-0.08	-0.09	-0.08
Rural	1.12***	1.12***	1.12***	1.13***	1.14***	1.13***	1.41***	1.41***	1.41***
IMD	-0.26**	-0.25**	-0.26**	-0.27	-0.25	-0.27	-0.57***	-0.54***	-0.58***
F20 ave	1.13***	1.10***	1.14***	1.27***	1.23***	1.27***	1.45***	1.39***	1.47***
Pop dens	-0.04*	-0.05**	-0.04*	-0.14***	-0.14***	-0.14***	-0.08*	-0.08**	-0.08*
SEN Pupils (%)	-0.88***	-0.88***	-0.88***	-1.61***	-1.62***	-1.61***	-1.30***	-1.30***	-1.31***
Pupils ('00)	-0.04**	-0.04**	-0.04**	-0.04	-0.04	-0.04	-0.05*	-0.06*	-0.05*
Free school meal (%)	0.13	0.11	0.12	0.28	0.26	0.27	-0.37	-0.38	-0.39
Download Speed Change b/f supp	0.00***	-	0.00***	-0.01***	-	-0.01***	-0.01***	-	-0.01***
Voucher before	-	-0.20*	-0.18	-	-0.17	-0.13	-	-0.32	-0.27
FY 2019	-1.32***	-1.28***	-1.33***	-1.61***	-1.58***	-1.61***	-1.77***	-1.73***	-1.79***
FY 2020	-0.54***	-0.54***	-0.55***	-0.69***	-0.68***	-0.70***	-0.71***	-0.69***	-0.71***
Constant	-2.89***	-2.86***	-2.90***	-1.12**	-1.08**	-1.13**	-1.70***	-1.64***	-1.74***
Adjusted R-square	**0.30**	**0.30**	**0.30**	**0.33**	**0.32**	**0.33**	**0.41**	**0.41**	**0.41**
Observations over three years	**43462**	**43464**	**43462**	**3984**	**3984**	**3984**	**3675**	**3675**	**3675**

Note: Estimation also included regional dummies, which are not in tables for brevity.

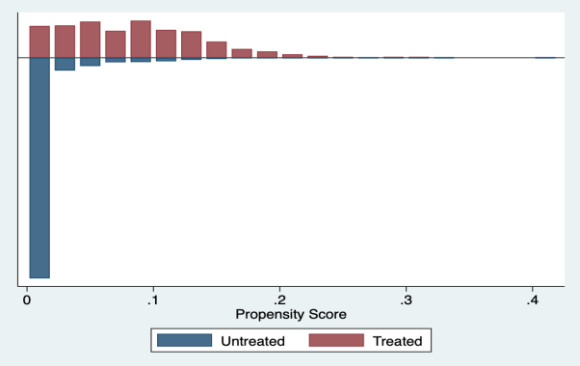
Robustness of Selection Modelling

The selection modelling associates as propensity score to the supported output areas and all the areas in the pool that were not supported. For each supported area, a similar one is matched based on which area is closest in terms of the score. This is done with replacement, so the same output area can be matched to more than one supported areal.

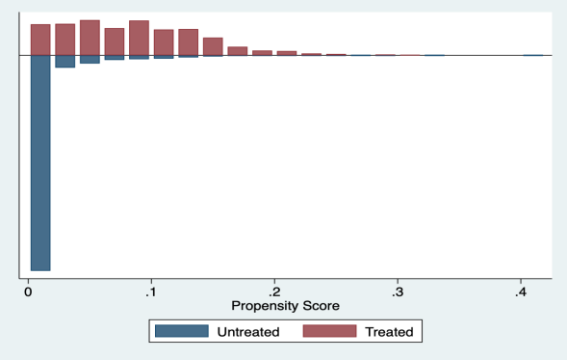
Modelling produces a set of robustness tests. Propensity score plots indicate whether there is common support after the selection modelling in that for all supported businesses there was a match found. Figure B1(a) and B1(b) look at whether the matching spans the supported OAs when modelling focuses on the schools in England. There was a match across all OAs (called a support) where all OAs with schools are used and some of the other models. Some supported areas are not matched when the pool from which the counterfactual is selected is the OAs with schools that are in the same exchange as the supported schools.

