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Broadband access speeds across the Northern Powerhouse: A comparative analysis of English cities

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Abstract

The UK economy is unbalanced, with the country's economic activity being dominated by London and the south-east of England. To address this imbalance, governments have initiated a series of initiatives aimed at creating a 'Northern Powerhouse' that will realise the north of England's economic potential. While the discussion around the realisation of the 'Northern Powerhouse' has highlighted the need for improved transportation infrastructure across the north of England, this has largely focused on rail or roads with little discussion of telecommunications.

This paper seeks to overcome this surprising omission by focusing on the broadband speeds of Leeds and Newcastle, two cities located in the north of England. Using data from a variety of sources, our analysis demonstrates how broadband speeds vary within and between the two cities and are often worse than the UK average. Furthermore, our analysis of the relationship between affluence and broadband speeds in Newcastle reveals a complex picture that requires further investigation.

Keywords: broadband, UK, Northern Powerhouse, digital divide

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1. Introduction

The UK is a notoriously imbalanced economy. In 2016, total output for the country was £1,748 billion but the overwhelming majority of this was accounted for by England (Harari and Ward, 2018). England accounted for 85% of the total, with Scotland, the next largest nation within the UK, generating just 8.9%. England, in turn, is also unbalanced: London is, by far, the largest part of the English economy with total output of £408 billion, while the north-east is the smallest at £51 billion (Harari and Ward, 2018). In other words, London, with a population of 8.8 million people, accounts for almost a quarter of the UK's economy.

To help address this economic imbalance, George Osborne, the then Chancellor of the Exchequer of the coalition government, launched an initiative that became known as the 'Northern Powerhouse'. Through devolving powers and greater budgetary control to cities and regional authorities across the north of England, coupled with additional investment in infrastructure, it was argued that the economic potential of the region would be realised (Etherington and Jones, 2016; SQW, 2016). These initiatives have, unsurprisingly, heralded considerable discussion (see, for example, Bailey, 2017; Cox and Raikes, 2015; Haughton, Deas, Hincks & Ward, 2016; Lee, 2017; Nurse, 2015).

One interesting aspect of this discussion is that it has vividly demonstrated how infrastructure investment is skewed towards London and the south-east of England. For example, while expenditure per resident on publicly funded infrastructure is £5,426 in London, it is just £223 in the north-east of England (Arnett, 2014). While the difference in transport infrastructure across England has generated considerable debate, it is somewhat surprising that there has been little or no discussion regarding telecommunication infrastructures. Not only does the availability of mobile and broadband (fixed) infrastructures differ across the UK (Ofcom, 2017a), but many regional English cities are home to thriving information, communication and technology (ICT) sectors (Tech Nation, 2018). For example, the Manchester ICT cluster generated gross value added of £3.4 billion in 2017, while the corresponding figure for Newcastle and Leeds was £1.3 billion, £684 million for Sheffield and £456 million for Liverpool (www.technation.io). Quite simply, if these clusters are to continue to thrive, then access to telecommunications needs to be as good as London, which is home to the country's largest ICT cluster that generated £36 billion in 2017.

With this in mind, this paper focuses on the fixed broadband infrastructure in cities integral to the Northern Powerhouse. Through drawing on speed test data, our aim is relatively straightforward, namely, to explore how broadband access speeds differ across urban areas in the Northern Powerhouse. As our analysis is exploratory in nature, we shall focus on two cities: Leeds and Newcastle. The remainder of this paper is divided into five sections. In the following section, relevant literature is reviewed before the data used and methodology adopted is described in Section 3. Our findings are outlined in Section 4, while conclusions are drawn in the final section of this paper.

2. Literature review

A growing and wide-ranging body of literature has highlighted the socio-economic benefits of broadband. Several studies have found that greater broadband penetration results in more economic activity, for example:

- Qiang, Rossotto and Kimura (2009), using data from 120 countries, found that for every 10% increase in broadband penetration additional per capita growth of 1.21% occurred in developed countries and 1.38% in developing.

- Examining OECD countries between 2002 and 2007, Koutroumpis (2009) observed that a 1% increase in broadband penetration resulted in increased economic growth of, on average, 0.025%.
- In the United States, it was found that for every 1% increase in broadband penetration increases employment by between 0.2% and 0.3% per year (Crandall, Lehr & Litan, 2006).

Given these findings, it is perhaps no surprise that some have argued that the socio-economic impact of broadband is substantial. de Rausas, Manyika, Hazan, Bughin, Chui and Said (2011), for example, estimated that the Internet contributed a fifth of the UK's economic growth between 2004 and 2009, while Buttkereit, Enriques, Grijpink, Moraje, Torfs and Vaheri-Delmulle (2009) argued that as the level of mobile broadband penetration in emerging markets approaches that of Western Europe it would add between \$300 and \$420 billion to their economies and create an additional 10 to 14 million jobs.

Moreover, as a 'general purpose technology' broadband's socio-economic impact is far-reaching (Whalley and Sadowski, 2015). Not only does the provision of broadband itself create employment as the networks are built and then operated (Singer, 2014) but further jobs are created as companies develop their online presence and innovation occurs (Cardona, Kretschmer and Strobel, 2013; Katz, 2012). Several studies in the United States have found that greater broadband availability is associated with reduced levels of employment (Atasoy, 2013; Jayakar and Park, 2013; Kolko, 2012).

Not everyone, however, benefits from broadband. Even though considerable progress has been made at expanding the availability of broadband (Broadband Commission for Sustainable Development, 2017; European Commission, 2018a, 2018b), 'access' digital divides still remain within and between countries (ITU, 2015, 2016, 2017). These divides are further compounded by other factors such as the lack of the necessary skills or suitable devices for businesses and individuals to embrace the Internet and maximise the benefits of being online. As such, not everyone benefits to the same extent or in the same way from the Internet. This can be observed in an analysis of the likely benefits of high-speed Internet in Australia. Deloitte Access Economics (2013) identified 10 scenarios reflecting different socio-economic contexts – single, married with / without children, old, young etc.

As can be seen from Table 1 (below), significant variations exist when it comes to the benefits that occur. For example, a 'single mother' may not save that much from being online but will benefit in other ways, unlike a 'student under 25' who saves considerably more from being online than in other ways. A 'student under 25' saves a considerable amount of time each year through being online, unlike a 'single professional over 25' or 'empty nesters over 65'.

