



Munich Personal RePEc Archive

Broadband and Uneven Spatial Development: The Case of Cardiff City-Region

Jones, Calvin

Cardiff Business School

8 February 2018

Online at <https://mpra.ub.uni-muenchen.de/86636/>

MPRA Paper No. 86636, posted 11 May 2018 13:27 UTC

Broadband and Uneven Spatial Development: The Case of Cardiff City-Region.

Calvin Jones
Cardiff Business School
Colum Drive
Cardiff CF10 3EU
UK
Jonesc24@cf.ac.uk
+44 (0)2920 875470

@welshecon

Abstract

The internet and e-connectivity more generally are increasingly held to be an important element of business success. Evidence however suggests that the productive impacts of such technologies are contingent on factors that include firm size and sector, and human capital. It follows that if companies with these characteristics are unevenly distributed across space, the increasing importance of broadband in economic activity might impact unevenly on economic outcomes across space. We examine the Cardiff City-Region in South Wales, where the distribution of businesses and skills suggests that without policy intervention the roll out of broadband might further increase economic disparities between the relatively prosperous coastal belt and the poorer post-industrial hinterland.

1. Introduction

Technological change is progressing at an extremely fast pace. Information technology now allows production, sale and distribution and consumption to occur in ways unthinkable only a few decades ago (Kellerman, 2010). This fourth wave of the industrial revolution implies more fundamental changes in the way workers work and are managed, and in the scope of human work (Frey and Osborne 2017; Goldberg and Kehoe 2013). The first (English) industrial revolution, wherein a novel financial architecture combined with the exploitation of fossil fuels, had stark consequences for people *and* for places. The spatial distribution of people changed more quickly than any time in history (outside of wars and natural disasters), as new productive mechanisms required the clustering of workers in cities to be near factories (Floud *et al*, 2014). New industries and occupations were invented) whilst some work became uneconomic; such urbanisation and sectoral change is a characteristic of economic development (Floud *et al*, 2014; Drakakis-Smith, 2012).

Current technological upheavals will have significant impacts on business location, place competitiveness and spatial development, especially as such developments enable automation and the wider application of artificial intelligence (Brynjolfsson, and McAfee, 2014). However, the spatial impacts of such developments have been understood rather broadly, if at all (Kerry and Danson, 2016). In the UK, government policy generally downplays the

importance of spatial elements in economic development and industrial and spatial planning interventions are limited (Bentley and Pugalis, 2013; Department for Business, Energy and Industrial Strategy, 2017). However, if industrial (and related social) change has uneven spatial impacts, there will be differential impacts on the economic success of diverse (Graham, 2002). For broadband particularly, whilst the roll-out narrative and associated debate is about connecting (and engaging) SMEs, and on the urban-rural divide, evidence suggests that impacts will be much more nuanced (Department for Culture, Media and Sport, 2015; Murray, 2016; Mack, 2015; Mack and Grubestic, 2009).

To investigate the potential for these spatially differential outcomes we examine the potential impact of high-speed broadband roll-out in the Cardiff Capital City-Region in Wales, a poor part of the UK. There are reasons why this is an illustrative case. Firstly, City-Regions and City-Deals are the primary way in which UK Government interacts with 'economic space'; devolving relevant planning, development, transport and (sometimes) skills policies to city-region level political coalitions, along with budgets and challenging economic targets (O'Brien and Pike, 2015; HM Cabinet, 2016). Secondly, South Wales is an economically place. It currently has five levels of relevant governance – local authority; City-region, Welsh; UK and (historically developmentally-important) EU. It has a prosperity divergence between the coastal counties and the poorer post-industrial valleys, and a long history of policy intervention in innovation and 'regional learning' (Pugh 2014; Morgan, 2016).

This paper then presents an *ex ante* analysis of how broadband roll-out might impact economic development in different parts of the region, examining evidence from existing studies on what kinds of businesses and sectors benefit from e-connectivity and then suggesting which places across the Cardiff City-Region might win or lose (relatively) as the productive use of high speed e-connectivity becomes an increasing factor in economic success. The following Section briefly presents the policy context for the region and describes the scope and objectives of the 2016 Cardiff City-Deal. Section Three summarises what we know about how broadband (and ICT) contributes to productivity in businesses and hence to competitiveness. Sections Four and Five relate these findings to the business and workforce characteristics of the ten local authorities that comprise the City-Region; an analysis that strongly suggests that if internet-enabled activity is becoming more important, the net effect is likely greater spatial economic divergence. Section Six concludes.

2. City-Deals and City-Region Policy in the UK and Wales

After 2010 the UK Government made a strong statement on its approach to spatial economic policy, abolishing the nine English Regional Development Agencies in favour of smaller, business-led Local Enterprise Partnerships with a more limited remit and budgets. At the same time, planning and development policy in England was re-engineered (under Austerity) to become much more local, whilst innovation policy moved to the UK level (Pike *et al* 2016; Bentley

and Pugalis, 2010; Hildreth and Bailey, 2013; Kerry and Danson, 2016). Meanwhile, responsibility for development policy in general shifted, with the Department of Business Innovation and Skills (BIS) losing policy prominence and autonomy to the Treasury and Chancellor. This direction of travel continued under the 2015-17 Conservative Government with the Chancellor in *de facto* charge of spatial economic policy (in England). The only game in town – or at least English cities – was the devolution of development and related policy via bilateral agreements between the Treasury and city-region growth coalitions (O'Brien and Pike, 2013). A number of such agreements were signed offering policy devolution and a (sometimes modest) investment pot in exchange for attainment of 'gateway' targets, usually based on growth in Gross Value Added (GVA) or employment, and often on the promise to directly elect a local mayor (Meegan *et al*, 2014). This City-deal approach was criticised as a way to shift perceived responsibility and accountability for the impacts of UK Austerity policies from Westminster to City Hall (Meegan *et al*, 2014; O'Brien and Pike 2016). Despite the existence of devolved competence in relevant areas, eight Authorities in Central Scotland signed the Glasgow City Region City-Deal, with a £1.1bn investment fund, focussed on innovation and infrastructure hoping to create 28,000 jobs¹.

