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Urban polycentricity in northern England: economic catalyst or chimera?

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Abstract. The UK Government's 'Northern Powerhouse' seeks to *"unleash the full economic potential of the North"* by *"joining up the North's great towns, cities and counties, pooling their strengths, and tackling major barriers to productivity."*

This paper argues that this agenda can be understood as an attempt to define northern England as a polycentric urban region (PUR), and furthermore that a polycentric approach to investment planning will generate improved economic outcomes.

To test this hypothesis, a multidimensional framework is developed to analyze regional urban polycentricity. As well as traditional morphological structure (spatial and population distribution), industrial structure (relative sector specialization; distribution of knowledge workers) and functional structure (size and pattern of intra-regional flows) should be considered.

This framework is applied to both a review of the literature linking polycentric urban structures to economic outcomes, and to the case study of northern England.

The evidence linking PURs and economic performance is inconclusive. Whilst a large body of literature exists on increasing returns to scale in urban settings (agglomeration), there is little evidence at a polycentric regional level. Where analysis has been undertaken, a one-dimensional definition of polycentricity is typically used, leading to incomplete results.

Applying the framework to northern England, the region is shown to be highly polycentric in morphological terms. Functionally, commuting patterns within the region are complex, though high levels of self-containment within centres are observed compared to major European PURs. In industrial terms, centres in northern England show low levels of specialization on both regional and national levels. These results suggest that there is latent potential in the northern England regional economy. Given a fixed, highly polycentric morphological structure, targeted interventions – particularly in infrastructure and regional governance – should allow the region to better leverage agglomeration economies. However, more empirical analysis is necessary to fully understand the link between polycentricism and economic growth.

Content

List of acronyms.

APS - Advanced Producer / Professional Services
DCLG - Department for Communities and Local
Government
DfT - Department for Transport
GVA - Gross Value Added
HMT - Her Majesty's Treasury
FUR - Functional Urban Region
FUA - Functional Urban Area
NUTS - Nomenclature of Territorial Units for Statistics
OECD - Organization for Economic Co-operation and
Development
ONS - Office of National Statistics
PUR - Polycentric Urban Region

1. Introduction

"There is a hard truth we need to address. The cities of the north are individually strong, but collectively not strong enough. The whole is less than the sum of its parts. So the powerhouse of London dominates more and more. And that's not healthy for our economy. It's not good for our country. We need a Northern Powerhouse too. Not one city, but a collection of northern cities - sufficiently close to each other that combined they can take on the world."
George Osborne M.P., former Chancellor of the Exchequer. 23 June 2014

The 'Northern Powerhouse' is a new entrant into British political vocabulary, but claims to address an old problem: the north-south economic imbalance. This imbalance has been evident since at least the mid-20th century (Bachtler 2004). By 2015, workers in Manchester, Liverpool and Leeds were generating just two-thirds of the GVA of their peers in London (Cities Outlook 2017).

As a slogan, the 'powerhouse' has certainly captured the imagination of politicians. Scottish First Minister Nicola Sturgeon was soon insisting that Scotland was the *real* 'Northern Powerhouse' (BBC 2015). Leaders in Birmingham declared themselves to be the 'Midlands powerhouse', though subsequently settled on "Midlands Engine" (BBC 2014, DCLG 2017).

But what does the 'Northern Powerhouse' mean? The term has been employed extensively since the Chancellor's speech in 2014, but initial analyses define the 'Powerhouse' simply by aggregating the existing regional territories – the North East, North West, and Yorkshire (Centre for Cities 2015, HMT 2016). This suggests that the concept is little more than a label.

An alternative interpretation is possible. The Treasury's strategy paper says: "The Northern Powerhouse is a vision for joining up the North's great towns, cities and counties, pooling their strengths, and tackling major barriers to productivity to unleash the full economic potential of the North" (HMT 2016, p.5). The strategy emphasizes the roles and interconnections of cities *within* regions, in contrast to earlier initiatives with explicitly regional objectives, such as the New Labour-vintage 'Northern Way' (Davoudi 2004). I argue that the 'Northern Powerhouse' can therefore be understood as an argument for *urban polycentrism* in northern England.

Accepting this premise leads to three questions. How should we define and analyze polycentric regions? What is their relationship to economic outcomes, if any? And specifically, what is the nature of polycentricism in northern England? Answering these questions will allow us to assess the ability of the 'Powerhouse' to improve regional economic outcomes and identify effective policy interventions.

This paper begins by developing an analytical framework for polycentric urban regions (PURs), drawing upon the established literature (Section 2). PURs should be considered multidimensional phenomena: their industrial structure and functional interrelations must be understood alongside their *physical* morphology.

With this framework established, we can attempt to analyze the link between PURs and economic outcomes. Is it valid to argue, as the Treasury implicitly does, that polycentricism can catalyze economic growth? Primary research into this question is beyond the scope of this paper, but Section 3 provides a critical overview of the existing literature, focusing on whether polycentric regions can generate agglomerative (scale-based) economic benefits.

We then consider the state of polycentricism in northern England (Section 4). Through empirical analysis, guided by our multidimensional framework, we can gain a nuanced understanding of the nature of polycentricism in the region – in particular, understanding the degree of *interactions* and *co-dependence* (for example, via commuting patterns). Quantitative analysis has been conducted using data from sources such as the Office of National Statistics. Data has been taken at the most appropriate spatial level available (typically NUTS2). Where possible, comparative analysis is presented, for example comparing northern England to other polycentric regions in Europe. Finally, Section 5 considers the potential role of policy.

Fundamentally, we hope to understand whether governing northern England through a PUR lens could be a catalytic intervention that unlocks significant latent potential, as the Government evidently hopes; or whether, as some scholars argue, polycentricism is chimerical: a structure whose claimed benefits are seductive but elusive (Bailey, Turok 2001).

2. Framework

The first requirement for this analysis is to build an analytic framework that draws upon the established literature of polycentricism and its conceptual foundations. This enables the subsequent analysis of the links between polycentricism and economic performance (Section 3), and of polycentricism in northern England (Section 4).

I develop a multi-dimensional understanding of polycentric urban regions. Each dimension – morphological, functional, and industrial – can be analyzed empirically. This gives a robust understanding of the nature and extent of polycentric development in that region, crucial for policy formulation. There is sometimes a tendency for policy prescription to be made via appeals to both the normative aspirations of polycentricism and of the power of agglomeration economies. Through the correct deployment of the multi-dimensional analysis, we can ensure policy prescription is more effectively targeted. Finally, it is worth noting that the empirical literature linking agglomeration economies to PURs is under-developed (see Section 3).

2.1 The modern city: functions and flows

In theory, economic success in a given city – especially where new building is restricted – quickly translates into higher land values and rents; this in turn acts as a moderating force on that city's future growth (Krugman 1995). In reality, when looking to contemporary primate cities, we often see *consolidation* of economic dominance rather than a process of hinterland-to-primate catchup. This is certainly evident in the UK, where accelerating property market growth in London does not appear to be resulting in net outward migration of

Figure 2.1. Concept Map. Source: Author.
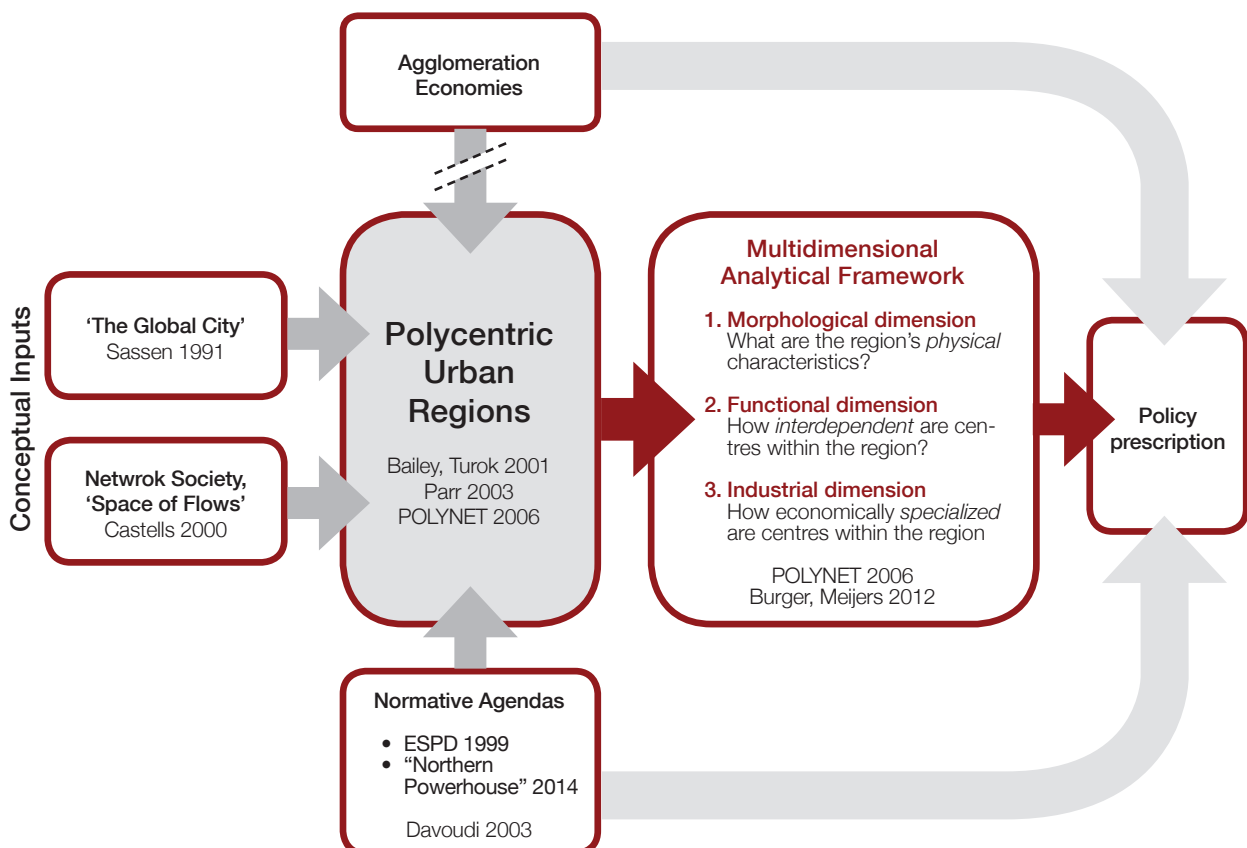
individuals, businesses, or jobs; instead London has consistently grown faster than the rest of the UK (Bowie, 2010; Cities Outlook 2017).