[Insert Table 1 about here]

Deloitte Access Economics (2013) explored the impact of broadband within a specific context, namely, the advent of high-speed broadband within Australia. As the socio-economic benefits of broadband are now widely accepted, attention has increasingly turned to another issue, namely, broadband speed and its socio-economic consequences. Broadly speaking, the literature suggests that there are socio-economic benefits associated with increasing broadband speeds. For example, one study of OECD countries found that a doubling of broadband speeds between 2008 and 2010 contributed 0.3% to growth (Rohman and Bohlin, 2014), while another report found that increasing broadband speeds by 4 Mbps resulted in household gains of \$2100 (Ericsson, 2014).

Improving broadband speeds enable users to engage in activities that were previously not possible. This may take the form of more simultaneous users being online within a household, or of increasingly more demanding activities being undertaken (Ezell, Atkinson,

Castro and Ou, 2009; Yiu and Fink, 2012). Moreover, faster broadband speeds may result in innovative activity that creates new services and products.

To capture the widespread socio-economic benefits of broadband, many governments have enacted national plans (Economist Intelligence Unit, 2011, 2012; OECD, 2011). While these plans often share many similarities and reflect the scope and complexity of the role played by broadband as a general-purpose technology, an increasingly prominent feature is a focus on speed. The focus on speed becomes, in essence, shorthand for the changes and improvements that are occurring, and thus overshadows the other features of any broadband plan that is adopted. For example, the European Union's 'Digital Agenda for Europe' is a wide-ranging report that seeks to enhance the availability and quality of infrastructure while encourage the digital economy. It is, therefore, a wider-ranging document that highlights in the process the inherent complexity and dynamism of the digital economy. For many, however, a prominent feature of the report are the three broadband targets, namely:

- That everyone will have access to 'basic broadband' by 2013;
- Everyone will have access to broadband with speeds of at least 30 Mbps by 2020; and,
- Half of all Europeans will have access to broadband with speeds of at least 100 Mbps by 2020 (European Commission, 2010).

These targets were then complemented by the European Commission's 'Gigabit Society' initiative that was outlined in late 2016 (European Commission, 2016). By 2025 all of what is described as the 'main socio-economic drivers' – schools, hospitals etc. – should have access to gigabit connections, while every household, regardless of whether they are located in urban or rural areas, should be able to access the Internet through a connection with a download speed of at least 100 Mbps (European Commission, 2016). Whether these new targets are achievable is debatable, especially in light of the difficulties that Member States are experiencing to meet them (European Court of Auditors, 2018). Moreover, that subsequent reports focus on the original set of targets and not the more recent ones reflect the latter's non-binding nature as well as the significant challenges associated with achieving them (Jackson, 2018).

But what progress has been made towards achieving the original goals? The most recent progress report highlights the progress that has been made to date (European Commission, 2018a). In 2017 everyone across the EU was able to access 'basic' broadband, while a 'fast' connection (i.e., >30 Mbps) was available to 80% of homes (European Commission, 2018a). Improvements in rural availability contributed to the increased availability of 'fast' broadband connections across Europe. In contrast, 'ultrafast' broadband (i.e., >100 Mbps) was available to 15% of European homes. In both cases, considerable variation is evident across the EU. The top five countries for 'fast' broadband access were, in descending order, Netherlands, Belgium, Sweden, Malta and Romania (European Commission, 2018a), whereas the best five countries when it came to 'ultrafast' broadband were, again in descending order, Sweden, Romania, Belgium, Portugal and Latvia.

The UK is noticeable by its absence from these two lists of the best performing countries for 'fast' and 'ultrafast' broadband. While broadband, regardless of speed, is available to around 90% of UK premises, 'fast' connections are available to around 40% of premises whereas 'ultrafast' services are provided to only 15% of premises (European Commission, 2018a). While the availability of 'fast' connections in the UK is above the EU average (42% cf. 34%), 'ultrafast' is more or less the same. Not only does this suggest that the UK is a long way from achieving the targets laid out by the European Commission, but also that broadband connections are, in general, slower rather than faster, which is perhaps why

15% of businesses feel that the speed of their broadband connection is too slow for their needs (European Commission, 2018a).

3. Methodology and data

Data sources

The data is taken from uSwitch, an online (price) comparison website. For Newcastle and Leeds, 4,750 observations were obtained from the website in July 2015. Each observation relates to a speed test undertaken through the website by a member of the public. For each observation, we have the following data: download speed, upload speed, post code, provider, exchange, distance of the speed test from the exchange and the time when the speed test was undertaken.

In addition, drawing on SamKnows (www.samknows.com), for each exchange it was possible to identify whether ADSL, local loop unbundling or cable were available as well as the number of premises served by each exchange. Socio-economic data is taken from the Office of National Statistics (www.ons.gov.uk). House prices data was taken from Rightmove, an online property company that lists houses for sale (www.rightmove.co.uk).

The sample runs from September 2009 to July 2015. The observations of the sample corresponding to an individual who undertook a broadband speed test. As several observations may have occurred on the same day, a daily average was created for ease of analysis when it is longitudinal in nature.

Methodology

Although the observations were daily, a time (monthly) average was undertaken to ease the analytical process. Initially the resulting sample was analysed by postcode as a time series. This enabled any changes in broadband speeds over the sample period to be determined. An approach consistent with Box and Jenkins (1976) was adopted.

Different models were analysed in order to approximate the relationships between download speed and postcode, broadband service provider or telephone exchange. General linear models are estimated by least squares, using Eicker-White heteroskedasticity consistent covariance matrix estimators (Eicker, 1967; White, 1980).

Data

While we have data for all five of the largest cities in the Northern Powerhouse, our focus is on just two of them: Newcastle and Leeds. These cities are different in character, and often overlooked when the Northern Powerhouse is discussed in the media.

Table 2 and 3 describe the demographic profile of both cities. For Newcastle it is possible to distinguish four zones based on local authority. These are: Gateshead, Newcastle, North Tyneside and South Tyneside. In contrast, there are three zones within Leeds: Bradford, Leeds and Wakefield.

[Insert Table 2 about here]

[Insert Table 3 about here]

Leeds has a greater population than Newcastle, but Newcastle has better access to ICT technologies and, interestingly, a higher average broadband speed than Leeds - see Tables 4 and 5 below.

[Insert Table 4 about here]

[Insert Table 5 about here]

4. Findings

How fast are connections in Newcastle?