¹ <https://www.gov.uk/government/publications/city-deal-glasgow-and-clyde-valley>

More recently the Cardiff City Region City-Deal formally recognised the importance of devolved regional government by including the Welsh Government as a signatory (and source of funding) in a tripartite agreement². The area in South East Wales covered by the Deal is in desperate need of regeneration. Whilst the five authorities that cover the coastal belt (two cities and two largely rural Counties, plus Bridgend) are relatively prosperous, the Valleys hinterland – home to around 1m people – suffers from long established economic and dysfunction related to the decline of coal mining and manufacturing (Dicks, 2014). Employment rates and economic inactivity in all Valleys authorities are worse than the UK (Jones *et al*, 2015). Whilst South East Wales overall has a GVA per head in 2014 at around 73% of the UK average, this ranges from around 90% of the UK in the NUTS3 area of Cardiff and the Vale of Glamorgan, down to only 65% of the UK in the Valleys (Office for National Statistics, 2017).

Cardiff has performed better economically than the rest of Wales, helped by employment growth over the longer term in (principally) retail and hospitality and the public sector. Of a total workforce in 2015 of 214,000, around 83,000 in-commute, 63,000 of these from Valleys authority of Rhondda-Cynon-Taff alone (Welsh Government, 2016). The long term shift of employment opportunities (along with population and infrastructure) from the Valleys to the coast, forms a

² See <https://www.gov.uk/government/publications/city-deal-cardiff-capital-region>

backdrop for city-regional policymaking, collaboration and debate. 'Saving' the Valleys has been a perennial theme, and with ameliorative policies over recent decades (whether enacted by UK government or Welsh Government) following the UK-standard approach developed in the 1980s. Inward investment, skills (and entrepreneurship) development, enterprise zones and new connectivity infrastructure are consistent themes (Dicks, 2014; Stroud *et al*, 2015) ; These interventions have failed to improve the position of the Valleys relative to the UK, for complex and poorly understood reasons (Foden *et al*, 2014).

3. Winners and Losers in the ICT and Broadband Revolution

The impact of information technology (ICT) on productivity has never been straightforward to conceptualise and measure, leading to Solow's famous aphorism that 'you can see the computer age everywhere except in the productivity statistics' (see Triplett, 1999 for a discussion). This is in large part because investments in ICT generate productivity increases over different (and extended) time periods, and require significant up-front investment, not just in terms of cash but also in complementary product and process innovation and in organisational restructuring (Brynjolfsson and Hitt, 2003; Pilat, 2005). ICT investment also has manifold potential impacts on firm productivity and hence competitiveness, with avenues including improved access to markets and suppliers; streamlined and lower cost management, logistical, design and other processes; and the spurring of within firm innovation (Bertschek *et al*, 2013; Higón, 2012;). ICT also enhances the productivity of some workers whilst

replacing others (Frey and Osborne, 2017; Levy and Murnane, 2012). Add to this uncertain time lags, the potential importance of unobserved variables and the relative weight of ICT impacts to other factors, and it is unsurprising that debate remains around just how (and how much) ICT affects productivity – or will in the future as ‘Industry 4.0’ advances become more embedded (Hempel, 2005; Brynjolfsson and McAfee, 2014).

This uncertainty is just as prevalent when assessing the firm-level (and consequent household and place) impacts of “broadband” adoption, with the question further complicated by a fast-moving technological environment. The term itself is easily understood as always-on, high-speed access to the internet, but the notion of ‘high-speed’ grew from 2 to 4Mbps in the US Federal Communications Commission definition of 2009, then to 25Mbps by 2015 (Federal Communications Commission, 2015). Then the question is not just whether (and how) broadband access might impact productivity, but also whether different available speeds (peak and/or average) or reliability might have different impacts – and indeed on different types of firms (Kenny and Kenny, 2011). Even when broadband access (or use) is treated as a binary, empirical difficulties remain, not least related to the lack of information available on how far firms have access to, and then use, broadband enabled services and then how these firms perform. Some country-level studies avoid such micro-empirical difficulties to suggest broadband roll-out spurs economic growth at national level, (Röller and Waverman (2001). Similar positive findings (again using a micro-macro approach) are reported by Koutroumpis (2009) for fifteen

EU countries between 2003-2006, and Katz *et al* (2010) suggest that for Germany the economic impact of broadband would total over €170bn by 2020. There is however a concern that in approaches shared by some macro-level studies (e.g. Czernich *et al*, 2011), instrumental variables often address broadband roll-out or availability *not* actual firm take-up, let alone productive use (Holt and Jamison, 2009; Forman *et al*, 2003).

Several studies have undertaken extensive survey work to fill the theoretical gaps. Grimes *et al* (2012) combined a (compulsory) survey of over 6,000 New Zealand businesses with a longitudinal business database to estimate a 7-10% productivity improvement consequent on broadband adoption. Such time- and firm-extensive data are the exception however. For example, while Bertschek *et al* (2013) surveyed 4,400 German businesses, their findings – that broadband positively impacted on innovation but not labour productivity – may have been affected by their two-year survey timeframe (2001-2003); perhaps too short to allow any innovative actions to play out. In Italy meanwhile, Colombo *et al* (2013) report on the (discoverable but very contingent) productivity impacts on Italian small and medium businesses whilst Haller and Lyons (2015) find no impact at all for Irish manufacturers. These firm level studies (and see Díaz-Chao *et al*, 2015; Hall *et al*, 2013) for work on ICT more generally) are complemented by a suite of ‘meso-level’ investigations that seek to examine the performance (or location) of firms in small areas (US Counties for example) that are differentiated by broadband provision or adoption (Mack, 2014; Whitacre *et al*, 2014; McCoy *et al* 2016). These investigations, mostly using US data, reveal

some interesting facts about the relative economic performance of places that benefit from broadband provision, and by implication the firms that are based there. This work is important in seeking to link broadband impacts with the local economic context (Kolko, 2012; Mack and Faggian, 2013; Mack and Rey, 2013). In each of these studies broadband is found to have economic and productive impacts (although not, perhaps for households), but only in partnership with other necessary within-firm, and perhaps place-related competencies and factors. Very recently a number of policy studies have emerged to suggest that the new technologies – automation, AI and the application of algorithms for example – that are e-connectivity enabled will have geographically differential impacts (for example Future Advocacy, 2017).