What explains the enduring economic dominance of these primate cities? I believe three theoretical concepts answer this question.

First, agglomeration economies explain why growth in absolute urban size is economically advantageous. This concept will be discussed in more detail in Section 3. Second, Sassen (1991, 2005) applies agglomerative forces to certain modern industries to build her concept of the 'global city': a command-centre for the new era of globalization. These centres are typified by a new type of business function – advanced producer/professional services (APS) – that exhibit particularly high agglomeration economies. Sassen demonstrates that a large proportion of global economic 'decision-making' has become concentrated in a small number of cities with large pools of these 'APS' workers. The original study identified London, New York, and Tokyo as three archetypal 'global cities'.

Sassen's concept gives us a theory for why certain types of cities and industries have been successful in the 21st Century. To this, we can add the third concept: the 'network society' and 'space of flows' (Castells 2000). Castells updates the Leibniz conception of 'space' – as not an entity itself but a property of objects themselves – for the era of mass electronic communications. Castells also emphasizes the importance of *flows* – of people, goods, but most importantly, of information – as the new primary foundation of social processes. Crucially, he argues that from the 1980s, we have entered an era in which the sharing of proximate physical space is no longer society's primary organizational paradigm, and instead, communication technologies have enabled the construction of a new 'space' built over significant distances.

Hall and Pain (2006) use both Sassen and Castells as the conceptual foundations of POLYNET, their landmark study into polycentric regions in Europe.[1] They argue that economic agglomeration, the rise of APS industries, its concentration in certain urban centres, and new means of communication have all conspired to allow the realization of a new form of urban structure.

2.2 Polycentric Urban Regions

Whilst it may have taken until the turn of the millennium for these technological changes to allow polycentricism to come to the fore, the concept of spatial polycentricism is older. Ebenezer Howard's 1898 edition *Garden Cities of To-morrow* illustrated a polycentric 'Social City', where a central city (pop. c.60,000) was surrounded by six peripheral towns (pop. 30,000 each). The centres were clearly separated by agricultural or forested land, but were interconnected by infrastructure and intended to function as a cohesive, singular unit; clearly a polycentric region as understood today. But from this auspicious start, interest in polycentricism remained relatively weak through the 20th-Century (Hall 1996).

By the 1990s, however, the idea had begun to stir interest among policymakers in north-west Europe, particularly Germany and the Netherlands (e.g. Priemus 1994). In this form, the focus was on using polycentricism to balance continued economic expansion with better environmental outcomes than mid-century sprawl-based urban development. Subsequently an explicit aspiration for polycentric urban development was included in the European Spatial Development Perspective (EC 1999).

Since the ESDP, a significant literature has consequently grown with the aim of establishing a more robust analytical framework for polycentricism. Most fundamentally, it is important to observe that polycentricism is exhibited at different scales: national, regional, and metropolitan (Brezzi and Veneri 2014). *National* polycentricism would imply a country's urban hierarchy tends to a more equal, multipolar distribution. Similarly, *metropolitan* polycentricism is where one urban environment has multiple centres of economic activity, rather than a simple core-periphery structure.

For this paper's analysis, I concentrate on *regional* polycentricity: the co-location of multiple sizeable urban centres in the same region. Building on earlier work by Bailey and Turok (2001), Parr (2004) has helped to defined the concept by suggesting a set of criteria that must be satisfied in a 'Polycentric Urban Region' (PUR):

Table 2.1. Parr criteria for Polycentric Urban Regions. Adapted from Parr (2004) pp.232-233

Criteria	Requirements
Clustering of centres	Existence of multiple urban nodes, separated by tracts of open land
Upper limit on centre separation	Typically operationalized as maximum one hour's journey time, either between neighboring centres or between the two centres furthest apart
Lower limit on centre separation	An arbitrary lower limit is required to prevent the undesired redefinition of conurbations as PURs
Size and spacing of centres	Relative to size, centres are spaced more closely-together than in the benchmark region
Size distribution of centres	No centre has population dominance over all the others
Interaction among centres	Economic interaction or linkage is at a greater intensity than found in the benchmark region

These criteria represent a useful starting point for an analytical framework, but some ambiguity remains. For example, Parr acknowledges two alternative 'hurdles' for the important upper centre separation criteria, which would result in very different PUR boundaries. Centre population 'dominance' is not quantified. Furthermore, several of the criteria are judged relative to an unspecified 'benchmark region' elsewhere in the same country, the choice of which affords an analyst considerable discretion.

2.3 Formalizing a multidimensional framework

Parr's structure has been usefully clarified by Burger and Meijers (2012) who identify a key differentiation between two dimensions: *morphological* versus *functional* polycentricity. Morphological polycentricity captures the poly-centered spatial or demographic distribution of a given region. Functional polycentricity, however, refers to the *nature of interaction* between these centres. This is a crucial distinction. Morphological polycentricism is much easier to observe quantitatively; however, as the work of Sassen and Castells illustrates, flows and functional relationships are key to understanding the economics and sociology of modern city regions. We will consider this nuance in more detail in Section 3, in particular the implications for the empirical literature that attempts to analyze the connections between polycentricism and

economic growth. It is clear at this point though that a framework for polycentric regions must explicitly and clearly differentiate between these dimensions.

Instead of resorting to questions with binary answers, our framework should provide a range of specific *analyses* to be performed on regions. These analyses will likely give varied (or even bidirectional) answers. Understanding the answers collectively – and through comparative analysis with *other* regions – we will gain a deeper understanding of the full nature of polycentricism in a given region.

The Morphological dimension is relatively straightforward and follows the suggestions of Parr. The Functional dimension was alluded to as the sixth of Parr's criteria, but in my view was insufficiently substantiated. POLYNET suggests two tests that can be conducted on a dataset of intra-regional flows (typically commuting patterns). Two tests are necessary because as well as pure *scale* of flows between centres, their *pattern* is important: if all flows in a region are to/from the primate centre, it cannot be said to be as polycentric as in a region where there are flows between many centres (see Figure 2.2).