Figure B1: Propensity score of supported and matched OAs

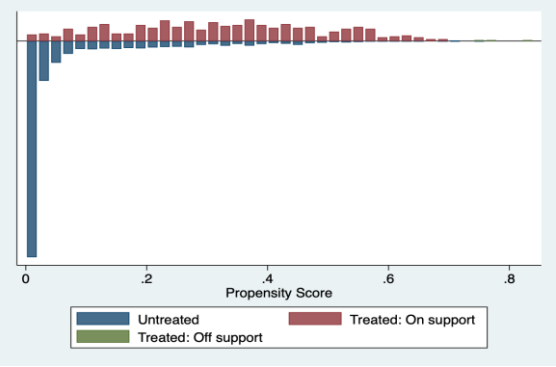
(a) Model III, all OAs with schools



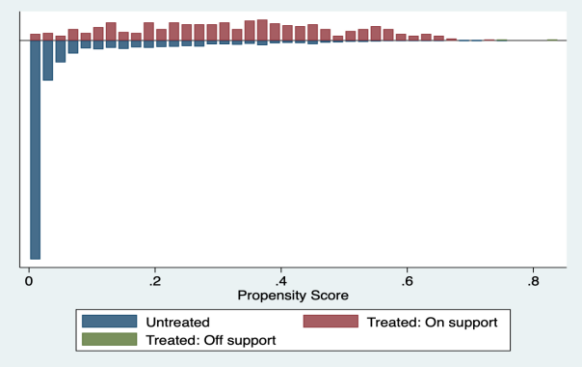
(b) Model V, all OAs with schools



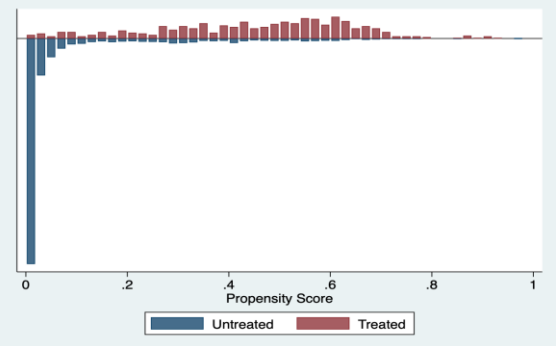
(a) Model III, same exchange as schools



(b) Model V, same exchange as schools



(a) Model III, schools in fringe OAs



(b) Model V, schools in fringe OAs

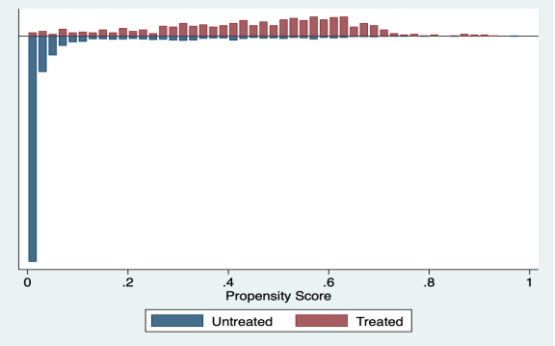


Table B5 considers some other robustness tests. A first test is whether – after matching – the counterfactual is similar to the supported OAs in terms of the characteristics. To some extent, PSM delivers this because the matching seeks out areas that are statistically similar.

Table B5: Characterising OAs before and after matching

VARIABLE	OAs with Schools	All OAs with schools	Matched OAs (Mod V)
Proportion rural (%)	95.8	29.5***	96.6
Employment in LSOA	492	436***	499
Population density LSOA	103	1135***	88**
Employment in digital businesses, 2019 (%)	61.9	45.5***	63.1
Distance to exchange (km)	1.8	1.4***	1.9
F20 Score	0.8	0.6***	0.8
Variables about broadband outcomes prior to support			
Value of vouchers in OA (£)	£1280	£197***	£649
Count of Vouchers	0.6	0.1***	0.4
Change in download speed	6.46	10.60***	6.03
Premises passed by BDUK funded projects	3.12	0.57***	4.13
% premises Full Fibre available	14.0	37.0***	22.2***
Average download speed, 2021 (Mbps)	48.0	82.9***	62.5***
No of connections >=30 Mbits/s	87.2	101.9***	90.9
Variables used about schools where OA is in England and has a primary school			
Pupils in school	144.6	290.0***	136.3
Proportion entitled to free school meal (%)	13.3	19.6****	12.4
Proportion receiving SEN support (%)	2.7	7.0***	3.2
Observations	**528**	**42934**	**528**

Note: Significance levels are 1% (***), 5% (**) and 10% (*) with testing whether difference from the supported OAs. All OAs estimates for stacked dataset.

A further robustness test further explores whether the counterfactuals are similar to the supported, considering whether the broadband outcomes in Hub areas were similar to those seen in the counterfactuals in the periods before support. This can be forced on to the selection model by including past broadband performance variables in the model, such as level and changes in broadband speed. This then tests how different results for effects are after the support.

Estimates of the additional effects

Tables B6 focus on the availability effects in supported areas (OAs with a Hub, called treated in the tables) in relation to the control areas. The estimates are the change in outcomes from the year before support to the end of the first year, and then the difference between the treated and control OAs.