Drawing from this range of studies enables a picture of what types of firms, workers and places might benefit *relatively more* from broadband provision and/or take-up. Table 1 summarises these stylised facts, accepting the evidence is far from definitive. There are several factors that emerge with perhaps the clearest finding that for broadband to have positive economic impacts a high level of ‘complementary’ human capital is required – in terms of occupations and/or qualifications (Mack and Faggian, 2013; McCoy *et al*, 2016; Arvanitis and Loukis 2009). Another repeated finding is that ‘knowledge intense’ firms and specific industries – professional and business services, telecoms, utilities, finance and insurance – benefit more than manufacturing and retail operations (Kolko, 2012; Johnston *et al*, 2007; Mack 2015). The work of Elizabeth Mack and colleagues is especially interesting in a spatial context,

suggesting that not only the economic structure of a place matters, but also its relationship to other places – be this the relevant urban/metro core or dominant knowledge hub – as does economic history (Mack and Rey, 2013; Mack, 2015). Whilst some of these insights may directly apply only to the US context, the possibility that there is a nuanced relationship between broadband, business productivity and economic and geographic space is important when reflecting on a currently rather crude spatial context to broadband policy in the UK.

Table 1 - The Economic Impacts of Broadband and Internet Access

Impact Domain	Findings	Studies
Firms	Requires firms with higher levels of internal human capital/highly qualified workers/occupations	Mack and Faggian (2014) Arvanitis and Loukis (2009)
	Requires wider organisational response and restructuring, favouring the 'fleet of foot'	Arvanitis and Loukis (2009) Colombo et al (2013)
	Greater cost savings and impacts and swifter adoption in medium and large firms	Fornefeld <i>et al</i> (2008) Johnston <i>et al</i> (2007)
	Requires use of advanced, rather than basic, enabled software/services	Colombo <i>et al</i> (2013)
Industry	More beneficial to services than manufacturing and retail	Johnston <i>et al</i> (2007); Haller and Lyons, 2015
	Largest effects in 'modern' (business/professional/management/technical) services; utilities; communications; finance and insurance; science	Kolko (2012)
Workers	ICT Complementary to highly skilled and qualified workers;	Frey and Osborne (2017) Mack and Faggian (2014) Levy and Murnane (2012)
	ICT substitute for 'routine' jobs and workers	Frey and Osborne (2017)
	Automation impacts low skill workers relatively more	Arntz et al (2016)
Places	Positive impact on location of knowledge intensive firms	Mack and Rey (2014)
	More modest locational impact in places with 'industrial legacy' and in US rust belt	Mack and Rey (2014)
	Encouraging of new firm start-ups and positive impacts on local economic growth - but only where local human capital is high	McCoy <i>et al</i> (2016)

	Impacts diminished by near location to already tech-dominant metro area	Mack and Rey (2014)
	More beneficial to rural areas and agricultural firms, and to intermediate urban locations	Mack and Grubestic (2009) Mack (2014) Mack (2015)

4. Cardiff Capital City-Region Case Study

The literature suggests that the productivity and growth impacts of broadband will be mediated by firms' sector, orientation and size, and especially by the existence of complementary human capital. Because these factors are uneven over space – and because spatial factors themselves mediate broadband impacts – we can make an *a priori* judgement on how an economy which increasingly values the outputs of broadband-enabled activities, services and products will affect economic development over space. This is potentially applicable (and policy relevant) in a place such as the Cardiff City-Region, with significant differences in economic conditions, firm populations and skills and qualifications within a single functional economic area (Jones *et al*, 2015).

Wales is now at the forefront of Superfast (24Mbps+) broadband availability across most of its geography, largely due to a publicly funded roll-out of fibre (Ofcom, 2015), but as the literature makes clear the penetration or provision of broadband does not guarantee business take up, let alone productive use (Whitacre *et al*, 2014): this is by no means then wholly, or even largely, a 'supply side' problem (especially in Wales). If then, we assume that engaged

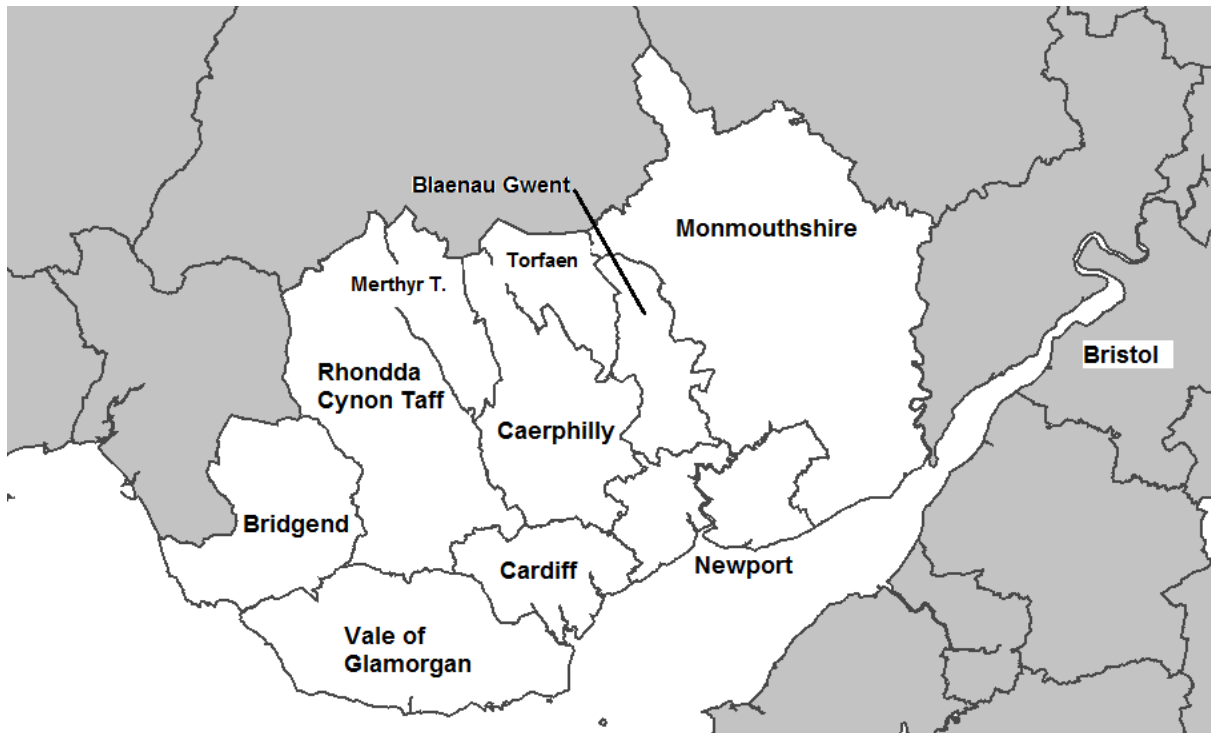
businesses who require broadband can access reliable and speedy services on site (or move premises), the question arises as to whether different parts of the city-region might, via their firms, workers and other economic characteristics, make 'better' use of this technology than others, with implications for within-region uneven spatial development (Boschma *et al*, 2013).