The 'Industrial' dimension could conceivably be modelled as a sub-type of Functional polycentricism (as specialized centres will therefore perform differing *functional* roles in the regional economy); however, for clarity I separate it into its own dimension. I identify three core Industrial tests: measuring sector specialization within the region; measuring specialization in the region relative to national

Figure 2.2. Schematic illustration of morphological and functional polycentric regions
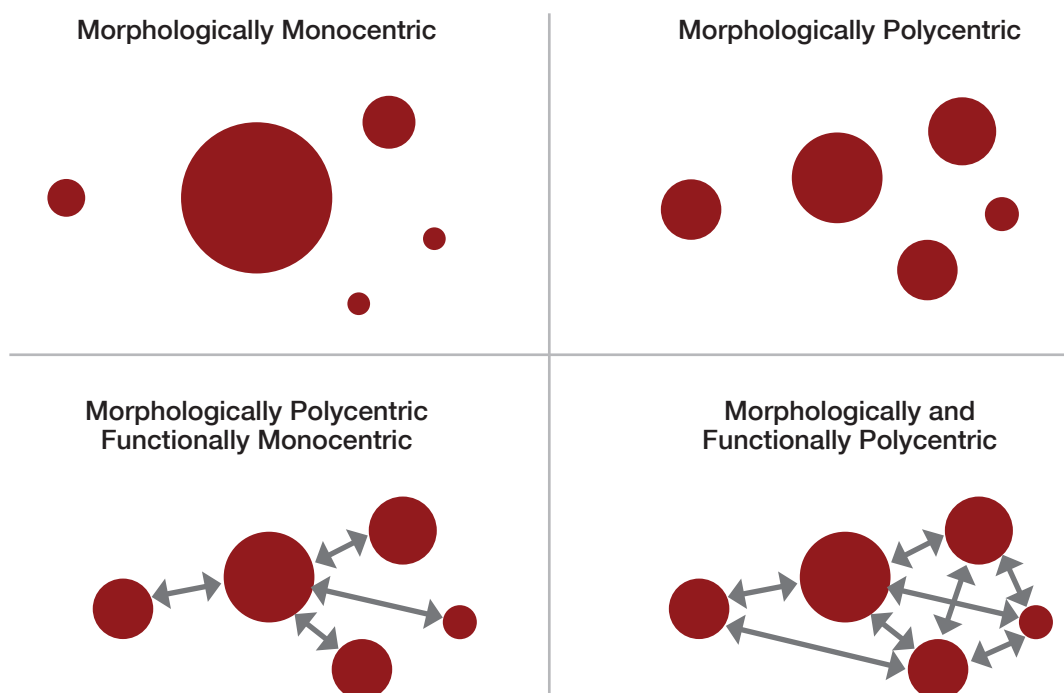
benchmarks; and measuring the distribution of the APS labour force, crucial as it is to Sassen's (1991) conception of modern urban economies. Parr argues that centres within PURs should exhibit clear specialization, as each can concentrate on sectors of comparative advantage.

With this structure in place, we have an analytical framework that conceptualizes PURs as multidimensional phenomenon. This framework will be used to analyze the nature and degree of polycentricism in the north of England (Section 4). However before narrowing our focus to this specific region, we will consider the evidence that links polycentricism to economic outcomes, primarily via agglomerative mechanisms (Section 3). In doing so, we must be careful to employ this multidimensional understanding of polycentricism when interpreting the empirical research that has been conducted to date.

Table 2.2. Multidimensional framework for analyzing Polycentric Urban Regions

Dimension	Analytical test	Operationalization
Morphological	Spatial distribution	Rank-size analysis of centre populations
	Demographic distribution	Rank-size analysis of centre populations
Functional	Scale of inter-centre flows	Commuting containment
	Pattern of inter-centre flows	'General functional polycentricity'
Industrial	Regional specialization	Intra-regional sector specialization
		Inter-regional specialization
		Distribution of APS labour force

NOTES TO CHAPTER 2

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1. POLYNET was a major pan-European research exercise funded by the European Commission, whose findings were published in Hall and Pain (2006). Through this paper, 'POLY- NET' refers to the study as a whole; individual chapters within Hall and Pain (2006) are referenced separately.

3. Polycentricism and economic growth

Establishing a link between polycentricism and economic growth would be a convincing argument for the catalytic capabilities of polycentric development in northern England.

There are two mechanisms through which spatial variables can influence economic outcomes. First, through the physical distribution of human and economic capital: how wealth, industries, and workers are sorted geographically. Some industries generate greater economic output per worker than others; therefore their physical distribution impacts regional-level economic characteristics. This sorting of labour and capital is highly path-dependent and exhibits durability over very long-term horizons (Michaels, Rauch 2013). Policymakers in market economies – who can rarely compel workers and industries to shift location – have few opportunities to influence economic geography via this mechanism. It is difficult to identify a direct causal link from polycentricism to changes in labour and capital distributions; however, Section 3.4 outlines some means by which polycentricism may be able to indirectly affect this structural change.

The second mechanism is through 'agglomeration' or urban scale. Agglomeration economies explain how the physical clustering of economic activity produces economic gains. Larger clusters are superior at efficiently matching supply to demand; allow participants to share and learn more information; and support better public goods (Duranton and Puga 2004). These benefits are mutually reinforcing and generate positive feedback loops. Larger cities therefore become more productive per-capita.[1]

Policymakers again have little ability to directly affect urban scale: they generally cannot force urban mergers or dictate where population growth occurs. Polycentricism, however, offers a means by which this could be sidestepped. If multiple urban nodes can 'pool' their resources and function as a single economic entity, they could benefit from the agglomeration economies that would apply to their collective 'whole' rather than the component parts. They would consequently generate per-capita productivity uplifts. Doing so would require high levels of *interaction* between nodes in the polycentric region, but this offers a direct causal link by which polycentricity could lead to improved economic outcomes.

I will survey the empirical evidence for agglomeration economies in Section 3.1, before discussing the attempts of the existing literature to understand agglomeration in a polycentric regional context in Section 3.2. The case study of northern England (Section 4) will consider the nature of interactions between nodes across the region, and therefore give insight into the degree to which agglomeration economies are currently being generated (or forfeited).

3.1 Agglomeration economies: evidence

A large empirical literature has developed to quantify agglomeration benefits. Rosenthal & Strange (2004) provide a thorough review of studies using microempiric datasets and find strong evidence for the existence of all three agglomerative mechanisms ('sharing', 'matching', 'learning'). Rice and Venables (2004), using UK NUTS3-level data, estimate a +3.5% improvement in labour-productivity per 100% change in the size of the working-age population. Meta-analysis conducted by the Manchester Independent Economic Review finds that this 'elasticity of productivity' ranges from +2% to +20% across 11 studies (Coyle et al 2009); a significant variation, which cautions against applying generalizations from one region to another. Nevertheless it suggests Rice and Venables' result is conservative. Some scholars (e.g. Melitz 2003) have attempted to argue that the large city productivity advantage is explained by 'firm selection' rather than agglomeration benefits. This has been disputed by econometric analysis (Combes 2009); nevertheless they present an alternative hypothesis that also speaks to the power of absolute scale in improving urban productivity.

3.2 Agglomeration in polycentric regions

The power of agglomeration in driving economic outcomes is therefore well-established, both theoretically and empirically. However, our discussion must introduce spatial structure as a further variable to understand the strength of agglomeration in *polycentric* regions.

Polycentricism's historical rooting is tied to the hypothesis that it allows the harnessing of positive agglomeration without the equivalent diseconomies, such as congestion or lack of access to open space. In an early expression of this idea, Alonso (1973) hypothesized that centres in a polycentric region can 'borrow scale' from one another. Parr (2004, p.238), however, struck a note of caution:

"In the literature considerable stress has been laid on the supposed economic advantages of the PUR, particularly in terms of its capacity to foster cooperation and to permit the efficient exchange of goods, services and information. It is very difficult to accept the argument that these advantages are unique to the PUR and are therefore not present in economic systems based on alternative spatial structures, particularly in an age of continually improving transport and communications systems."

Bailey and Turok (2001) are similarly skeptical of the economic benefits of polycentricism in their analysis of central Scotland. However, these objections are misplaced: there has been no attempt to claim that any such economic advantages are *unique* to PURs. Instead, it is more defensible to argue that, given a relatively fixed morphological structure (which in some regions may be polycentric), there could be economic gains when constituent centres behave cohesively. Furthermore, these objections originate from a Planning-led academic tradition, and do not fully acknowledge the urban economics literature that empirically quantifies agglomeration economies.

This empirical literature, however, does find that agglomeration externalities decline steadily with distance, which could exponentially reduce their power in a polycentric region. Rice and Venables (2004, p.1) find agglomeration effects "decline steeply with time, ceasing to be important beyond approximately 80 minutes." Graham et al (2010) concur and additionally find that this decay varies by sector, with steeper decays observed in consumer and business service industries versus manufacturing.

Nevertheless, a typical PUR as defined by Parr's criteria should contain several major population centres comfortably within this 80-minute decay threshold. It is therefore reasonable to expect PURs to enjoy some level of positive agglomeration benefits. However, there is currently no consensus around the degree of these benefits; there remains no robust analysis of the linkage between polycentricity (fully defined) and economic performance. Tellingly, the POLYNET study did not attempt to analyze this relationship - its economic analysis was largely limited to static decompositions of industrial specialization.

Some analyses (for example Meijers and Sandberg 2008) have found that at a *national* level, monocentric spatial patterns are identified with better economic outcomes. Meijers (2013) finds polycentricism at a *metropolitan* level to be associated with positive labour productivity.

Unfortunately, few studies have attempted to look at the economics of *regional* polycentricism. Brezzi and Veneri (2014) *did* examine regional polycentricity across OECD nations, and again found more *monocentric* regions were associated with better economic outcomes when controlling for education-levels, country effects, and so on. This corroborates studies such as Cervero (2001) and Vandermotten et al (2007) who emphasize the positive relationship between economic outcomes and primate (monocentric) spatial structures.