How fast are broadband connections in Newcastle? Broadband speeds by postcode are depicted in Figure 1. From this figure, a number of conclusions can be drawn. Firstly, average broadband speeds for Newcastle, irrespective of postcode, have increased over time – at the start of the period covered by our sample, broadband speeds were, on average, around 7 Mbps while at the end the period covered this had increased, albeit slightly, to around 8 Mbps. This is, however, misleading. As Figure 1 clearly demonstrates, the trend is upward with average speeds being more than 30 Mbps in early 2014 and close to 30 Mbps in early 2015. The decline at the end of the period covered is, we believe, due to the statistical technique adopted. It is worth noting that while the trend is upwards, considerable variation in average broadband speeds across the city is evident.

[Insert Figure 1 about here]

This general upwards trend masks considerable variation across Newcastle. Recalculating the data so that average broadband speeds by postcode are revealed vividly demonstrates the variability that is observable. There are 17 postcodes within the city of Newcastle. Of these, only three (NE1, NE2 and NE16) start and end the period covered by our sample with a broadband speed that is above the city average. In contrast, seven postcodes (NE3, NE9, NE10, NE15, NE26, NE28 and NE32) witness an improvement in their speeds, that is, they start the period covered by our sample with below average broadband speeds and end it with above average speeds. The reverse is true for just one postcode (NE11). Finally, six postcodes (NE5, NE6, NE8, NE30 and NE33) start and end the period covered by our sample with below average broadband speeds. In other words, these postcodes demonstrate no improvement relative to the city-wide average though, of course, speeds in absolute terms may have increased.

[Insert Figure 2 about here]

Between 2009 and 2015, average broadband speeds for the UK improved. In April 2009 the average broadband speed across the UK was 4.1 Mbps, whereas by November 2015 this had increased to 28.9 Mbps (Ofcom, 2009, 2016). Figure 2 compares broadband speeds in each postcode to the UK average. Newcastle compares poorly with the UK average: just two postcodes (NE9, NE16) start and end the period with above UK average broadband speeds. The rest of the city's postcodes demonstrate below average speeds, either throughout the whole period (NE8, NE10) or at the end (NE1, NE2, NE3, NE5, NE6, NE11, NE12, NE15, NE26, NE28, NE30, NE32, NE33). Significantly, all of those postcodes that ended the period with below UK average broadband speeds started the with above average speeds. In other words, these 14 postcodes witnessed a relative decline in their broadband speed between 2009 and 2015.

Tables 6 and 7 recast Figures 1 and 2. Through doing so, the two tables vividly illustrate the dynamics of change across the city. While Table 6 shows that a considerable proportion of the city has seen average broadband speeds increase over time, this is more or less offset by the number of areas where below average speeds persist. Having said this, Table 7 clearly shows that the bulk of the city has seen their average broadband speeds decline relative to the UK average. This raises a number of issues, not least of which is whether this is due to under-investment or overbooking that reduces average speeds to reflect network congestion.

[Insert Table 6 about here]

[Insert Table 7 about here]

How fast are connections in Leeds?

Figure 3 depicts the average broadband speed in Leeds between July 2009 and July 2015. Similar to the situation in Newcastle, average speeds have increased over time. At the beginning of the period covered by the sample average speeds in Leeds were around 7.5 Mbps, and this increased to around 9 Mbps by July 2015. As in the case of Newcastle, this is slightly misleading – there has been a gradual increase over time, from a low of 7.5 Mbps in July 2009 to above 25 Mbps in early 2015, with the decline being caused by the statistical approach we have adopted.

[Insert Figure 3 about here]

While broadband speeds have, on average, increased in Leeds considerable variation exists across the city. As can be seen from Figure 3, there are 17 relevant postcodes in our sample. Of these, no postcodes started and ended the period with above average broadband speeds. Four postcodes (LS6, LS7, LS9 and WF10) saw above average speeds at the start of the period become below average by the end, while seven postcodes (LS12, LS15, LS16, LS18, LS20, LS27, LS28) saw the reverse happen. Finally, six postcodes (BD2, BD4, LS14, LS21, LS25, LS26) saw no change in their relative broadband speeds – they started and end the period with below average speeds.

If we compare the average broadband speeds per postcode in Leeds against the UK average, a very depressing picture emerges. While two postcodes start and end the period with broadband speeds higher than the UK average (LS12, LS27), the rest of the city ended the period with below average speeds. Significantly 13 postcodes (LS6, LS7, LS9, LS14, LS15, LS16, LS18, LS20, LS21, LS25, LS26, LS28, WF10) saw initial above average speeds reversed by July 2015. The remaining two postcodes (BD2, BD4) saw no change, starting and ending the period with below average broadband speeds. The data contained in Figure 4 is represented as Tables 8 and 9, underlining in the process the disappointing performance of broadband speeds across Leeds.

[Insert Figure 4 about here]

[Insert Table 8 about here]

[Insert Table 9 about here]

Empirical models for Newcastle

Table 10 explores the variation of broadband speeds across Newcastle as defined by three local authorities, namely, Newcastle, South Tyneside and North Tyneside. Our first finding is that broadband speeds increase with distance from the exchange. This is highly surprising and is contrary to expectations and previous research (Gijon, Whalley and Anderson, 2016). One possible explanation is that this reflects the limitations of the sample, and that when all five cities for where we have data are analysed the observed relationship will conform to that expected, that is, speeds will decline the further away the observation is from the exchange.

[Insert Table 10 about here]

The speed of cable observations is faster than those over other access technologies. This is to be expected. Various Ofcom documents illustrate the faster speeds provided by cable compared to DSL based access technologies – for example, in November 2015, Ofcom (2016) reported that ADSL 2+ connections had an average broadband download speed of 8.4 Mbps compared to 50.5 Mbps on ‘up to 50 Mbps’ cable services. Although SDSL was found to be associated with slower download speeds, the result was not significant.

Table 10 also examines the relationship between income and broadband speeds. Our analysis found that in Newcastle and South Tyneside increased salary was associated with faster broadband speeds, whereas in North Tyneside it was not. Of course, all three local authorities are not homogenous, which begs the question as to whether the same relationships between broadband speed and affluence hold true at a smaller geographical level. Using house prices as a proxy for affluence, with data from www.rightmove.co.uk, it is possible to investigate the relationship at the level of a three-digit postcode (i.e., NE1, NE2 etc.). our findings are outlined in Table 11.