There are datasets that enable this forward-looking examination of potential spatial impacts. In most cases, relevant, up to date and reasonably robust economic data are available for the ten local authorities that comprise the Cardiff Capital city region, and this is how we structure our analysis³. These comprise the coastal cities of Cardiff and Newport, and largely rural coastal Counties of Monmouth and Vale of Glamorgan; plus five urban, post-industrial inland counties suffering severe economic and social deprivation (Rhondda-Cynon-Taff; Bleanau Gwent; Caerphilly; Merthyr Tydfil and Torfaen). The coastal County of Bridgend lies somewhere in between in terms of economic conditions and industrial history (see Map 1). At this spatial scale we can assess the skills and qualifications of the workforce; training levels; wages and the size and sector distribution of the private sector firm population. Key datasets include the UK Business Counts (Office for National Statistics, 2016a);

³ Some relevant data (for example on population skills and occupations) are available for 2011 from the UK Census at very local area and are the subject of a paper in development; see <http://www.neighbourhood.statistics.gov.uk/dissemination/LeadHome.do> .

the Annual Population Survey (Office for National Statistics, 2016b) and the Annual Survey of Hours and Earnings (Office for National Statistics, 2015).

Map 1 – The Cardiff Capital City Region



As with extant US studies, the greatest lacuna relates to unobservable firm characteristics – including the composition of workforce, organisational approach and capability, and here access to (and take up of) broadband. There is also potential concern with our analysis: that of conflating issues relevant to the resident population of an area with those affecting local firms. In reality, many residents work in different counties, with Cardiff being by far the greatest attractor of labour; for Caerphilly and Vale of Glamorgan outflows of commuters are larger than the number of residents working domestically (Welsh Government, 2016). Here then we must be aware that there will be a complex relationship between broadband; firm productivity and success; local (within county) economic activity; and the welfare of the resident population. It may be

that (some) residents of a County are able to commute easily to work in innovative and productive broadband-enabled firms in more successful parts of the City-Region. We should not then conflate local economic activity with local welfare outcomes (see Section 6).

5. Data Presentation and Analysis

In this section, we draw from the factors presented in Table 1 to examine how well-placed firms and workers in the ten different counties that comprise the Cardiff City-Region may be to take productive advantage of broadband. We accept that these data are only indicative of *actually*-important firm and worker characteristics. Nonetheless, there are significant differences presented here that suggest the productive impacts of any (past or future) broadband roll out may be very unevenly spread. The post-industrial, inland part of the region (the five authorities collated in the tables as ‘Valleys’ (and highlighted in grey) share a number of important (negative) characteristics in comparison to the five (more heterogeneous) ‘Coast’ authorities. Unless otherwise noted, any differences between the Valleys and the Coast, are sufficiently large to be statistically significant at a 5% confidence level.

Table 2 presents some key summary data related to human capital across the City-Region, aggregated to Counties, using job-related training, qualifications and wages as proxies. It is notable that overall the poorer Valleys area performs

worse than the Coast in terms of resident human capital. The starkest difference is in the level of qualified population, where the five worst Counties are those in the Valleys (around 28% having a degree or equivalent), and where there is an over 11 percentage-point advantage for the Coast area (almost 40%). This difference is driven in part by the three higher educational establishments located (in whole or part) in Cardiff, but the two rural Coast counties have similarly high levels of qualified labour. Note we use the NVQ4+ level of qualifications here to address Mack and Faggian's (2013) finding that it is this level of qualification that matters most for broadband impact, but Valleys authorities perform worse than the Coast at every level of qualifications attainment, albeit to a lesser extent (Office for National Statistics, 2016b). The position is somewhat better for the Valleys in terms of workers receiving job-related training in the prior 3 months, with two Valleys authorities in the 'top five' for training, although overall the level of job related training is lower in the Valleys.

It is worth noting that pay is much lower in the Valleys than on the Coast, suggesting lower levels of labour productivity and human capital embedded in Valleys workers and firms. Wages on the Coast are almost 8% higher⁴. Here there is some heterogeneity between Counties. Cardiff and Bridgend present

⁴ Here we have used estimates of the resident workforce from the Annual Population Survey (Office for National Statistics, 2106b) in conjunction with the Annual Survey of Earnings and Hours to estimate average gross wages for the Valleys and coast: there may then be some small error in our presented estimates for these aggregate areas due to differing survey methodologies.

the highest level of wages by far, related to in the first case, employment in high value services and in the (relatively well paid) public sector, and in the latter case many high-paying manufacturing jobs, including some large multinational firms – although in Bridgend’s case, the susceptibility of well-paid but routine manufacturing task to automation should be a concern (Frey and Osborne, 2017). Notably, the two Coast authorities that are in the lower half of the wage distribution are the rural areas of the Vale and Monmouth, although sample sizes restrict our ability to judge whether their rurality and consequent agricultural and related employment are the cause. It is perhaps interesting that there is some evidence that rural firms and areas benefit more from broadband than others, but the notion of rurality and distance employed in the relevant US studies is very different to that in the UK (Mack and Grubestic, 2009).