Table B6a: Effect on Broadband Availability of Hub Investments in English School OAs after One Year

	All OAs with Primary Schools			Primary Schools in same Exchange			Primary Schools in the Fringe		
	I	II	III	I	II	III	I	II	III
Premises passed by BDUK funded projects									
Treated	14.28	14.28	14.28	16.39	16.35	16.35	14.28	14.53	14.28
Control	6.49	6.32	7.20	10.87	7.16	13.68	9.08	7.89	6.72
Difference	7.79***	7.96***	7.08***	5.52*	9.19***	2.67	5.20**	6.63***	7.56***
Gigabit availability (% premises)									
Treated	10.8	10.8	10.8	11.2	11.2	11.2	10.8	11.0	10.8
Control	8.2	9.8	8.5	9.2	9.0	9.9	8.4	8.8	8.0
Difference	2.6**	1.0	2.4*	2.0	2.2	1.2	2.4	2.2	2.8**
Gigabit availability (% premises, logged)									
Treated	0.6	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.6
Control	0.4	0.3	0.3	0.5	0.4	0.5	0.1	0.2	0.3
Difference	0.3***	0.3***	0.4***	0.1	0.2***	0.1	0.5***	0.4***	0.3***
UFBB availability (% premises)									
Treated	9.23	9.23	9.23	9.34	9.32	9.32	9.23	9.35	9.23
Control	6.15	6.40	6.38	6.34	7.09	7.74	4.97	5.47	6.24
Difference	3.08***	2.83**	2.85**	3.00**	2.23	1.58	4.26***	3.88***	2.99**
% of premises unable to receive 30Mbps									
Treated	-1.51	-1.51	-1.51	-1.24	-1.23	-1.23	-1.51	-1.51	-1.51
Control	-1.68	-1.39	-1.48	-2.13	-1.60	-1.16	-1.17	-1.87	-1.78
Difference	0.17	-0.12	-0.03	0.90*	0.36	-0.07	-0.34	0.36	0.27

All Observations									
Treated	528	528	528	426	426	426	528	528	528
Control	42934	42936	42934	3558	3558	3558	3147	3147	3147

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

Table B6b: Effect on Broadband Availability of Hub Investments in all Hub OAs after One Year

	All OAs as Pool			Same exchange OAs			**All OAs 4-5km from Hubs**		
	I	III	V	I	III	V	I	III	V
Premises passed by BDUK funded projects									
Treated	92.2	92.2	23.7	92.2	92.2	23.7	92.3	91.5	23.7
Control	43.1	65.3	8.4	86.5	94.3	14.2	48.5	78.0	7.6
Difference	49.1	26.9	15.3***	5.7	-2.1	9.6***	43.8	13.5	16.1***
Gigabit availability (% premises)									
Treated	11.87	11.87	11.87	11.87	11.87	11.87	11.88	11.71	11.87
Control	14.75	11.63	11.55	12.33	11.92	13.70	13.96	14.59	11.84
Difference	-2.88**	0.24	0.32	-0.45	-0.05	-1.83	-2.07*	-2.88**	0.03
Gigabit availability (% premises, logged)									
Treated	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.63
Control	0.36	0.41	0.47	0.39	0.38	0.35	0.39	0.37	0.32
Difference	0.27***	0.21***	0.15**	0.24***	0.24***	0.27***	0.23***	0.25***	0.31***
UFBB availability (% premises)									
Treated	10.99	10.99	10.99	10.99	10.99	10.99	11.00	10.82	10.99
Control	11.71	9.01	10.46	9.52	9.95	11.42	10.31	11.29	9.79
Difference	-0.73	1.98**	0.52	1.47	1.03	-0.43	0.69	-0.47	1.20
% of premises unable to receive 30Mbps									
Treated	-2.18	-2.18	-2.18	-2.18	-2.18	-2.18	-2.18	-2.17	-2.17
Control	-2.97	-2.95	-3.34	-2.85	-3.18	-3.47	-3.03	-2.98	-2.86
Difference	0.79*	0.77*	1.16**	0.67	1.00**	1.29***	0.85**	0.81*	0.69

All Observations									
Treated	949	949	949	949	949	949	949	949	949
Control	598311	598234	598311	52139	52134	52139	33460	33459	33460

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

Table B6c: Effect on Broadband Availability within 400m of Hub Investments after One Year

	All OAs as Pool			Same exchange OAs			**All OAs 4-5km from Hubs**		
	I	III	V	I	III	V	I	III	V
Premises passed by BDUK funded projects									
Treated	20.28	20.28	20.28	20.11	20.28	20.21	20.28	20.28	20.28
Control	10.42	9.13	8.56	11.39	11.71	12.01	6.58	5.72	6.81
Difference	9.87***	11.15***	11.72***	8.71***	8.58***	8.20***	13.71***	14.57***	13.47***
Gigabit availability (% premises)									
Treated	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Control	13.5	13.4	13.0	13.2	13.0	11.9	13.4	14.1	13.9
Difference	-2.3***	-2.1***	-1.7**	-1.9**	-1.8**	-0.6	-2.2***	-2.8***	-2.6***
Gigabit availability (% premises, logged)									
Treated	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
Control	0.33	0.28	0.35	0.40	0.32	0.31	0.29	0.30	0.37
Difference	0.19***	0.24***	0.17***	0.12***	0.19***	0.21***	0.23***	0.22***	0.14***
UFBB availability (% premises)									
Treated	10.26	10.26	10.26	10.25	10.26	10.27	10.26	10.26	10.26
Control	9.13	8.66	10.73	10.83	10.41	10.31	9.59	10.02	12.31
Difference	1.13	1.60**	-0.47	-0.58	-0.15	-0.04	0.67	0.24	-2.05***
% of premises unable to receive 30Mbps									
Treated	-1.22	-1.22	-1.22	-1.23	-1.22	-1.23	-1.22	-1.22	-1.22
Control	-1.64	-1.59	-2.31	-1.74	-1.77	-1.89	-1.93	-2.14	-2.68
Difference	0.41*	0.36*	1.08***	0.51**	0.55**	0.67***	0.71***	0.92***	1.46***