[Insert Table 11 about here]

The analysis outlined in Table 11 identifies two different types of areas within Newcastle. Four postcodes (NE6, NE11, NE16, NE33) demonstrate an inverse relationship between house prices and broadband speed, that is, as prices increase over time, speeds decline. Although the results for three of these areas are not significant (NE11, NE16, NE33), for one – NE6 – they are. In recent years the composition of residents in NE6 has changed, through a combination of gentrification on the one hand and students on the other who initially moved into the area but have recently been departing for other parts of the city. Gentrification may have encouraged new or additional infrastructure investment on the part of broadband providers, while the departure of students could have reduced population densities and thus network congestion.

In contrast, our analysis found that in a majority of postcodes across Newcastle as house prices increased, so did broadband speeds. Four seven postcodes our findings were significant (NE3, NE5, NE8, NE9, NE10, NE12, NE32) while for two (NE15, NE30) they were not. The inherent diversity of these postcodes suggests that a multitude of explanations are possible, though the suburban nature of some of the postcodes gives rise to the possibility that speeds reflect low population densities. Other postcodes combine residential and business premises. As our data is comprised of broadband speed tests undertaken by residential customers, the increasing speeds may reflect the investment that has been undertaken to meet business (commercial) demands rather than rising house prices. In other words, residential users are freeloading on the investments made to satisfy commercial demand.

5. Conclusion

This paper has focused on the broadband speeds in Leeds and Newcastle. These two cities are of interest as they are part of the Northern Powerhouse, the government's initiative to rebalance the UK economy away from London so that the economic possibilities of the north of England are realised. The socio-economic benefits of broadband are widely acknowledged, and there is a growing consensus that faster speeds are also advantageous. Responding to these benefits, governments have enacted often wide-ranging national broadband plans.

With this in mind, our analysis, which covered by 33 postcodes across the two cities, explored broadband speeds in Leeds and Newcastle. Through comparing data from broadband speed tests undertaken between September 2009 to July 2015 against national averages, we show how speeds in Leeds and Newcastle are generally lower than the UK average. Given the aforementioned socio-benefits associated with faster broadband speeds, this clearly places Leeds and Newcastle at a disadvantage. Our analysis demonstrated how broadband speeds vary within both cities, and, significantly, found that many postcodes witnessed a relative decline in their broadband speeds. This was particularly true of Leeds, where 13 postcodes started the period covered by our sample with above average broadband speeds compared to the UK but ended it with below average speeds.

A closer examination of broadband speeds in Newcastle revealed some surprising results. Our finding that broadband speeds increased with greater distance from the exchange, which is contrary to expectations. This may reflect the limitations of our approach, in terms of both a focus on individual cities on the one hand or the 125 observations per exchange on the other hand. In contrast, that cable speeds are faster is keeping with expectations. Through a two-stage approach, which initially focused on the local authority before switching to the post-code, shed some light on the relationship between affluence and broadband speed.

Variations in broadband speeds exist between and within Newcastle and Leeds. The analysis has raised a number of issues that require further consideration. Firstly, the relationship between broadband speed and distance requires further investigation. Not only should this consider the investment made in each exchange, but also how speed varies by service provider. Distance bands – 0 to 250 m from the exchange, 250 to 500 m etc. – could be used to ascertain if broadband speeds suddenly change at a particular point from the exchange, and the density of premises considered.

Secondly, the relationship between affluence and speeds needs to be further explored. Exploring this relationship at the local authority geographical level was inconclusive, not least because this unit of analysis was too large to illustrate the nature of this relationship. By using house prices as a proxy for affluence, our analysis revealed an arguably interesting but complex relationship between affluence and broadband speeds. While a handful of postcodes demonstrated an inverse relationship between affluence and broadband speeds, for only one of these was this relationship significant. It is not clear why in one postcode speeds have declined as house prices have increased, nor for that matter does a single explanation emerge to explain why many more postcodes witnessed a positive relationship between affluence and speed.

Further investigation to explain these findings is needed. The nature of the relationship could be due to the balance between residential and business premises, or due to the changing nature of the composition of the areas (students vs. young families vs. older people etc). The informative nature of the findings that emerged from the more nuanced geographical approach suggests that it should be replicated in the other cities (Leeds, Sheffield, Manchester and Liverpool).

In addition, further socio-economic variables could be included in the analysis. This is, unfortunately, easier said than done as the data is not available in a consistent (geographical) format. This ensures that combining data from different sources is not only a challenging activity, but one that shapes the analysis that can be undertaken. Finally, the analysis could be updated to include more recent broadband speed tests but collecting such data across all five cities would be a time consuming, and perhaps expensive, activity.

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Table 1: The benefits in 2020 (A\$)

Scenario	Financial savings A\$	Other impacts A\$	Time saved (hours per year)
Single person over 75	7402	14586	58
Student under 25	5074	651	268
Single professional over 25	-599	13113	-377
Double income, no kids	9673	n/a	146
One income, two kids	7458	3367	204
Unemployed under 21	13074	-370	6
Empty nesters over 65	2237	n/a	-33
Carer / disability household	23154	6392	275
Single mother	484	6532	14
Single person household	-1844	5367	35

Source: Deloitte Access Economics (2013)

Table 2: Demographic profile – Newcastle

		Gateshead	Newcastle Upon Tyne	North Tyneside	South Tyneside
Population		202,400	295,800	204,500	149,600
	Males	99,500	149,400	98,800	72,500
	Females	102,900	146,400	105,600	77,100
Economically Active		101,500	146,100	105,500	70,900
	In Employment	95,900	137,000	99,000	65,000
	Employees	85,900	121,100	85,200	58,400
	Self Employed	9,900	15,700	13,200	6,300
Economically Inactive	Unemployed	5,800	10,100	6,100	5,300
		28,300	58,300	24,000	23,000
	Student	6,300	27,200	6,100	4,400
	Looking After Family/Home	6,700	9,100	6,000	6,700
	Long-Term Sick	9,700	10,300	5,900	6,700
	Retired	3,100	5,600	3,400	2,800
	Other	1,700	2,800	2,000	1,800
	Wants a Job	8,900	12,100	6,700	6,000
	Does Not Want a Job	19,300	46,200	17,300	17,000
Employment by occupation	Group				
	1	7,400	10,900	7,800	4,400
	2	17,500	33,600	21,200	12,400
	3	10,800	14,200	14,600	8,600
	4	12,400	14,800	12,100	6,600
	5	9,600	13,300	8,000	7,200
	6	9,900	12,500	8,500	7,900
	7	10,700	12,200	10,800	6,400
	8	7,300	5,900	5,900	4,900
	9	10,300	19,100	9,600	6,600
Qualifications					
	NVQ4 And Above	37,500	75,200	46,800	26,900
	NVQ3 And Above	63,200	122,900	73,100	48,000
	NVQ2 And Above	91,400	156,000	99,000	69,600
	NVQ1 And Above	105,500	171,500	112,800	80,200
	Other Qualifications	8,200	11,800	6,700	4,700
	No Qualifications	13,100	18,100	7,300	7,200
Earnings by residence	Full Time Workers (£)				
	Gross Weekly Pay	495.70	532.50	545.50	475.30
	Hourly Pay	12.67	13.43	14.38	12.06
Claimant Civil Service jobs		4,790	8,385	3,470	4,425
		2,320	10,950	1,050	540
	Full Time	1,300	7,170	610	380
	Part Time	1,010	3,780	440	170