Table 2 – Broadband-Relevant Labour Market Characteristics: Cardiff Capital City Region

Job related training 2015 (% 16-64yrs last 13 weeks)		Qualified Population 2015 (% pop. NVQ4+/Bachelor degree)		Gross weekly wages 2014 (£) (all employees)	
Merthyr Tydfil	14.2	Blaenau Gwent	19.0	Merthyr Tydfil	404.70
Caerphilly	15.3	Merthyr Tydfil	25.4	Blaenau Gwent	431.20
Blaenau Gwent	16.7	Torfaen	27.4	Torfaen	451.00
The Vale of Glamorgan	19.9	Caerphilly	28.0	The Vale of Glamorgan	456.00
Bridgend	20.0	Rhondda, Cynon, Taff	29.6	Monmouthshire	463.90
Cardiff	20.2	Bridgend	31.0	Caerphilly	466.50
Rhondda, Cynon, Taff	20.3	Newport	34.0	Newport	471.50
Torfaen	23.9	The Vale of Glamorgan	40.7	Rhondda, Cynon, Taff	477.90
Monmouthshire	24.1	Monmouthshire	41.7	Cardiff	504.40
Newport	24.7	Cardiff	43.5	Bridgend	509.50
<i>Valleys</i>	<i>18.5</i>	<i>Valleys</i>	<i>27.9</i>	<i>Valleys</i>	<i>446.26</i>
<i>Coast</i>	<i>21.3</i>	<i>Coast</i>	<i>39.4</i>	<i>Coast</i>	<i>481.06</i>

As far as the data allow us to judge then, the Valleys labour force would seem to be in a poorer position than that of the Coast to take productive advantage of broadband roll out. There is a caveat here however: *so far*, manual work that is harder to routinize and requires contextual awareness, such as driving, care work and food serving have resisted computerisation (as have high-end professional occupations), leading Goos and Manning (2007) to talk about the divergence of the economy into 'lovely and lousy jobs'. The extent to which this remains true (witness for example very rapid recent strides in vehicle automation and the prevalence of order-via-screen in McDonald's) will have important implications for areas that specialise in supplying labour for such dextrous occupations (Autor, 2015).

The results from prior studies also suggest that *firms* within the Valleys part of the region might be less advantaged than those on the Coast by any increase in the economic importance in broadband-enabled activities (Table 3), although here data are more restricted and the findings from prior studies less definitive. In the first part of the Table, we follow Kolko (2012) and present information on the industries that appear to benefit most from broadband provision, amended from the US NAICS to UK-relevant SIC2007 categories⁵. The work of other studies such as Johnson *et al*, 2007 generally supports the finding that broadband and ICT has most impact in these industries.

⁵ 2-Digit SICs 36, 61, 62, 63, 64, 65, 66, 69, 70, 71, 72, 73, 74; covering utilities, telecoms, computing, financial services, professional and business services and technical and scientific activities

Here, again the data are clear. The first part Table 3 presents the percentage of firms located in each County and across our two sub-regions that are in Kolko's top 'broadband benefitting' industries (industries that experience a 12%+ increase in employment following broadband penetration). The two Coast cities, and the two rural Coast counties have (proportionally) significantly more of such firms. The bottom five counties in this regard are our five Valleys authorities (Bridgend is closer to the Valleys than its Coast compatriots, but still marginally better; the dataset here, the UK Business Counts, is notionally at least a Census so sampling considerations do not apply). Overall the Valleys has 15% of its businesses in the most broadband-benefitting industries, the Coast 22.4%. The best authority in this regard, Cardiff, at 25.5% has almost 2.5 times (proportionately) more businesses than the worst (Blaenau Gwent at 10.5%). The Table also provides information on the size of businesses in different counties, particularly in the medium-large size bands that studies such as Fornefeld *et al* 2008 and Johnston *et al* 2007 suggest might benefit more from broadband. Here we present the number of firms of such size in proportion to the resident population, as the overall number of firms (and hence local employment opportunity) varies across the region. We can see there is again a differential in favour of the Coast, with around 25% more such firms per head of population than the Valleys. Here, though, the rural Coast authorities perform quite poorly, with a relatively small 'Mittelstand' of mid-sized firms. Care needs to be taken here however with business size and broadband exploitation interacting in ways not fully understood (Fornefeld *et al*, 2008; Johnston *et al*,

2007), but the overall import of Table 3 is clear, reinforcing the earlier labour market analysis. If the existing US and EU evidence on the industrial impacts of broadband are correct, then poor Valleys authorities are likely to be less well positioned to benefit from broadband than the already relatively wealthy coast.

Table 3 - Broadband Relevant Firm Characteristics: Cardiff Capital City Region

Percent of private firms in top broadband-benefitting industries 2015		Medium/Large firms (50-250emp) per 10,000 Population 2015	
Blaenau Gwent	10.5	The Vale of Glamorgan	5.1
Merthyr Tydfil	12.3	Blaenau Gwent	5.7
Rhondda, Cynon, Taff	15.5	Monmouthshire	6.0
Caerphilly	16.0	Merthyr Tydfil	6.8
Torfaen	16.2	Caerphilly	6.9
Bridgend	16.7	Rhondda, Cynon, Taff	7.2
Newport	20.6	Bridgend	7.4
The Vale of Glamorgan	21.3	Torfaen	8.7
Monmouthshire	21.7	Newport	11.2
Cardiff	25.5	Cardiff	13.5
Valleys	15.0	Valleys	8.1
Coast	22.4	Coast	10.1

The analysis of US local areas and broadband productivity by Mack and Rey (2014), whilst only one study and in a very different national context, offers further concern. That paper suggests that the nature and hierarchy of metropolitan areas might affect how far broadband attracts ‘knowledge intense’ firms. Some findings may have limited application to the UK – for example that broadband may offset transaction costs in sprawling urban areas such as Las Vegas. However, the finding that broadband has less of an ‘attractive’ effect for metropolitan areas with an industrial past, and, a separate finding, for those in the rust belt states, may be important. Mack and Rey (2014) also suggest that new broadband provision in areas near already established technology or knowledge hubs has no economic impact. Our five Valleys authorities all have

an industrial legacy, and are all in the geographic shadow of Cardiff as the existing hub for knowledge intense firms. If broadband exploitation does rely in part upon the attraction of high value firms, the relative attractiveness of the Valleys and Coast should be considered relevant, especially given McCoy *et al*'s (2016) finding that in Ireland, broadband must be combined with high levels of local human capital to stimulate business re-location (as well as start-up).

In summary then, the evidence suggests that the prospect of broadband roll out narrowing intra-regional economic disparities in South Wales is remote, at least in the absence of ameliorative policy. The opposite is more likely, and indeed, the relative widening of intra-Wales economic disparities in the last decade may be in part related to telecommunications investments already enacted. If future competitiveness and productivity in 'Industry 4.0' relies increasingly upon leveraging cloud and internet infrastructures and services, and if ICT relatively enhances the productivity of the highest-qualified in the workforce who are concentrated on the Coast (and especially in the cities), then the 'policy off' prospect is for more uneven economic development within this (and perhaps other similar) regions (Graham, 2002; Akerman *et al*, 2015; Boschma *et al*, 2013).