All Observations									
Treated	2178	2178	2178	2178	2178	2178	2178	2178	2178
Control	597082	597005	597082	50948	50943	50948	33461	33460	33461

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

Table B6d: Effect on Broadband Availability within 1000m of Hub Investments after One Year

	All OAs as Pool			Same exchange OAs			**All OAs 4-5km from Hubs**		
	I	III	V	I	III	V	I	III	V
Premises passed by BDUK funded projects									
Treated	17.37	17.47	17.47	17.15	17.48	17.31	17.48	17.48	17.35
Control	6.33	6.61	6.67	8.79	8.43	9.55	5.85	5.48	6.94
Difference	11.04***	10.86***	10.80***	8.36***	9.05***	7.76***	11.63***	12.00***	10.41***
Gigabit availability (% premises)									
Treated	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Control	14.9	15.3	13.9	13.7	14.5	14.4	15.4	15.5	14.4
Difference	-4.4***	-4.8***	-3.4***	-3.2***	-4.0***	-3.9***	-4.9***	-5.0***	-3.9***
Gigabit availability (% premises, logged)									
Treated	0.41	0.40	0.40	0.41	0.40	0.41	0.40	0.40	0.41
Control	0.33	0.33	0.37	0.35	0.34	0.40	0.28	0.27	0.31
Difference	0.07***	0.08***	0.04	0.06**	0.06**	0.00	0.13***	0.14***	0.10***
UFBB availability (% premises)									
Treated	9.61	9.60	9.60	9.61	9.60	9.60	9.60	9.60	9.64
Control	8.67	9.18	11.27	10.35	11.28	11.79	10.33	10.11	11.92
Difference	0.94**	0.41	-1.67***	-0.74	-1.67***	-2.19***	-0.73	-0.51	-2.28***
% of premises unable to receive 30Mbps									
Treated	-0.93	-0.93	-0.93	-0.93	-0.93	-0.92	-0.93	-0.93	-0.93
Control	-1.49	-1.49	-1.96	-1.48	-1.49	-1.53	-1.25	-1.45	-1.93
Difference	0.57***	0.57***	1.04***	0.55***	0.57***	0.61***	0.32**	0.52***	1.00***
All Observations									
Treated	5049	5049	5049	5049	5049	5049	5049	5049	5049
Control	594211	594134	594211	48235	48230	48235	33461	33460	33461

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

Table B7a: Effect on Broadband Uptake of Hub Investments in English School OAs after One Year

	All OAs with Primary Schools			Primary Schools in same Exchange			Primary Schools in the Fringe		
	I	II	III	I	II	III	I	II	III
Number of vouchers in OA									
Treated	0.51	0.51	0.51	0.31	0.31	0.31	0.51	0.50	0.51
Control	0.24	0.16	0.26	0.19	0.25	0.17	0.41	0.50	0.24
Difference	0.27	0.35	0.25	0.11	0.06	0.15	0.10	0.00	0.27
Value of vouchers in OA (£)									
Treated	1094.0	1094.0	1094.0	523.2	533.7	533.7	1094.0	1085.0	1094.0
Control	811.7	654.6	727.7	293.0	342.6	168.1	745.7	854.6	313.0
Difference	282.3	439.4	366.3	230.2	191.1	365.6	348.3	230.5	781.0
Number of connections >=30Mbps (number of lines)									
Treated	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.7	8.6
Control	8.4	9.0	8.4	8.5	8.7	8.8	8.3	8.3	8.5
Difference	0.2	-0.4	0.2	0.2	-0.1	-0.2	0.3	0.3	0.0
Average download speed (Mbps, logged)									
Treated	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Control	0.22	0.22	0.20	0.18	0.22	0.17	0.20	0.25	0.21
Difference	0.00	0.00	0.02	0.03	0.00	0.05***	0.02	-0.03	0.01
Treated	528	528	528	426	426	426	528	528	528
Control	42934	42936	42934	3558	3558	3558	3147	3147	3147

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

Table B7b: Effect on Broadband Uptake of Hub Investments in all Hub OAs after One Year