3.3 Applying a multidimensional framework

The measure of polycentricity used in these studies, however, was basic, one-dimensional, and morphological (typically the rank-file index). As outlined in Section 2, polycentricism must be understood as a multidimensional concept. If we restrict our analysis to a single dimension, we risk significant misinterpretation. A polycentric region with no interconnectivity between centres has no means by which agglomeration benefits can be exploited. Furthermore, once other variables are controlled, we should *expect* morphologically-monocentric regions to perform better than polycentric ones economically: the primary centres in such regions will be larger and therefore generate greater agglomerative benefits than those in more polycentric regions. To fully understand the role of polycentricity in economic outcomes, we need empirical research that utilizes the *functional* and *industrial* dimensions of the concept, as well as the morphological dimension. Such research is elusive at present, primarily due to empirical complexity and data availability.

A basic challenge is that multi-dimensional analysis significantly raises the data burden on researchers. *Flows* are difficult to measure directly: usually proxies such as commuting patterns or train timetables must be employed. This data is more difficult to access and manipulate than morphological data.

Multi-dimensionality also requires the researcher to make decisions and trade-offs when combining the dimensions into a single index. A loss of analytical granularity and definition is inevitable, but we also risk the introduction of bias in the index construction. It should not be surprising therefore that the studies mentioned above acknowledge this challenge but do not resolve it, instead typically resorting to a one-dimensional morphological index such as the rank-file index.

As well as this methodological challenge, there is a more fundamental conceptual challenge. Arguably, given the relatively fixed nature of the built environment, it is *functional* polycentricity that is of more interest to policymakers. As difficult as it may be to influence functional polycentricity (for example, by promoting interaction between nearby towns), this would surely be easier

than influencing the *morphological structure* of a region (which could require coerced movement of populations and fixed assets).

Despite this, existing analysis relies on morphological indices, largely because of the prohibitive difficulty in compiling a dataset of comparable functional indices across multiple regions. Ideally, an analysis would be longitudinal, looking at the same regions over time and examining the *changes* in both multi-dimensional polycentricity and economic performance. This would also address the question of the correct 'counterfactual' or benchmark against which to compare our results.

Such an analysis has not yet been attempted. This is a major empirical gap that prevents robust conclusions from being drawn at this stage around the relationship between regional polycentricity and economic outcomes. We cannot plausibly assert, for example, that polycentricism can be an economic catalyst until a systematic review of the link between economic outcomes and *multi-dimensional* polycentricism has been undertaken. This analysis is beyond the scope of this paper.

3.4 Polycentricism and structural change

Structural change involves a change in the relative distribution of human and economic capital – for example, a shift in a regional economy from manufacturing to APS services. Such change could result from a certain public intervention, or combination of interventions, attracting an influx of new workers or industries from elsewhere; or otherwise promoting an endogenous shift in the economic structure. As noted above, policymakers have limited powers to directly induce regional structural change. Attempts to do so in the UK have typically involved the relocation of government department secondary functions (e.g. moving the DVLA to Swansea), with little evident success (Adams et al 2003). Alternatively, fiscal policy can be manipulated, for example by using the tax system to incentivize firm-level locational choices. In the UK this occasionally happens at a na-

tional-level, e.g. the location of Nissan's plant in Sunderland (Hudson 1995). However, such examples are rare as national governments generally refrain from direct intervention in regional industrial planning.

It is difficult therefore to see a plausible *direct* link between polycentricism and structural change. However, one could argue that there are several means by which structural change could be a *second-order* effect of polycentric policymaking. For example, Dimitriou et al (2013) argue that major infrastructure projects 'reshape' regional economies in profound and unpredictable ways. Structural change could plausibly result from a change in the infrastructure endowment in a region, for example as a result of polycentric policymaking. Alternatively, Crouch (2003) argues that regional governance capabilities and attitudes can impact firm locational choices. Therefore, an active polycentric regional government could attract firm-level investment by fostering an environment of certainty and confidence, and by communicating to firms how they would benefit from direct agglomeration benefits by locating in the polycentric region.

Given the weight of evidence for agglomeration economies (Section 3.1), and this acknowledgement that structural economic change could be a second-order effect of polycentricism, I believe it is valuable to investigate of the nature of polycentricism in northern England. Following Hall and Pain (2006), it seems reasonable to suggest that polycentric regions generate at least some degree of agglomeration economies, even if these are not yet adequately quantified. This tentative conclusion is strengthened by case-study analysis of established PURs, which document the ability of these regions to share (for example) high-quality infrastructure and other fixed goods that their individual component centres would be unable to support individually (Lambregts et al 2006). A multi-dimensional analysis of polycentricism in northern England would therefore provide significant insight when assessing policy interventions for the region. This analysis will focus on the nature of *interactions* between the agglomerations of northern England. These interactions influence the ability of the region to generate regional agglomeration economies, as opposed to urban-level agglomeration economies.

NOTES TO CHAPTER 3

1. Agglomeration economies are most commonly associated with Marshall's (1890) 'trinity' of agglomeration mechanisms (sharing, matching, learning). See Duranton and Puga (2004) for a contem-

porary exposition and taxonomy. Whilst these mechanisms are typically applied to productivity, Glaeser et al (2001) add an additional dimension through application to consumption.

4. Polycentricism in northern England

I begin with brief overview of both regional economic performance and the economic-historical context of spatial development in northern England (Section 4.1). Sections 4.2–4.4 document the analysis I have conducted across the multi-dimensional framework. The results are summarized in Section 4.5. Interpretation and commentary follows in Section 4.6.

4.1 Context: regional economic performance

Though the 'North-South divide' is useful journalistic shorthand for the UK's persistent regional economic disparities, a thorough analysis supports a more nuanced view (Bachtler, 2004). For example, the poorest NUTS2 area in England is the most southerly: Cornwall (ONS

2014b). At a regional level, Wales has the lowest per capita output, whereas Scotland, much further north, has the highest output outside London and South East England.

As shown in Figure 4.1, rather than a simplistic north-south latitudinal divergence, the contemporary economic geography of the UK is driven more by the divergence between London and its environs, on one hand, and the rest of the country, on the other. Of the 12 UK regions, the lowest 10 (ranked by GVA per capita) are separated by differentials of approximately £500 (~3%). Then there is a much larger jump, of almost £4,000 (18%), from Scotland to South East England; followed by another even larger jump of over £14,000 (56%) to London, the top-performing region. The three regions of northern England – the North West, the North East, and Yorkshire and the Humber – are low-to-mid ranking. Furthermore, London has grown its *share* of UK economy dramatically over

Figure 4.1. UK Regional Economic Performance.Data source: ONS (2014a, b)
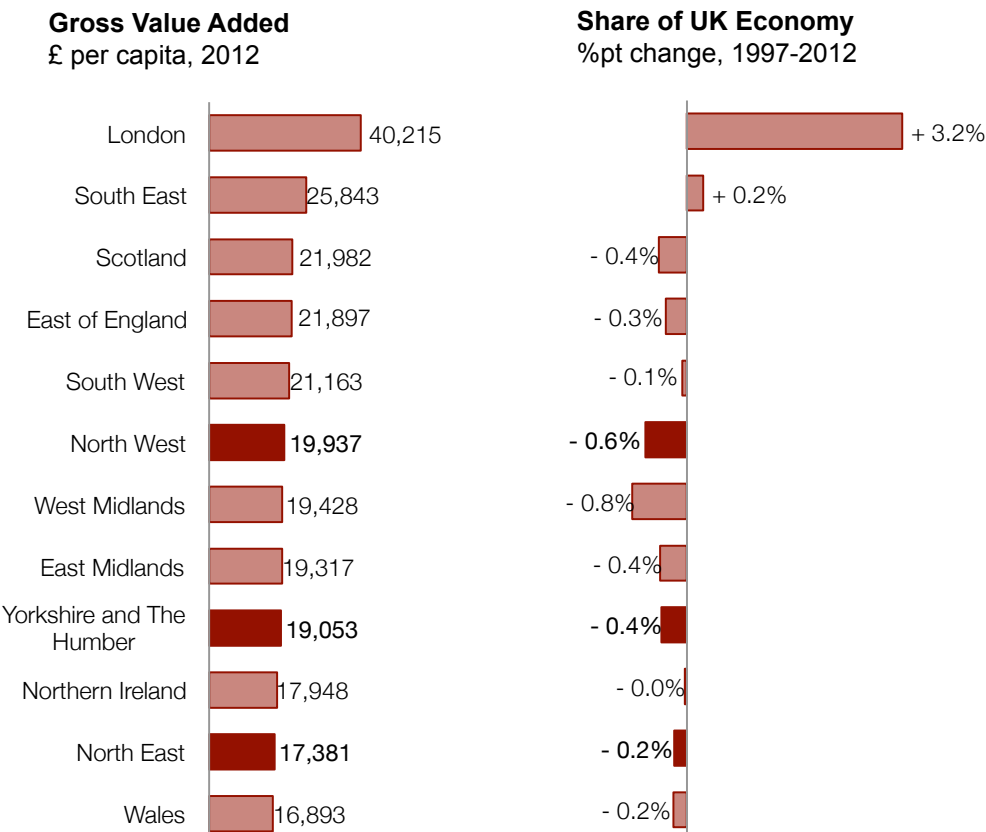
time; South East England has had modest positive share growth; every other region has seen its share of the UK economy decline, including the northern regions, which collectively comprise 1.2% less of the UK economy in 2012 than they did in 1997.