Notes:

Employment groups:

- 1 – Managers, directors and senior officials
- 2 – Professional occupations
- 3 – Associate professional and technical
- 4 – Administrative and secretarial
- 5 – Skilled trades and occupations
- 6 – Caring, leisure and other services
- 7 – Sales and customer service occupations
- 8 – Process plant and machine operatives
- 9 – Elementary occupations

Source: Office for National Statistics (www.ons.gov.uk)

Table 3. Demographic profile Leeds

		Leeds	Bradford	Wakefield
Population		784,800	534,800	340,800
	Males	385,300	263,700	167,700
	Females	399,600	271,100	173,100
Economically Active		417,600	242,500	169,800
	In Employment	399,400	228,100	159,500
	Employees	348,000	192,500	139,800
	Self Employed	49,000	35,400	19,100
	Unemployed	19,500	15,000	9,100
Economically Inactive		101,400	91,100	42,700
	Student	28,400	27,100	9,200
	Looking After Family/Home	27,800	29,500	10,200
	Long-Term Sick	17,600	19,000	12,000
	Retired	14,100	6,800	5,300
	Other	12,100	8,300	3,800
	Wants a Job	19,700	14,000	15,800
	Does Not Want a Job	81,700	77,100	26,900
Employment by occupation	Group			
	1	35,800	19,400	12,600
	2	86,000	37,500	27,200
	3	52,800	28,100	20,300
	4	37,000	24,000	16,200
	5	43,700	26,500	18,400
	6	41,000	22,900	12,300
	7	34,200	20,200	12,400
	8	21,300	21,200	16,100
	9	45,100	28,100	23,600
Qualifications				
	NVQ4 And Above	185.300	86.100	58.200
	NVQ3 And Above	280.800	151.800	101.100
	NVQ2 And Above	366.300	213.500	140.500
	NVQ1 And Above	421.700	256.300	168.500
	Other Qualifications	30.300	26.600	15.200
	No Qualifications	56.900	42.700	21.400
Earnings by residence	Full Time Workers (£)			
	Gross Weekly Pay	536.60	476.20	483.90
	Hourly Pay	13.66	11.85	11.76
Claimant		11,660	9,585	4,280
Civil Service jobs		7,740	3,370	1,520
	Full Time	5,970	2,170	1,220
	Part Time	1,770	1,200	300

Notes:

Employment groups:

- 1 – Managers, directors and senior officials
- 2 – Professional occupations
- 3 – Associate professional and technical
- 4 – Administrative and secretarial
- 5 – Skilled trades and occupations
- 6 – Caring, leisure and other services
- 7 – Sales and customer service occupations
- 8 – Process plant and machine operatives
- 9 – Elementary occupations

Source: Office for National Statistics (www.ons.gov.uk)

Table 4: Data description

		Obs.	Mean	Std. Dev.	Min	Max
Leeds	Download speed	2,250	15.44052	17.83583	.06	411.97
	Upload speed	2,250	1.718	2.490343	0	18.32
	Exchange distance	2,250	288.0004	218.5173	0	1798
Newcastle	Download speed	2,500	16.77439	17.7311	.07	170.28
	Upload speed	2,500	1.778292	2.460891	0	40.87
	Exchange distance	2,500	263.3804	151.5915	0	1475

Note: Download and upload speed are measure in Mbps, the exchange distance is measure in meters.

Table 5: Percentage of ADSL, SDSL, cable and LLU service by city

City	Technology			
	ADSL	SDSL	Cable	LLU service
Leeds	90.07%	35.03 %	70.06 %	90.07%
Newcastle	100%	50.00 %	95.00 %	100%

Table 6: Broadband speeds by postcode relative to the average for Newcastle, 2009 – 2015

		End of period	
		Above average	Below average
Start of period	Above average	NE1, NE2, NE16	NE11
	Below average	NE9, NE10, NE15, NE26, NE28, NE32,	NE5, NE6, NE8, NE12, NE30, NE33

Source: compiled by the authors

Table 7: Newcastle broadband speeds by postcode relative to the UK average, 2009 – 2015

		End of period	
		Above average	Below average
Start of period	Above average	NE9, NE16	NE1, NE2, NE3, NE5, NE6, NE11, NE12, NE15, NE26, NE28, NE30, NE32, NE33
	Below average		NE8, NE10