	All OAs as Pool			Same exchange OAs			All OAs 4-5km from Hubs		
	I	III	V	I	III	V	I	III	V
Number of vouchers in OA									
Treated	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.31	0.33
Control	0.33	0.20	0.10	0.22	0.48	0.34	0.14	0.32	0.10
Difference	0.00	0.14	0.24	0.11	-0.15	0.00	0.19	-0.01	0.23
Value of vouchers in OA (£)									
Treated	594.2	594.2	594.2	594.2	594.2	594.2	594.8	552.7	588.4
Control	684.9	561.4	265.8	301.1	926.7	642.7	363.1	902.4	297.3
Difference	-90.7	32.7	328.4	293.0	-332.5	-48.6	231.7	-349.8	291.1
Number of connections >=30Mbps (number of lines)									
Treated	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Control	7.1	6.8	6.8	6.4	6.4	6.3	6.9	6.9	6.6
Difference	0.2	0.5	0.5	0.9*	0.9**	1.0**	0.4	0.4	0.7
Average download speed (Mbps, logged)									
Treated	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Control	0.23	0.22	0.23	0.20	0.20	0.22	0.23	0.21	0.22
Difference	-0.02	0.00	-0.01	0.01	0.01	0.00	-0.01	0.01	-0.01
Treated	949	949	949	949	949	949	949	949	949
Control	598311	598234	598311	52139	52134	52139	33460	33459	33460

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

Table B7c: Effect on Broadband Uptake within 400m of Hub Investments after One Year

	All OAs as Pool			Same exchange OAs			All OAs 4-5km from Hubs		
	I	III	V	I	III	V	I	III	V
Number of vouchers in OA									
Treated	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Control	0.17	0.12	0.15	-0.02	0.24	0.11	0.04	0.09	0.31
Difference	-0.03	0.01	-0.02	0.15	-0.11	0.02	0.09	0.04	-0.18
Value of vouchers in OA (£)									
Treated	216.5	216.5	216.5	215.5	216.5	216.3	216.5	216.5	216.5
Control	298.5	241.1	227.8	-53.8	409.7	215.7	105.6	97.5	586.0
Difference	-82.0	-24.6	-11.3	269.2	-193.2	0.6	110.9	119.0	-369.5
Number of connections >=30Mbps (number of lines)									
Treated	6.13	6.13	6.13	6.14	6.13	6.13	6.13	6.13	6.13
Control	5.67	6.21	6.34	6.34	5.93	6.36	6.17	5.95	6.05
Difference	0.46	-0.08	-0.21	-0.20	0.19	-0.23	-0.04	0.18	0.08
Average download speed (Mbps, logged)									
Treated	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Control	0.20	0.21	0.22	0.19	0.19	0.19	0.20	0.20	0.21
Difference	-0.02**	-0.03***	-0.04***	-0.01	-0.01	-0.01	-0.02**	-0.02**	-0.03***
Treated	2178	2178	2178	2178	2178	2178	2178	2178	2178
Control	597082	597005	597082	50948	50943	50948	33461	33460	33461

Table B7d: Effect on Broadband Uptake within 1000m of Hub Investments after One Year

	All OAs as Pool			Same exchange OAs			All OAs 4-5km from Hubs		
	I	III	V	I	III	V	I	III	V
Number of vouchers in OA									
Treated	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Control	0.12	0.13	0.13	0.32	0.21	0.24	0.14	0.13	0.11
Difference	-0.10	-0.11*	-0.11*	-0.30***	-0.19***	-0.22***	-0.13**	-0.11*	-0.09
Value of vouchers in OA (£)									
Treated	-1.4	-1.4	-1.4	-3.4	-1.4	-1.5	-1.4	-1.4	-3.0
Control	257.6	215.4	175.4	536.5	316.2	388.8	312.9	243.5	249.0
Difference	-259.0*	-216.8*	-176.8	-539.9***	-317.6**	-390.2***	-314.3**	-244.9*	-252.0**
Number of connections >=30Mbps (number of lines)									
Treated	6.00	5.99	5.99	6.01	5.99	6.00	5.99	5.99	6.02
Control	5.61	5.78	6.17	5.85	5.92	6.21	5.79	5.66	5.86
Difference	0.38*	0.20	-0.18	0.17	0.07	-0.22	0.20	0.33*	0.16
Average download speed (Mbps, logged)									
Treated	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Control	0.20	0.20	0.21	0.19	0.18	0.19	0.19	0.20	0.21
Difference	-0.02***	-0.02***	-0.03***	-0.01**	0.00	-0.01***	-0.02***	-0.02***	-0.03***
Treated	5049	5049	5049	5049	5049	5049	5049	5049	5049
Control	594211	594134	594211	48235	48230	48235	33461	33460	33461

Table B8a: Effect on Broadband of Hub Investments in English School postcodes after One Year