UK economic growth since at least 1997 has therefore been highly concentrated in London and its environs, regions which were already significantly more affluent that the rest of the UK. This is clearly what Osborne alludes to when he describes a "London powerhouse" that dominates "more and more". The London 'powerhouse' is clearly visible in the economic data, and is a persuasive exposition of the three drivers of primate city dominance discussed in Section 2.1 – particularly agglomeration economies and London's role as one of Sassen's primary 'Global Cities'. In contrast, a 'Northern Powerhouse' is clearly an aspiration rather than an analytic or descriptive statement at this stage.

4.2 Morphological analysis: defining a Pennine PUR

Northern England in its entirety is clearly not a single functional urban region (Figure 4.2). We must therefore limit ourselves to a smaller sub-region for meaningful analysis. I argue that it is possible to define a 'Pennine Polycentric Urban Region' that satisfies the criteria for PURs as outlined in Section 2. It is clear that the Pennine area features a very dense spatial structure that is not seen elsewhere in the north of England. Indeed, as Caunce (2015) argues, it is an urban structure almost unique in Europe: without a dominant centre, driven by many medium-sized settlements, a function of topography, deposits of natural resources (e.g. coal), and the costs of transporting these resources in the 18th and 19th centuries. This urban structure was subsequently protected by the post-1945 Green Belt land designation which has prevented the development of a conurbation structure as found in Rhine-Ruhr, Germany.

Figure 4.2. A Pennine PUR within northern England. Circle sizes scaled to FUR population size based on data from OECD (2012). Settlements smaller than 140,000 population omitted.
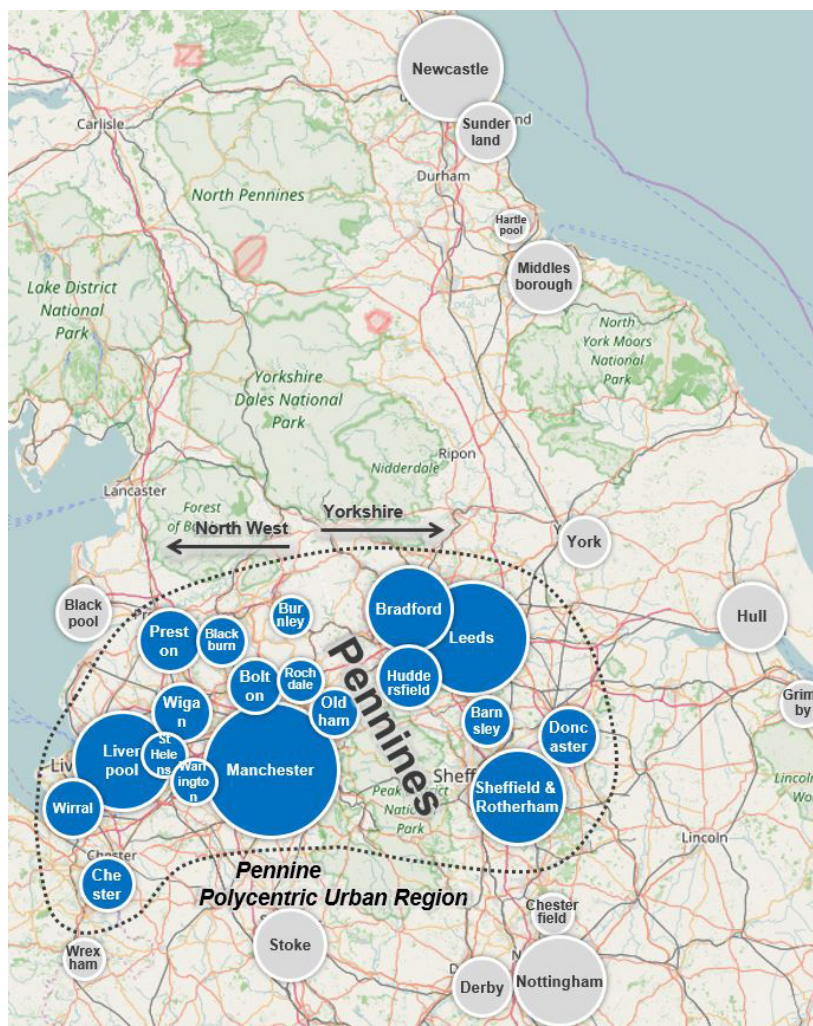
At the margins, I have elected to exclude Blackpool, York, Wrexham, and Chesterfield: these are 'spoke' centres separated by relatively large distances from the rest of the PUR. All centres within the PUR boundary are within, at most, 30 minutes' travel-time from *at least* two other centres. Nowhere else in the UK are such large cities located so close together. For example, Liverpool (pop. 925,145) is located 48km from Manchester (pop. 1,744,723), which itself is 56km from Bradford (pop. 720,506); Leeds (pop. 1,211,608) is then 16km away.

It is worth noting the importance of the topographical feature that gives the region its name: the Pennine hills. This range of mountains and hills forms a spine across northern England and serve to separate the North West from Yorkshire. As such, two distinct sub-clusters are visible in Figure 4.2 on either side of the range. Whilst the small physical distance separating the two means justifies aggregating them into a single PUR, it remains an important consideration. I acknowledge this distinction in the subsequent analysis where relevant by showing the two sub-regions separately alongside the primary Pennine region.

Aside from physical structure, the most common analysis of polycentric regions is the rank-size plot: ordering the centres in population size, relative to the largest. Urban structures are often found to loosely follow the stylized 'Zipf's law' (Gabaiz 1999).

Figure 4.3 shows that at a national level, the UK follows a highly primate distribution: its second-tier cities are significantly under-sized relative to London. However in the Pennine region, a very different pattern is observed. The largest five cities are much more evenly-distributed in scale than typically expected, and even the 'long-tail' of urban centres maintains a larger population than modelled. This result is particularly striking given Hall, Pain and Green's (2006) finding that urban primacy is *more* pronounced at a regional level vis-à-vis national level: we find the opposite to be the case in the Pennines.

Along the morphological dimension, therefore, the Pennine PUR is extremely polycentric.

4.3 Functional analysis

Functional polycentricity measures the nature of *flows* between centres. Our framework specifies two tests on the functional dimension: one testing the *scale* of flows; the other testing their *pattern*. There are many types of 'flow' between urban centres: of people, goods, and information. The first decision for an analyst is to find an acceptable proxy with an accessible dataset. My analysis uses commuting patterns, which was also chosen as the primary flow indicator in the POLYNET analysis. A matrix of local area residence and workplace counts was accessed from the 2011 Census (ONS 2014c).

Figure 4.3. Rank-size population plot, Pennine PUR vs UK. Data source: OECD 2012
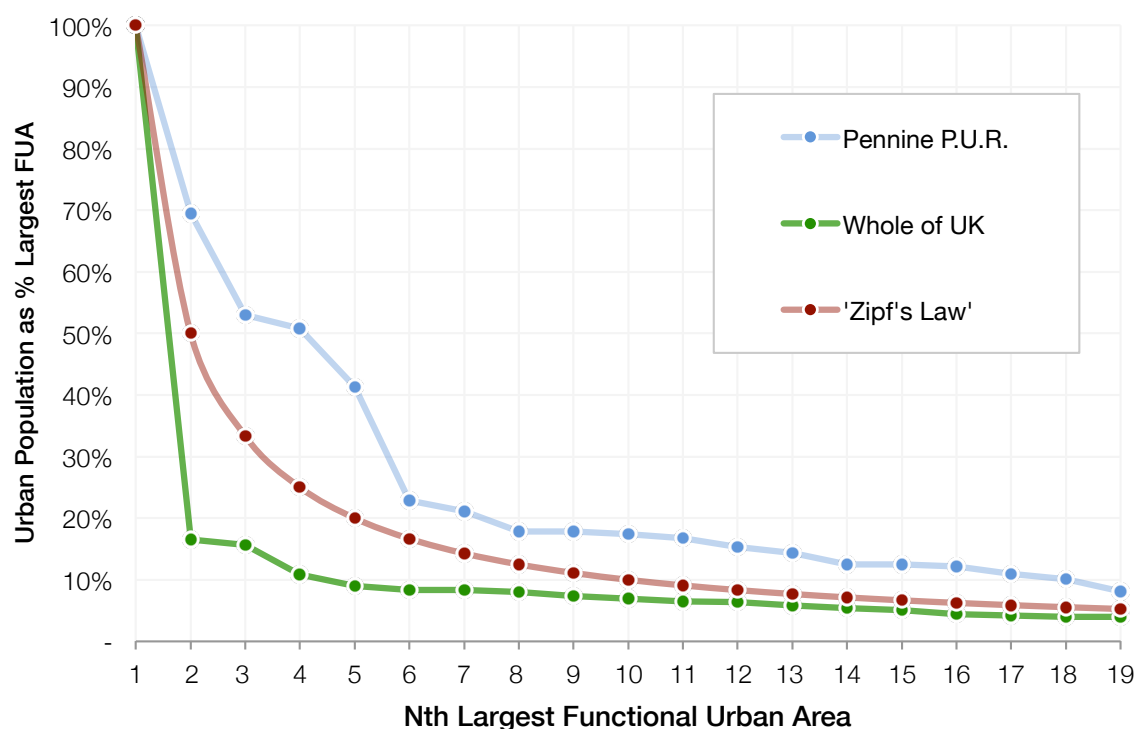
To estimate *scale* of flows, we analyze the urban containment of commuters: the proportion of workers who are employed within their home centre's boundaries. Figure 4.4 plots containment against employment size for the centres in the Pennine PUR:

A positive relationship is observed between centre size and containment; at the top of the distribution is Manchester where 91% of residents with a job do not commute outside Manchester's borders. In the smallest centre, Rossendale, only 42% of resident workers do not commute outside the centre's boundaries. Overall, the scale of flows between centres appears relatively limited with more than 70% of workers commuting within their centre-of-residence only.

Whilst this relationship is intuitive, the degree of containment in large Pennine cities appears to be high when compared to results from POLYNET. For example, the larger cities of the Randstad (Amsterdam, Rotterdam, Utrecht, the Hague) exhibit containment of approximately 50%. In the Rhine-Main region, the largest centre (Frankfurt) displays containment of 37%. The only POLYNET regions displaying similar levels of containment in the largest centres to those found in the Pennine PUR are Paris and Zurich. This finding for the Pennine region is corroborated by the ONS 'Travel to work area' analysis which observes commuting containment at significantly tighter geographic scales in northern England than in the South East (ONS 2001).

A more complex picture emerges when we analyze the *pattern* of flows in the Pennine PUR. Green (2007) provides a methodology based on graph theory analysis to calculate an index number for 'general functional polycentricity'. This captures not just the *scale* of inter-centre flows but also their *pattern*: if all flows are to/from a single centre, the index number will tend towards zero; if the flows are more equal to/from all centres, the index will tend towards 1. The index is defined as

$$P_{GF}(N) = \frac{(1 - \sigma_\delta \sigma_{\delta max})\Delta}{n}$$

Where:

$P_{GF}(N_1, N_2, \ldots, N_n)$ is the General Functional Polycentricity for functional networks $N_1, N_2, \ldots, N_n$
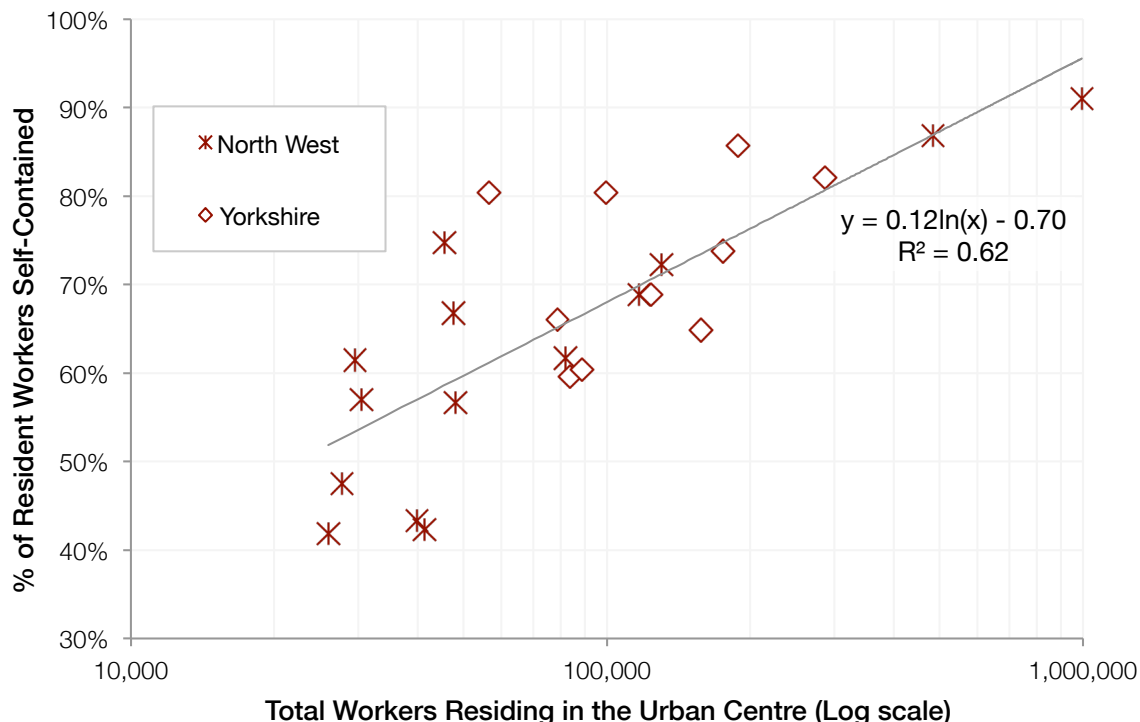
n is the number of networks

σ_δ is the standard deviation of nodal degree

$\sigma_{\delta max}$ is the standard deviation of the nodal degree of a 2-node network derived from N where $d_{n1}=0$ and $d_{n2}=$ value of the node with the highest value in N.

Δ = the density of the network

(Green 2007, quoted in Hall, Pain, and Green 2006)

Figure 4.4. Self-Containment in Pennine PUR Centres. Data source: ONS (2014c).

Using the commuting dataset described above (ONS 2014c) I have calculated a value of general functional polycentricity for the Pennine PUR, as well as its two sub-PURs; Figure 4.5 illustrates these values alongside results from POLYNET. Some caution should be taken with this comparison given the time-differential (c.10 years) between datapoints; nevertheless this is an interesting result. The Pennine region exhibits a relatively high index-number that is smaller, but comparable, to the 'canonical' European polycentric regions of Rhine-Ruhr and the Randstad. The Yorkshire region is relatively more 'polycentric' than the North West on this measure.

4.4 Industrial analysis

The final dimension of our framework is Industrial polycentricity. Here I will analyze the nature of economic specialization (Section 4.4.1) and the distribution of advanced knowledge workers (Section 4.4.2) across the Pennine PUR.

Relative industrial specialization

To measure industrial specialization, I have accessed a dataset for UK economic output (GVA) by sector and by NUTS2 region (ONS 2014a). This allows the calculation of the 'share' of output each sector holds in a given region, and for us to compare regions against each other (and against the UK as a whole). For the four Pennine NUTS2

regions, I calculate the *delta* between (1) each industry sector's share of economic output in the region, and (2) the share of economic output that industry sector accounts for in the UK as a whole. For example, if 20% of Region A's GVA is from the Agricultural sector, but only 10% of the UK's overall GVA comes from this sector, then the delta for Agriculture in Region A is +10%. Figure 4.6 illustrates the industry *deltas* for the four primary Pennine regions.

West Yorkshire (Leeds/Bradford) and Greater Manchester both adhere tightly to the wider UK economic structure. South Yorkshire (Sheffield/Rotherham) and Merseyside (Liverpool) exhibit more variation, and interestingly are quite aligned; both over-index in Manufacturing and Health and Social Work to similar degrees, and under-index in Financial services.

However, it is difficult to interpret these results in isolation: is the +~3% skew in Manufacturing, for example, significant or unusual when compared to other regions around the UK? It is necessary to give context to this analysis to understand the degree of relative industrial specialization.

To do this I have created an index of regional economic specialization. It calculates the *deltas* as above, for each industry in every UK NUTS2 region (therefore 20 deltas for 36 regions). By definition the sum of *deltas* = 0. For each region, the Standard Deviation across its 20 *deltas* is then computed to produce a single index of relative specialization. An index number of 0% would imply that the industrial structure of that region exactly mirrors that of the UK as a whole.