Source: compiled by the authors

Figure 1: Average broadband speeds in Newcastle, 2009 – 2015

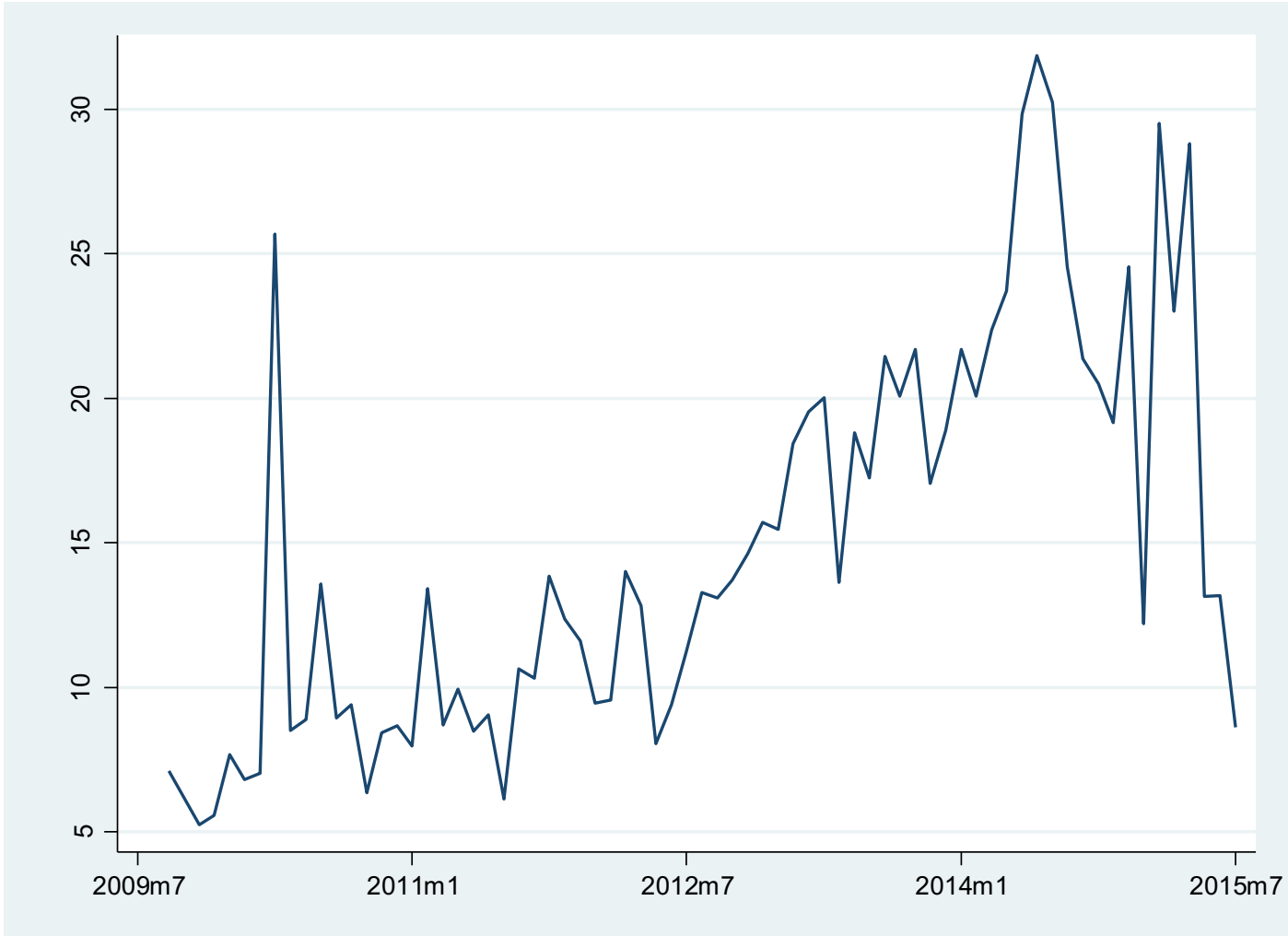


Figure 2: Broadband speeds in Newcastle by postcode relative to city and UK averages, 2009 - 2015