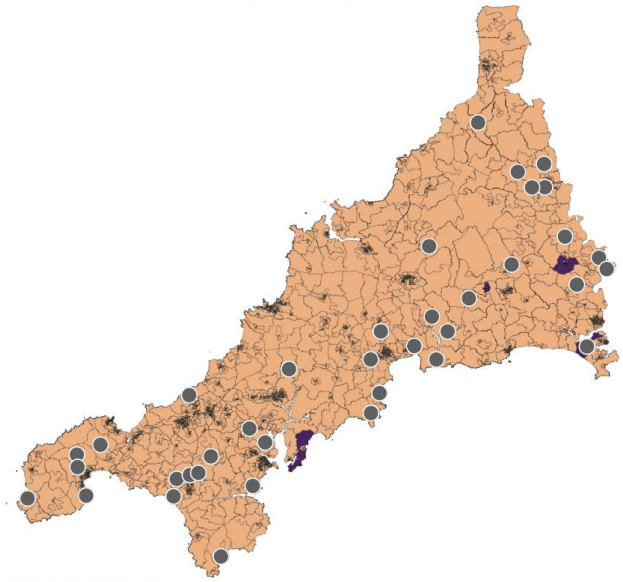
	All OAs with Primary Schools			Primary Schools in same Exchange			Primary Schools in the Fringe		
	I	II	III	I	II	III	I	II	III
Postcode level: Gigabit availability (% premises, logged)									
Treated	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Control	0.08	0.10	0.13	0.11	0.14	0.13	0.13	0.07	0.06
Difference	0.24***	0.22***	0.19***	0.21***	0.18**	0.19**	0.19**	0.25***	0.26***
Postcode level: Average download speed (Mbps, logged)									
Treated	0.28	0.28	0.28	0.29	0.29	0.29	0.28	0.28	0.28
Control	0.21	0.22	0.17	0.09	0.22	0.17	0.21	0.15	0.18
Difference	0.07*	0.06	0.11***	0.20***	0.07	0.12**	0.07	0.13***	0.10*
Treated	528	528	528	426	426	426	528	528	528
Control	42934	42936	42934	3558	3558	3558	3147	3147	3147

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

Mapping the area level data

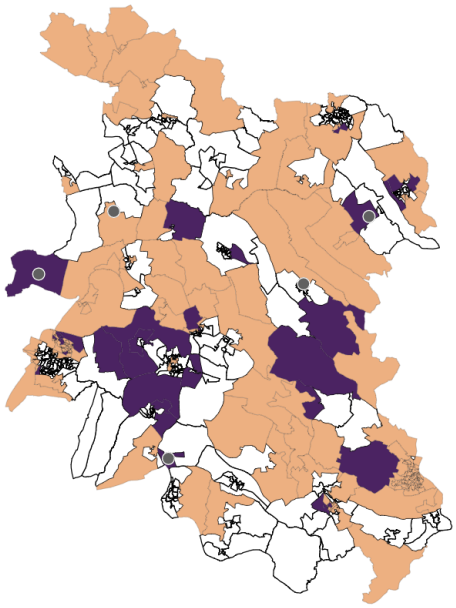
The analysis is underpinned by a geographical dataset at the OA level. This geography is attached to shape files to allow mapping of the data and, in the case study analysis of Cornwall and South Oxfordshire, some maps of key availability and uptake outcomes have been analysed. The additional maps are provided in this section.

Figure 6.2: Cornwall premises passed change & Hubs



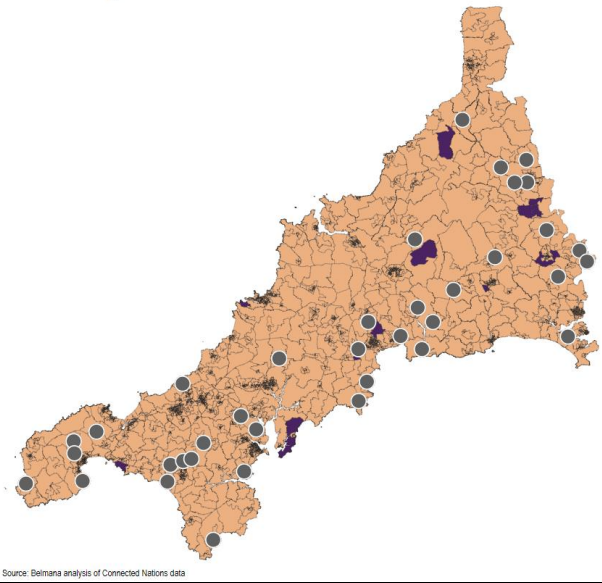
Source: Belmana analysis of Connected Nations data

Figure 6.3: South Oxfordshire gigabit coverage rises & Hubs



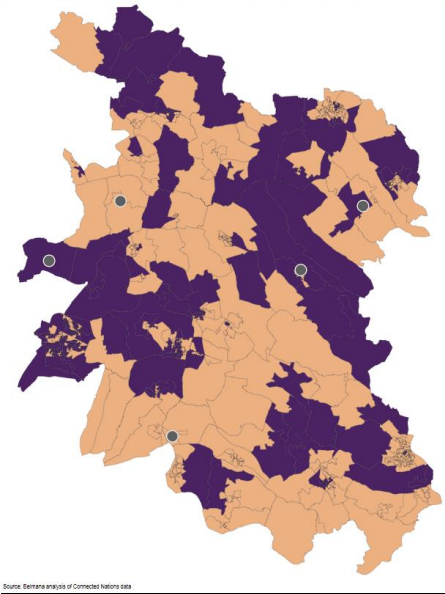
Source: Belmana analysis of Connected Nations data

Figure 6.4: Cornwall voucher value & Hubs



Source: Belmana analysis of Connected Nations data

Figure 6.5: South Oxfordshire download speed rise & Hubs



Source: Belmana analysis of Connected Nations data

Annex C: Surveys conducted for the study

Population and sample

As the main purpose of this study was to establish the impact of the Hubs, all beneficiaries in the population under review were located within a 5km radius of a hub and had received a voucher between December 2021 and September 2022.