6. Discussion

Much of the above analysis may come as no surprise to the authors of Cardiff's original City-Region strategy (Welsh Government, 2012). This was predicated

on leveraging city-region development using Cardiff as the internationally recognised 'brand', and the key employment generator. Forecasts suggesting the population is to grow faster than any other UK city in the period to 2040 have reinforced this narrative (Welsh Government, 2013). This conceptual approach – effectively a Perrouxian growth pole paradigm emphasising agglomeration economies – is also inherent in the various city deals signed by the (former) UK Chancellor: Although the relevant deals are often light on detail the sense in reading the agreements is that cities, and their research and education establishments, hubs and brands, are the motive development force, and that the attraction of (inward) investment is the primary development mechanism. Under this reading of the economic landscape, cities will do their job of attracting investment and growing the employment base, providing economic opportunity for those living within the functional economic area. One can argue that the identification of the intra-region South Wales Metro transport network as the key project for the Cardiff City-Deal responds to the vision of Cardiff as offering increasing opportunity to better-connected Valleys residents.

However, as the literature shows, the ability of firms and places to benefit from broadband depends in large part on their available human capital (and the way it is organised). The penetration of ICT, the internet and cloud into businesses' production functions will result in the increased value of some workers and occupations, and a fall in the productivity and usefulness of others. Individuals who live in poor places are more likely to be in the second category than those living in already prosperous, core locations, and we know the lower skilled and

qualified tend to search for employment more locally, and that spatial and social network factors matter in employment success (Cingano and Rosolia, 2012; Huber and Nowotny, 2013). The prospect then of Coastal-located broadband and cloud exploiting firms lifting all South Wales boats is remote.

There are some signs that the Welsh Government realises this danger; there has been a long debate about the structure and function of the South Wales Metro; the idea that it should enable polycentric development via the connecting of complementary regional 'mini growth poles' has come to the fore (Barry, 2016) and, the Welsh Government and the EU have sponsored a programme of business support to ensure SMEs in Wales are placed to take advantage of the benefits of Superfast Broadband. How far such regional policy actions can ameliorate pervasive economic disadvantages is of course an open question (McQuaid, 2002; Becker *et al* 2010).

6. Conclusions

There are ongoing and robust debates about the impact of technology on the demand for labour (Arntz *et al* 2016). Here, though we are less concerned with whether ICT and automation reduces demand for labour in aggregate, and more with whether it adds to or mitigates already-evident core periphery economic trends; this paper has sought to place the emergence of broadband-enabled firm activities and resultant economic development more firmly within a spatial context. Using the example of the Cardiff Capital City-Region in South

Wales, we can see that the increasing economic importance of e-connectivity would suggest (*ceteris paribus*) an increased level of economic disparity across space. This increased disparity would be driven by the very different levels of relevant human capital, and the very different industrial structures in the post-industrial Valleys and the more prosperous coastal cities and rural counties. Moreover, there is some suggestion in the literature that post-industrial areas, those near already established tech-heavy centres, will be less successful in attracting knowledge intensive firms (Mack and Rey, 2014)

This is not a happy analysis for those seeking more 'even' economic development. Technology-driven economic change may increase the unevenness of outcomes and – especially in large conurbations like the Valleys – creating geographically concentrated communities of lower skilled and poorly people for whom finding employment is increasingly difficult. The varied implications of these trends are important and worrying. Indeed, the increased importance of e-connectivity may already have contributed to the increased spatial economic divergence we have seen in the UK – North-South, intra-regional and intra-urban (Martin *et al*, 2015; Jones *et al*, 2015).

The current devolution of power to more local areas as part of the last and current UK Chancellors' City-deal approach to economic development creates both threats and opportunities. The threat is in the implied and sometimes explicit orientation of the City-deals on global competitiveness, connectivity and

the identification of key city-regional industries and competencies as the path to economic success. This approach may prejudice the success of poorer places and people compared to the already relatively rich. The opportunity however relates to the devolution of power to the lower spatial scale, where there may be a more nuanced approach to economic development and a deeper understanding of the challenges faced by both specific parts of society and locales. Here, a more interventionist and 'careful' set of economic policies might emerge which seek to harness the power of e-connectivity to build the capacities of those currently economically left behind, and to spur a real 'march of the makers' by renewing and re-equipping re-shored manufacturing to succeed in the future economy (Bailey and de Propris, 2015). The ways in which these tensions play out in city-regions, as their economies increasingly automate, virtualise and head to the Cloud will be extremely interesting.

References

- Akerman A, Gaarder I and Mogstad M (2015) The skill complementarity of broadband internet *The Quarterly Journal of Economics* 130(4): 1781-1824. DOI: 10.1093/qje/qjv028.
- Arvanitis S and Loukis EN (2009) Information and communication technologies, human capital, workplace organization and labour productivity: A comparative study based on firm-level data for Greece and Switzerland. *Information Economics and Policy*, 21(1): 43-61.
- Arntz M, Gregory T and Zierahn U (2016) The risk of automation for jobs in OECD countries: A comparative analysis. *OECD Social, Employment, and Migration Working Papers*, (189)
- Autor DH (2015) Why are there still so many jobs? The history and future of workplace automation. *The Journal of Economic Perspectives* 29(3): 3-30.
- Bailey D and De Propris L (2015) Reshoring and Regions: A View from the West Midlands. *Regions Magazine*, 299(1): 4-5.
- Barry M (2016) *The next steps for the South Wales Metro* Wales WalesOnline <http://www.walesonline.co.uk/business/business-news/next-steps-south-wales-metro-11313133> (accessed 17th May 2016)
- Bentley G and Pugalis L (2013) New directions in economic development: Localist policy discourses and the Localism Act. *Local Economy*, 28(3): 257-274.

Becker SO, Egger PH and von Ehrlich M (2010) Going NUTS: The Effect of EU Structural Funds on Regional Performance, *Journal of Public Economics*, 94(1–2): 578–590.

Bertschek I, Cerquera D and Klein GJ (2013) More bits–more bucks? Measuring the impact of broadband internet on firm performance. *Information Economics and Policy*, 25(3): 190-203. DOI: 10.2139/ssrn.1852365

Boschma R, Iammarino S and Steinmueller E (2013) Editorial: Geography, Skills and Technological Change. *Regional Studies*, 47(10): 1615-1617.