Figure 4.5. General Functional Polycentricity in European PURs. Data source: This study: ONS (2014c). POLYNET: Hall and Pain (2006)
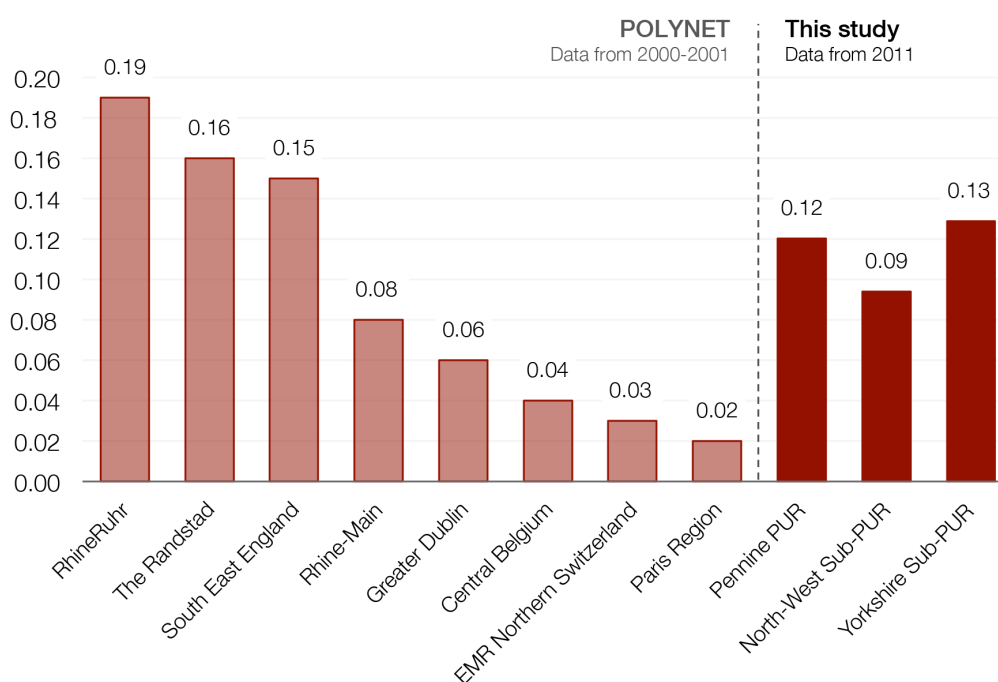
The index is expressed as:

$$Z_R = \sigma^2 \left\{ \left(\frac{Y_R^{Sector1}}{Y_R} - \frac{Y_{UK}^{Sector1}}{Y_{UK}} \right), \ldots, \left(\frac{Y_R^{SectorN}}{Y_R} - \frac{Y_{UK}^{SectorN}}{Y_{UK}} \right) \right\}$$

Where
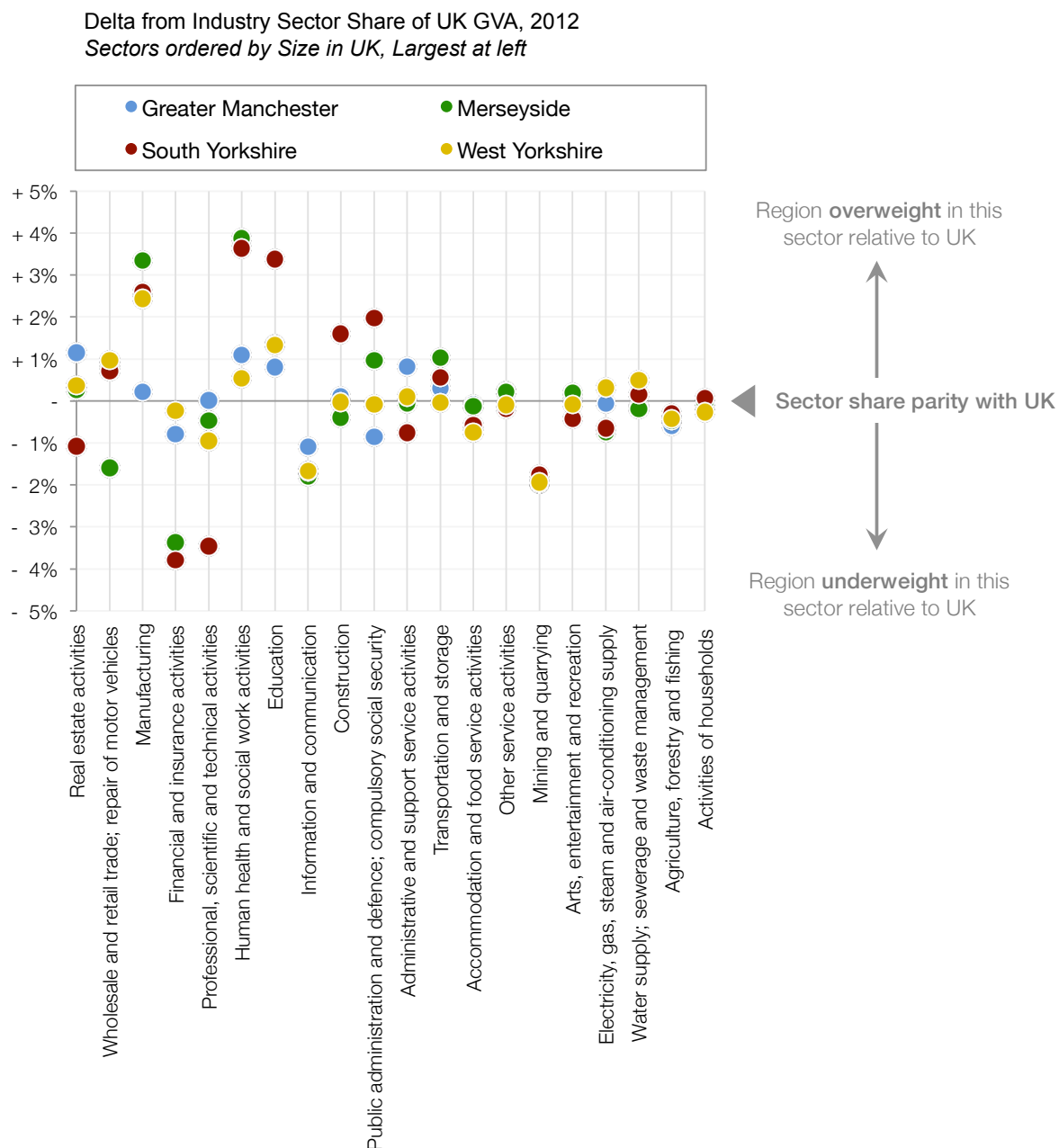
Z_R = Index of specialization for region R

σ^2 = Standard deviation

$Y_R^{Sector1}$ = Economic output of 'Sector 1' in Region R

Using ONS (2014a) I have calculated this index score for each NUTS2 region in the UK. The results are shown in Figure 4.7.

The most specialized region is North Eastern Scotland, where the Mining and Quarrying sector (i.e. Aberdeen's North Sea oil & gas industry) generates 23% of economic output, against 2% for that sector in the UK as a whole. Other highly specialized regions include Cumbria and East Yorkshire (both driven by high relative output in Manufacturing, which accounts for 10% of the UK's output but 25% and 23% of these regions respectively), and London, which has a high specialization in Finance and Insurance activities.

**Figure 4.6.** Industrial specialization in Pennine centres. Data source: ONS (2014a)

At the other end of the spectrum are two Pennine regions, Greater Manchester and West Yorkshire (Leeds and Bradford). The index of specialization for these regions is 0.8% and 1.0% respectively. This indicates that, of all UK NUTS2 regions, Manchester and Leeds-Bradford are *most* similar to the UK economy as a whole – they display the *least* industrial specialization of any UK region. The other primary Pennine regions of Merseyside and South Yorkshire (Sheffield) display slightly more specialization, but still less than the UK median.