There was some overlap with the sample of recipients used in previous vouchers primary research in terms of the voucher date. To ensure no duplication and avoid approaching anyone invited to complete a survey in the evaluation of the Vouchers programme, any case that had received a voucher in the period from September 2021 up to and including 13th December 2021 was removed. The database was further inspected for duplicate properties, duplicate emails and duplicate contact numbers. Duplicates were removed to leave a database of unique 7,964 vouchers.

Vouchers included in the final sample frame had been issued to properties within the vicinity of 314 Hubs, connected between July 2019 and March 2022. The table below summarises the number of vouchers associated with the type of public building that the Hub relates to.

Table C1 Number of vouchers by Hub Type

Type of Hub	Number of Hubs	Number of vouchers (business and residential) associated with these Hubs
Primary schools	204	6,701
GP surgeries	51	625
Fire stations	16	191
Community Centres	13	149
Recycling Centres	10	86
Other (including health or emergency services, tourist or visitor centres)	20	212
Total	314	7,964

The database was provided in two parts. One containing beneficiaries of a Residential voucher and the second containing beneficiaries of a Business voucher.

There were a large proportion (approx. 80%) of beneficiaries in the Business voucher database classed as Residential type[9]. In order to maximise response and ensure all beneficiaries were given the opportunity to respond in a way that was appropriate to their circumstances, those recorded as receiving a Business voucher were given the choice to complete the survey as either a business or as a resident.

In the same way, 19 beneficiaries of a residential voucher that were classified as a business type beneficiary were given the opportunity to respond either as business or a resident.

Thus, in the final population used in the research, there are four groups[10]:

- Recipients of a residential voucher, classified as a residential type beneficiary
- Recipients of a residential voucher, classified as a business type beneficiary
- Recipients of a business voucher, classified as a residential type beneficiary
- Recipients of a business voucher, classified as a business type beneficiary.

The table below sets out for each group how many contacts were in the original database and how many contacts remained after de-duplication, which was used for the population for the surveys.

[9] This was discussed with BDUK at the time and confirmed to be valid on the basis residential premises can be eligible for business vouchers where certain criteria are met. BDUK was unaware as to the specific reasons why the proportion of such cases had increased, but this may be a result of the pandemic.

[10] Note that in the previous vouchers survey there were fewer than 3% of Business voucher recipients coded as a residential type beneficiary and so they were not treated differently to the remaining Business voucher sample.

Table C2 Populations used for primary research

	Residential voucher		Business voucher		Total	
	Original database	**Population** used for primary research (Original database minus duplicates)	Original database	**Population** used for primary research (Original database minus duplicates)	Original database	**Population** used for primary research (Original database minus duplicates)
Residential type beneficiary	5,780	4,341	3,615	2,948	9,395	7,289
Business type beneficiary	19	19	948	656	967	675
Total	5,799	4,360	4,563	3,604	10,362	7,964

Mode of data collection

A mixed method approach was used, comprising an online survey and follow up telephone interviews in some of the groups to boost the response rate. The mode used for each group is set out in the table below.

Table C3 Survey mode used for each group

Voucher type	Voucher beneficiary type	Population used for primary research	Mode
Residential	Residential	4,341	Online Residential survey[11]
Residential	Business	19	Telephone interviews to ensure response given comparatively small sample size, with additional questions to understand why they were categorised as business beneficiary.

[11] It was not anticipated that this group would require the option of completing as a business given they received a residential voucher and were categorised as residential beneficiary type

			Respondents reporting that they didn't use the voucher for residential purposes could complete the survey as a business.
Business	Residential	2,948	Online survey. Respondents who reported that they were not a business but had used the voucher for residential purposes only, could choose to complete the survey as a resident. Telephone interviews to boost response rate, with some additional questions added to understand why they may have been categorised as residential type.
Business	Business	656	Online survey, with telephone interviews to boost response rate.
	Total	**7,964**	

The residents' survey was launched on 22nd October 2022 and the combined business and residents survey was launched on 24th October. Both surveys remained open until 4th January 2023. Telephone calls were conducted between 16th November and 23rd December 2022.

All participants were offered the opportunity to be entered into a prize draw for £100 Love to shop vouchers.

Number of survey responses achieved

In total, 1,518 responses to the residential survey and 219 responses to the business survey were achieved. The two tables below detail the number of responses achieved in each group[12].

[12] Note that analysis of some questions has used all residential or all business responses. In some cases, for comparison analysis, a subset has been analysed. This is noted in each section.