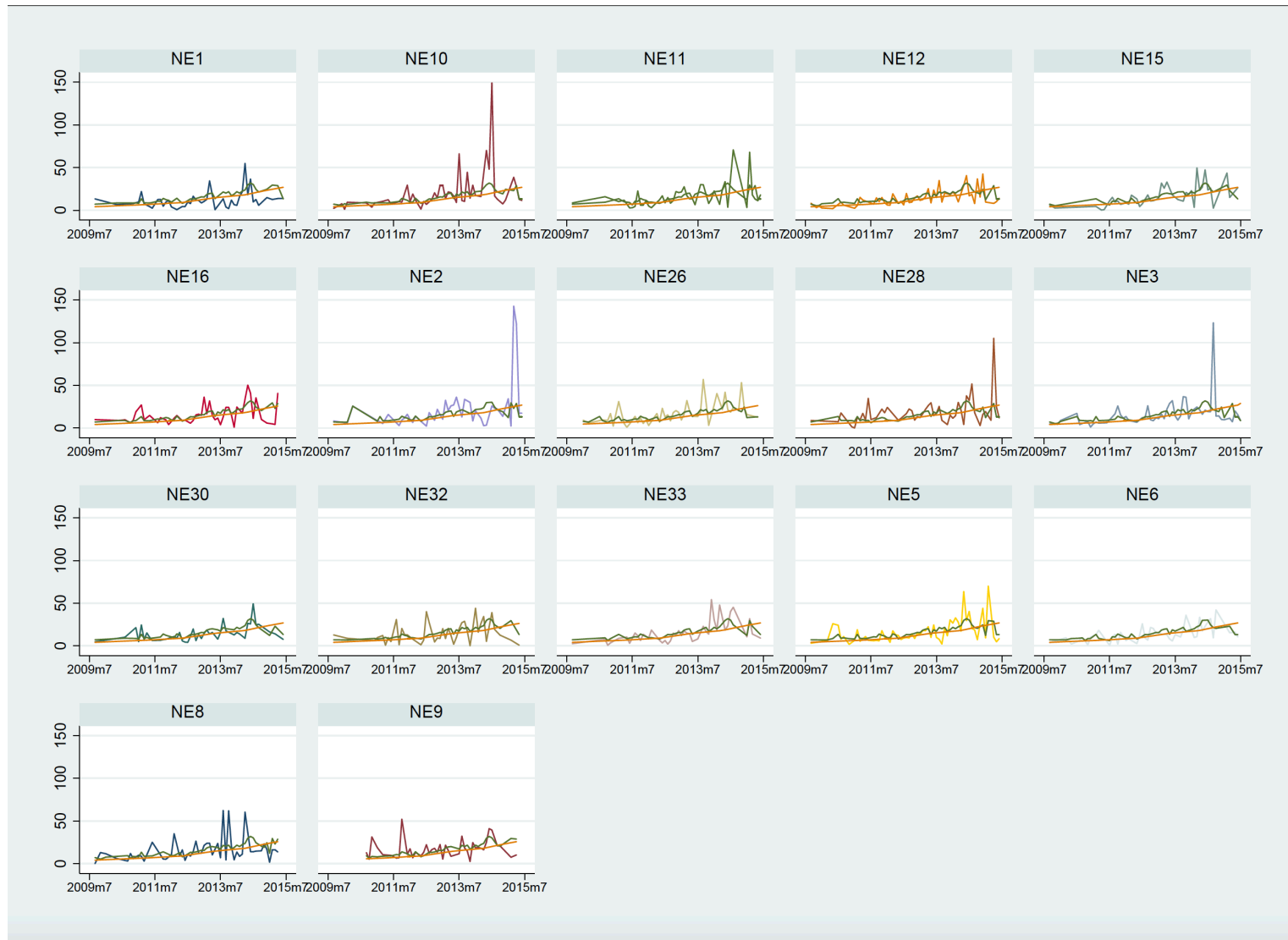


Figure 3: Average broadband speeds in Leeds, 2009 – 2015

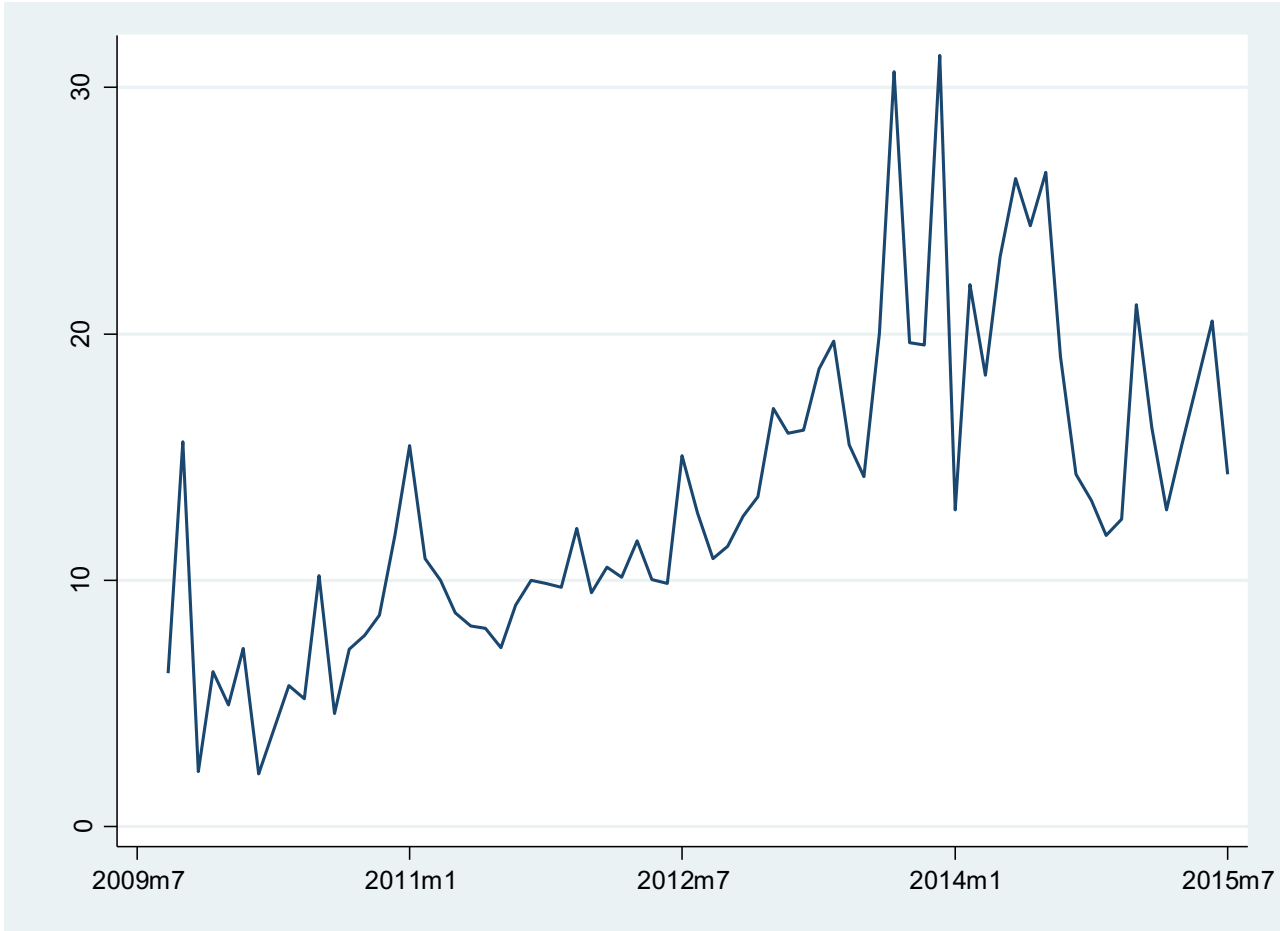


Figure 4: Broadband speeds in Leeds by postcode relative to city and UK averages, 2009 - 2015