Brynjolfsson E and Hitt LM (2003) Computing productivity: Firm-level evidence. *Review of economics and statistics*, 85(4): 793-808.

<http://www.jstor.org/stable/3211806>

Brynjolfsson E and McAfee A (2014) *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. WW Norton and Company.

Cingano F and Rosolia A (2012) People I know: job search and social networks. *Journal of Labor Economics*, 30(2): 291-332. DOI: 10.1086/663357

Colombo MG, Croce A and Grilli L (2013) ICT services and small businesses' productivity gains: An analysis of the adoption of broadband Internet technology. *Information Economics and Policy*, 25(3): 171-189. DOI: 10.1016/j.infoecopol.2012.11.001

Czernich N, Falck O, Kretschmer T and Woessmann L (2011) Broadband infrastructure and economic growth. *The Economic Journal*, 121(552): 505-532. DOI: 10.1111/j.1468-0297.2011.02420.x

Díaz-Chao Á, Sainz-González J and Torrent-Sellens J (2015) ICT, innovation, and firm productivity: New evidence from small local firms. *Journal of Business Research*, 68(7): 1439-1444. DOI: 10.1016/j.jbusres.2015.01.030

Department for Business, Energy and Industrial Strategy (2017) The UK's Industrial Strategy November 2017

<https://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy> (accessed February 2nd 2018)

Department for Culture, Media and Sport (2015) *Broadband Delivery UK Guidance Note* <https://www.gov.uk/guidance/broadband-delivery-uk> (accessed 16th May 2016)

Dicks B (2014) Participatory community regeneration: A discussion of risks, accountability and crisis in devolved Wales. *Urban studies*, 51(5): 959-977. DOI: 10.1177/0042098013493023

Drakakis-Smith D (2012) *Urbanisation, housing and the development process*. Routledge.

Federal Communications Commission (2015) *US Broadband Deployment Not Keeping Pace* <https://www.fcc.gov/document/fcc-finds-us-broadband-deployment-not-keeping-pace> (accessed 20th May, 2016)

Floud R, Humphries J and Johnson P eds (2014) *The Cambridge Economic History of Modern Britain: Volume 1, Industrialisation, 1700–1870*. Cambridge University Press; Cambridge, UK

Foden M, Fothergill S and Gore T, (2014) *The state of the coalfields: Economic and social conditions in the former mining communities of England, Scotland and Wales*. Centre for Regional Economic and Social Research Sheffield Hallam University, June 2014

Forman C, Goldfarb A and S. Greenstein (2003) Which industries use the Internet? *Advances in Applied Microeconomics* 12: 47–72. DOI: 10.1016/S0278-0984(03)12002-0

Fornfeld M, Delaunay G and Elixmann D (2008) *The impact of broadband on growth and productivity. A study on behalf of the European Commission*.

European Commission

<http://www8.gsb.columbia.edu/citi/sites/citi/files/Panel%203.Martin%20Fornfeld%20paper.pdf> (accessed 20th May 2016)

Frey CB and Osborne MA (2017) The future of employment: how susceptible are jobs to computerisation? *Technological Forecasting and Social Change* 114: 254-280.

Future Advocacy (2017) *The Impact of AI in UK Constituencies: Where will automation hit hardest?* <http://futureadvocacy.com/publications/> (accessed 2nd February 2018)

Goldberg K and Kehoe B (2013) Cloud robotics and automation: A survey of related work. *EECS Department, University of California, Berkeley, Tech. Rep. UCB/EECS-2013-5.*

Goos M and Manning A (2007) Lousy and lovely jobs: The rising polarization of work in Britain. *The Review of Economics and Statistics*, vol. 89, no. 1: 118–133

Graham S (2002). Bridging urban digital divides? Urban polarisation and information and communications technologies (ICTs). *Urban studies*, 39(1), 33-56.

Grimes A, Ren C and Stevens P (2012) The need for speed: impacts of internet connectivity on firm productivity. *Journal of Productivity Analysis*, 37(2): 187-201.

HM Cabinet Office, 2016 *City-Deals and Growth Deals*

<https://www.gov.uk/government/policies/city-deals-and-growth-deals> (accessed 20th May 2016)

HM Treasury, 2016. *Cardiff Capital Region City Deal*

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/508268/Cardiff_Capital_Region_City_Deal.pdf (accessed 16th May 2016)

Hall BH, Lotti F and Mairesse J (2013) Evidence on the impact of R&D and ICT investments on innovation and productivity in Italian firms. *Economics of Innovation and New Technology*, 22(3): 300-328. DOI:

10.1080/10438599.2012.708134

Haller SA and Lyons S (2015) Broadband adoption and firm productivity: evidence from Irish manufacturing firms. *Telecommunications Policy*, 39(1): 1-13. DOI: 10.1016/j.telpol.2014.10.003

Hempell T (2005). What's spurious, what's real? Measuring the productivity impacts of ICT at the firm-level. *Empirical economics*, 30(2), 427-464. DOI: 10.2139/ssrn.325261

Higón DA (2012) The impact of ICT on innovation activities: Evidence for UK SMEs. *International Small Business Journal*, 30(6): 684-699. DOI: 10.1177/0266242610374484

Hildreth P and Bailey D (2013) The economics behind the move to 'localism' in England. *Cambridge Journal of Regions, Economy and Society*, 6(2): 233-249.

Holt L and Jamison M (2009) Broadband and contributions to economic growth: Lessons from the US experience. *Telecommunications Policy*, 33(10): 575-581. DOI: 10.1093/cjres/rst004

Huber P and Nowotny K (2013) Moving across borders: who is willing to migrate or to commute. *Regional Studies*, 47(9): 1462-1481. DOI:10.1080/00343404.2011.624509

Johnston DA, Wade M and McClean R (2007). Does e-business matter to SMEs? A comparison of the financial impacts of internet business solutions on European and North American SMEs. *Journal of Small Business Management*, 45(3): 354-361.

Jones C (2015) On capital, space and the world system: a response to Ron Martin. *Territory, Politics, Governance*, 3(3): 273-293.

DOI:10.1080/21622671.2015.1064827

Jones M, Orford S and Macfarlane V eds. (2015) *People, Places and Policy: Knowing Contemporary Wales Through New Localities*. Routledge; Abingdon

Katz RL, Vaterlaus S, Zenhäusern P and Suter S (2010) The impact of broadband on jobs and the German economy. *Intereconomics*, 45(1): 26-34.