Table C4 Responses to the residential survey

	Population used for research	Responses
Recipients of a **residential voucher,** classified as a **residential type beneficiary**	4,341	1,085
Recipients of a **business voucher,** classified as a **residential type beneficiary,** and responded as a resident	2,948	433

Table C5 Responses to the business survey

	Population used for research	Responses
Recipients of a **business voucher,** classified as a **business type beneficiary**	656	176
Recipients of a **business voucher,** classified as a **residential type beneficiary**	2,948	38
Recipients of a **residential voucher,** classified as a **business type beneficiary** and responded as a business	19	5

Qualitative interviews

63 qualitative telephone interviews were conducted in total, 33 with beneficiaries of residential vouchers and 30 with beneficiaries of business vouchers. These were between 24th November 2022 and 29th January 2023. The main purpose of these interviews was to gather more in-depth insights into how voucher recipients had benefited from their upgrade, and their awareness and views on benefits of the hub upgrade on the wider community.

- In the residential survey, respondents were asked if they would be willing to participate in a follow up conversation about their upgrade experience, in greater depth. The respondents

that said they would be happy to be contacted for this purpose formed the sample for the qualitative interviews with residents.

- 200 business voucher (business beneficiary type) contacts were set aside for the purpose of the qualitative interviews as it was anticipated that business owners would not have the time to complete an online survey and a telephone interview.

Annex D: Case Study Approach

This annex explains the process for grouping areas, used in selecting areas to conduct case studies for the Hubs evaluation, and then provides materials used in the fieldwork. The aim is to conduct fieldwork in around 15 areas in the evaluation, each with at least half a dozen hubs. The aim in the first stage of the evaluation was s to identify 15 local authorities (LAs), representative of the overall portfolio of Hubs investments and to complete two of the studies, with later stages of the evaluation considering the further 13 LAs.

Selecting local areas to study

There are to be 15 case studies conducted at LA level for the Hubs evaluation and, to be in line with the regional spread, around two thirds or eleven of the study areas will be in England and Wales. The focus here is two of these study areas conducted for the first stage of the evaluation.

The table indicates the selection; it also provides some alternatives we might switch to should the selection require adjustment. The selection approach is discussed below, and central to this has been analysis placing the local authorities in England and Wales into four equally sized groups. Broadly, groups 1 to 3 are increasingly non-rural and better served by broadband. The local authorities categorised to group 1 have 295 hubs; group 2 has 254; and group 3 has 145. Group 4 was the most urban and includes all London boroughs. The group has very few hubs (5) and no case studies are proposed from this group of LAs. Then, the selection has focused on the LAs that have a high number of Hubs in each of the first three groups:

Grouping Local Authorities: How the LAs were selected

The selection process has focused on local authorities. There are 374 authorities across the UK. A first step was to structure the Hubs list by these authorities. As where each hub is located is available, this is straightforward. In all, 170 local authorities have at least one hub, and the 1,088 hubs, spread across the nations with 595 in England (59%), 216 in Northern Ireland (20%), 104 are in Wales (16%) and 173 in Scotland (16%).

To select study areas, a local authority level dataset was compiled. This includes the number of hubs, alongside data on whether an LA was classified as rural, its population density, connectivity speeds, F20, number of vouchers and index of multiple deprivation data for employment and income deprivation. An attached spreadsheet has this data.

A statistical technique – principal component analysis (PCA) – has been used to group the local authorities. This is a technique for reducing the dimensionality of datasets, increasing interpretability but at the same time minimizing information loss (see Joliffe and Cadima, 2016).

An index is created based on characteristics of each LA. The index distils data so that variables that are highly correlated, saying essentially the same feature of an LA, can be weighted appropriately and not given too much emphasis. The technique was applied to the 298 local authorities in England and Wales, and then used to generate four groups of LAs, with the grouping being equal in the number of LAs using the 25th, 50th and 75th percentiles for this. (Separate, similar analysis will be undertaken for Scotland and Northern Ireland, but, due to significant differences in the definitions for some variables, pooling analysis across the nations was not undertaken.)

Group 1 represented the most rural and hard to reach areas, with the highest F20 score average and lowest population density. Progressively as the group number increases, the locations become more accessible and as expected the number of hubs in those locations decreases. Group 4 covers metropolitan areas and London boroughs, where there were relatively few Hubs.

Table D1 presents the averages of the overall index and key variables by group.

Table D1: Summary Statistics on each of the generated groups

Group	1	2	3	4	Total
Total Number of Hubs	295	254	145	5	699
Total Built Hubs	195	191	125	3	514
Total Value of investment	£2,809,170	£2,900,930	£1,502,648	£57,716	£7,270,464
Vouchers	9,605	9,631	6,198	10,388	35,822
Av. Download speed 2021	60.7	75.8	92.4	99.4	82.09
Gigabit Av. 2021	20.1	27.5	37.1	63.1	36.97
UFBB Av. 2021	29.8	51.8	70.4	81.4	58.33
N. connections >30Mbps (ln)	10.2	10.6	10.8	11.2	10.68
Internet User Classification 2018	6.0	5.9	6.2	6.0	6.00
F20 Model	0.7	0.6	0.5	0.3	0.53
Density 2020 (ln)	7.2	7.8	8.2	8.8	8.00
Income deprivation	0.1	0.1	0.1	0.2	0.12
Employment deprivation	0.1	0.1	0.1	0.1	0.10
Rurality	0.6	0.2	0.1	0.0	0.23