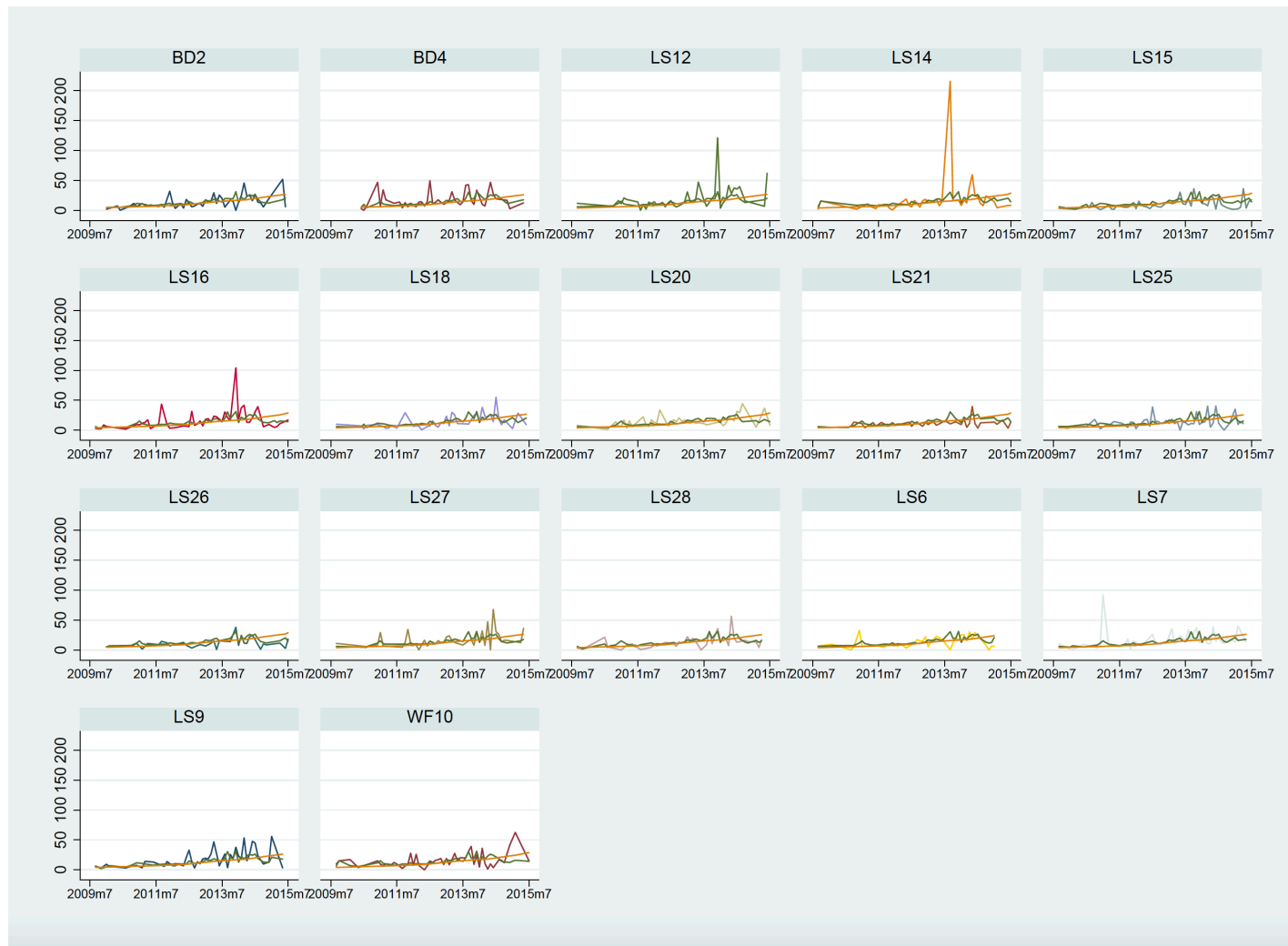


Table 8: Broadband speeds by postcode relative to the average for Leeds, 2009 – 2015

		End of period	
		Above average	Below average
Start of period	Above average		LS6, LS7, LS9, WF10
	Below average	LS12, LS15, LS16, LS18, LS20, LS27, LS28	BD2, BD4, LS14, LS21, LS25, LS26

Source: compiled by the authors

Table 9: Leeds broadband speeds by postcode relative to the UK average, 2009 – 2015

		End of period	
		Above average	Below average
Start of period	Above average	LS12, LS27	LS6, LS7, LS9, LS14, LS15, LS16, LS18, LS20, LS21, LS25, LS26, LS28, WF10
	Below average		BD2, BD4

Source: compiled by the authors

Table 10: Broadband speeds across Newcastle, South Tyneside and North Tyneside

```
. reg Download_speed Exchange_distance cable sdsl GWP_NE GWP_NT GWP_ST
```

Source	SS	df	MS	Number of obs	=	2,500
Model	59361.0979	6	9893.51632	F(6, 2493)	=	33.96
Residual	726303.883	2,493	291.337298	Prob > F	=	0.0000
				R-squared	=	0.0756
				Adj R-squared	=	0.0733
Total	785664.981	2,499	314.391749	Root MSE	=	17.069

Download_speed	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Exchange_distance	.0077516	.0023	3.37	0.001	.0032416	.0122616
cable	4.901274	1.643353	2.98	0.003	1.678797	8.12375
sdsl	-1.032492	.7044493	-1.47	0.143	-2.413858	.3488739
GWP_NE	.0896342	.0325341	2.76	0.006	.0258376	.1534309
GWP_NT	-.0360425	.0326575	-1.10	0.270	-.1000812	.0279961
GWP_ST	.4719722	.0726257	6.50	0.000	.3295592	.6143852
_cons	-229.2482	24.81715	-9.24	0.000	-277.9126	-180.5839

```
. vif
```

Variable	VIF	1/VIF
GWP_NE	2.99	0.334831
GWP_ST	2.53	0.394559
GWP_NT	1.57	0.635327
cable	1.10	0.908450
sdsl	1.06	0.939327
Exchange_d-e	1.04	0.959044
Mean VIF	1.72	

Table 11: House prices and broadband speeds in Newcastle by postcode

Source	SS	df	MS	Number of obs	=	2,500
Model	53038.1637	16	3314.88523	F(16, 2483)	=	11.23
Residual	732626.818	2,483	295.057115	Prob > F	=	0.0000
				R-squared	=	0.0675
				Adj R-squared	=	0.0615
Total	785664.981	2,499	314.391749	Root MSE	=	17.177

Download_speed	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Exchange_distance	.008595	.0023171	3.71	0.000	.0040515	.0131386
cable	4.978313	1.658752	3.00	0.003	1.725633	8.230993
sds1	-1.174549	.7085443	-1.66	0.098	-2.563947	.21485
lhp_NE6	-20.61298	5.048186	-4.08	0.000	-30.51206	-10.71389
lhp_NE10	9.891198	4.564655	2.17	0.030	.9402763	18.84212
lhp_NE11	-4.806083	3.7316	-1.29	0.198	-12.12345	2.511284
lhp_NE12	13.35985	4.320715	3.09	0.002	4.887275	21.83243
lhp_NE15	6.474411	3.967469	1.63	0.103	-1.305479	14.2543
lhp_NE16	-5.038564	3.523712	-1.43	0.153	-11.94828	1.871153
lhp_NE3	10.68205	3.881332	2.75	0.006	3.071072	18.29303
lhp_NE30	5.431811	4.821619	1.13	0.260	-4.022998	14.88662
lhp_NE32	9.464683	3.365004	2.81	0.005	2.86618	16.06319
lhp_NE33	-5.395294	3.569994	-1.51	0.131	-12.39577	1.605178
lhp_NE5	8.359208	4.691051	1.78	0.075	-.839567	17.55798
lhp_NE8	25.29214	4.021465	6.29	0.000	17.40636	33.17791
lhp_NE9	18.78837	3.773078	4.98	0.000	11.38967	26.18707
_cons	-842.5615	123.0457	-6.85	0.000	-1083.844	-601.2787

. vif

Variable	VIF	1/VIF
lhp_NE16	1.85	0.539456
lhp_NE6	1.83	0.547792
lhp_NE33	1.70	0.589248
lhp_NE8	1.52	0.659558
lhp_NE32	1.50	0.668201
lhp_NE30	1.45	0.688198
lhp_NE10	1.43	0.696963
lhp_NE15	1.39	0.718466
lhp_NE5	1.35	0.738613
lhp_NE9	1.33	0.749976
lhp_NE3	1.32	0.760065
lhp_NE12	1.27	0.786096
lhp_NE11	1.19	0.839617
cable	1.11	0.903045
sds1	1.06	0.940355
Exchange_d~e	1.04	0.957014
Mean VIF	1.40	