Kellernam A (2010) Mobile Broadband Services and the Availability of Instant Access to Cyberspace *Environment and Planning A*, 42(1), 12:.. 2990-3005

DOI: 10.1068/a43283

Kenny R and Kenny C (2011) Superfast broadband: is it really worth a subsidy? *info*, 13(4): 3-29. DOI: 10.1108/14636691111146127

Kerry C and Danson M (2016) Open innovation, Triple Helix and regional innovation systems: Exploring CATAPULT Centres in the UK. *Industry and Higher Education*, 30(1),. 67-78. DOI: 10.5367/ihe.2016.0292

Kolko J (2012) Broadband and local growth. *Journal of Urban Economics*, 71(1): 100-113.

Koutroumpis P (2009) The economic impact of broadband on growth: A simultaneous approach. *Telecommunications Policy*, 33(9): 471-485. DOI: 10.1016/j.telpol.2009.07.004

Levy F and Murnane RJ (2012) *The new division of labor: How computers are creating the next job market*. Princeton University Press.

McCoy D, Lyons S, Morgenroth E, Palcic D and Allen L (2016) The impact of local infrastructure on new business establishments. *MPRA Working Paper 69074* <https://mpra.ub.uni-muenchen.de/69074/>

McQuaid RW (2002) Entrepreneurship and ICT industries: support from regional and local policies. *Regional Studies*, 36(8): 909-919.

Mack EA (2014) Businesses and the need for speed: The impact of broadband speed on business presence. *Telematics and Informatics*, 31(4): 617-627. DOI: 10.1016/j.tele.2013.12.001

Mack EA (2015) Variations in the Broadband-Business Connection across the Urban Hierarchy. *Growth and Change*, 46(3): 400-423. DOI: 10.1111/grow.12095

Mack EA and Faggian A (2013) Productivity and Broadband The Human Factor. *International Regional Science Review*, 36(3): 392-423. DOI: 10.1177/0160017612471191

Mack EA and Grubestic TH (2009) Broadband provision and firm location in Ohio: An exploratory spatial analysis. *Tijdschrift voor economische en sociale geografie*, 100(3): 298-315. 10.1111/j.1467-9663.2008.00487.x

Mack EA and Rey SJ (2013). An econometric approach for evaluating the linkages between broadband and knowledge intensive firms.

Telecommunications Policy, 38(1): 105-118. DOI: 10.1016/j.telpol.2013.06.003

Martin R, Pike A, Tyler P and Gardiner B (2015) Spatially Rebalancing the UK Economy: Towards a New Policy Model? *Regional Studies*: 1-16. DOI: 10.1080/00343404.2015.1118450

Meegan R, Kennett P, Jones G and Croft J (2014) Global economic crisis, austerity and neoliberal urban governance in England. *Cambridge Journal of Regions, Economy and Society*, 7(1): 137-153.

Morgan K (2016) Nurturing novelty: Regional innovation policy in the age of smart specialisation. *Environment and Planning C: Government and Policy*, 35, no. 4 (2017): 569-583. doi: 10.1177/0263774X16645106

Murray R (2016) *The Challenge to Connect the Countryside* Huffington Post UK http://www.huffingtonpost.co.uk/ross-murray2/the-challenge-to-connect-_b_9883534.html (accessed 14th May 2016)

O'Brien, P. and Pike, A., 2015. City Deals, decentralisation and the governance of local infrastructure funding and financing in the UK. *National Institute Economic Review*, 233(1): R14-R26.

Ofcom, 2015. *Communications Market Report: Wales* http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr15/2015_CM_R_Wales.pdf (accessed 20th May 2016)

Office for National Statistics, 2015. Annual Survey of Hours and Earnings
<http://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/bulletins/annualsurveyofhoursandearnings/previousReleases>
(accessed 20th November 2016)

Office for National Statistics, 2016a. UK Business Counts – Enterprises
<https://www.nomisweb.co.uk/query/construct/summary.asp?menuopt=200andsubcomp>(accessed 13th May 2016)

Office for National Statistics, 2016b. Annual Population Survey
<https://www.nomisweb.co.uk/articles/948.aspx> (accessed 12th May 2016)

Office for National Statistics, 2017 *Gross Value Added*
<https://www.ons.gov.uk/economy/grossvalueaddedgva> (accessed 2nd February 2018)

Pilat, D (2005). The ICT productivity paradox. *OECD economic studies*, 2004(1), 37-65.

Pike A et al (2016) *Austerity States, Institutional Dismantling and the Governance of Sub-National Economic Development: The Demise of the Regional Development Agencies in England* SERC DISCUSSION PAPER 206
<http://www.spatialeconomics.ac.uk/textonly/SERC/publications/download/sercdp0206.pdf> (accessed 23rd November 2016)

Pugh RE (2014) 'Old wine in new bottles'? Smart Specialisation in Wales.

Regional Studies, Regional Science, 1(1): 152-157. DOI:

10.1080/21681376.2014.944209

Röller LH and Waverman L (2001) Telecommunications infrastructure and economic development: A simultaneous approach. *American economic review* 91(4): 909-923.

Stroud D, Fairbrother P, Evans C and Blake J (2015) Governments matter for capitalist economies: Regeneration and transition to green and decent jobs.

Economic and Industrial Democracy, DOI: 10.1177/0143831X15601731

Triplett JE (1999) The Solow productivity paradox: what do computers do to productivity?. *The Canadian Journal of Economics/Revue canadienne d'Economique*, 32(2): 309-334.

Welsh Government, 2012. *City-Regions Final Report*

<http://gov.wales/docs/det/publications/120710-city-regions-final-report-en.pdf>

(accessed 16th May 2016)

Welsh Government. 2013. Local Authority Population Projections

<http://gov.wales/statistics-and-research/local-authority-population-projections/?lang=en>

(accessed 16th May 2016)

Welsh Government, 2016. *Commuting*

<https://stats.wales.gov.uk/Catalogue/Business-Economy-and-Labour-Market/People-and-Work/Employment/Commuting>

(accessed 20th May 2016)

Whitacre B, Gallardo R and Strover S (2014). Does rural broadband impact jobs and income? Evidence from spatial and first-differenced regressions. *The Annals of Regional Science*, 53(3): 649-670. DOI: 10.1007/s00168-014-0637-x