Figure 4.7. Index of regional economic specialization. Data source: ONS (2014a)

Standard Deviation from UK Industrial Structure (GVA, NUTS2, 2012)
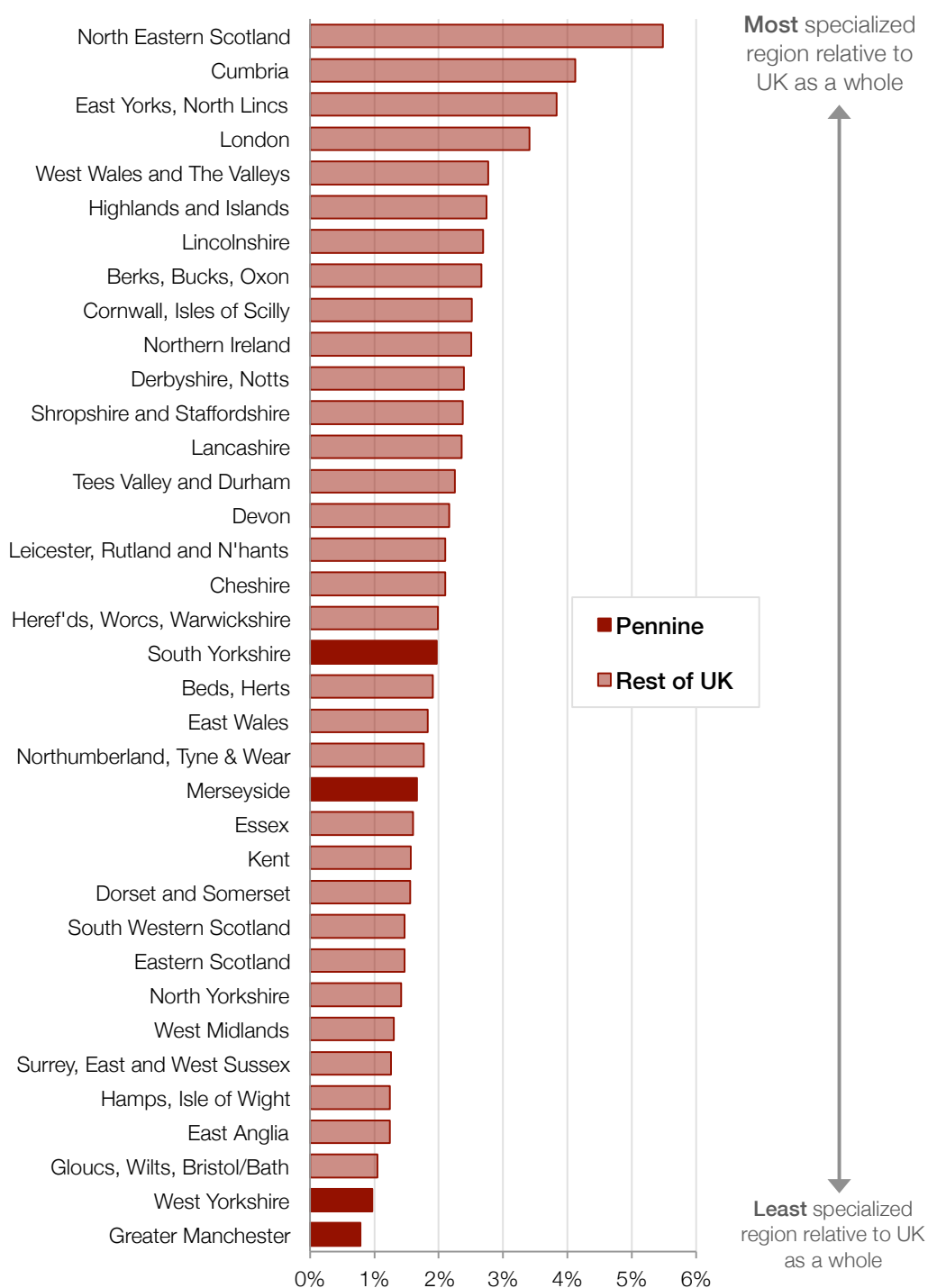
This result directly contravenes Parr's (2004) expectation that centres in a polycentric region would display greater specialization than in a benchmark region: we find that the centres of the Pennine PUR are *particularly* non-specialized. It also gives context to the intra-regional analysis (Figure 4.6), suggesting that even where some specialism is observed (e.g. by Merseyside and South Yorkshire in the health sector), these are not particularly significant specialisms on a national scale.

Concentration of knowledge workers

The final industrial lens involves the distribution of workers in 'knowledge-intensive business services', a proxy for the 'APS' sector discussed by Sassen (1991). The arrangement of APS labour was a primary theme of the POLYNET work, and Hall and Pain (2006b) argue that the 'First City' in each polycentric region has a key role as a knowledge 'gateway' for the region as a whole. The First City's role in this regard is particularly important due to the high agglomerative economies that are generated by APS sectors, and the importance of clustering and face-to-face interactions in these industries.

The distribution of knowledge-workers is shown in Figure 4.8. The bar widths are relative to the total size of the labour market in each centre; the heights indicate the proportion of the workforce in each centre that are knowledge-workers. Area is therefore proportional to the size of the APS labour force.

Manchester employs the largest pool of knowledge-workers, c.166,000. This represents 36% of the total knowledge workforce in the Pennine region. However, at 18% of its workforce, this represents the second-largest *proportion* – 21% of Leeds' workforce belongs to the knowledge-intensive categorization.

On one level, this result is reflects the 'first city' theory outlined by Hall and Pain (2006b). Large pools of APS workers are found in Manchester and, to a lesser extent, Leeds. There is a significant drop-off between the proportion of knowledge-workers in these cities and in Sheffield, the third-ranked centre. However, the extent of Leeds' lead over Manchester in proportional terms suggests a second, more subtle interpretation. It points to a possible failure of a dominant 'first city' to emerge in the Pennine region. Instead, two distinct 'first cities' are evident, one on either side of the Pennine hills, separately servicing their own sub-regions. The lack of economic linkages between the two sub-regions was identified by the Northern Way initiative (Overman et al 2009); the distribution of knowledge workers is perhaps a manifestation of this.
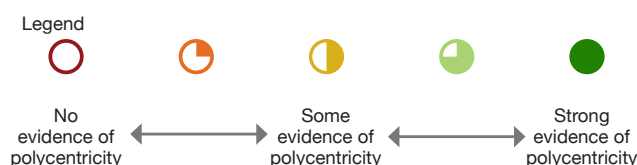
Figure 4.8. Knowledge-intensive labour pools in the Pennine PUR. Data source: Centre for Cities 2015b
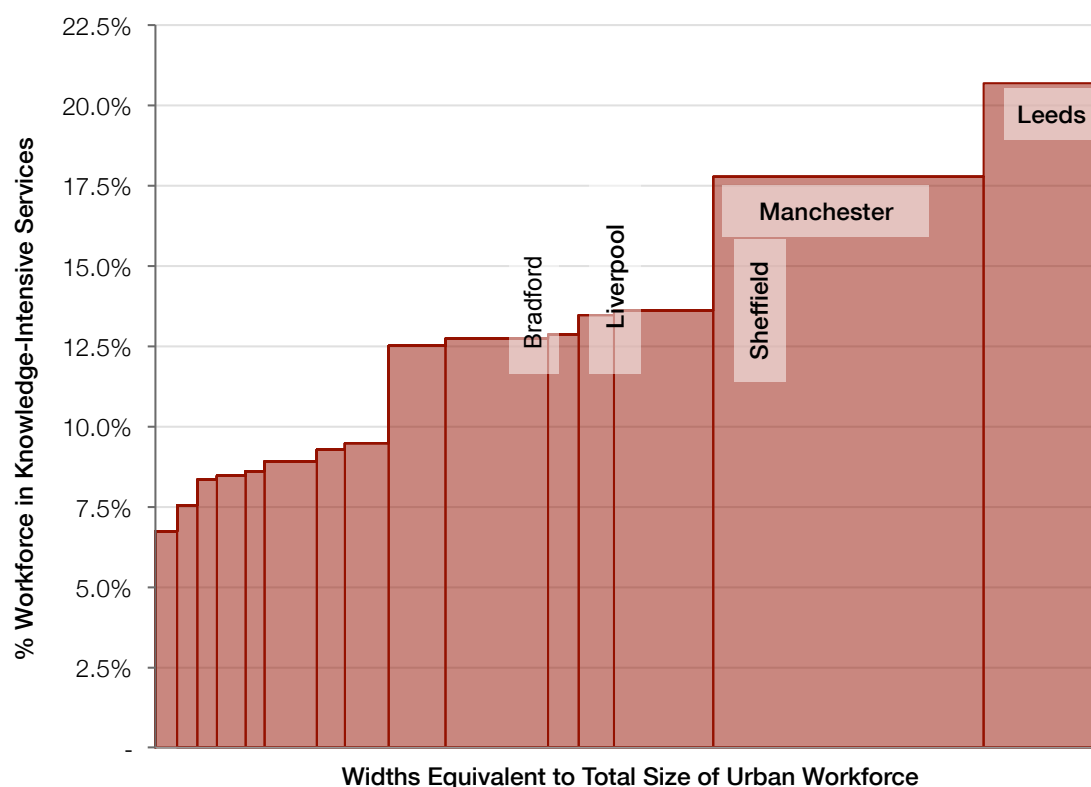
4.5 Summary of results

Table 4.1. Multidimensional framework: Summary of analysis for Pennine PUR

Dimen-sion	Analytical test	Operationali-zation	Pennine PUR
Morpho-logical	Spatial distribution	Rank-size analysis of centre populations	●
	Demographic distribution	Rank-size analysis of centre populations	●
Functional	Scale of inter-centre flows	Commuting containment	◔
	Pattern of inter-centre flows	'General function-al polycentricity'	◕
Industrial	Regional specialization	Intra-regional sec-tor specialization	◔
		Inter-regional specialization	○
		Distribution of APS labour force	◐

Legend

○   ◔   ◐   ◕   ●

No evidence of polycentricity ⟷ Some evidence of polycentricity ⟷ Strong evidence of polycentricity

4.6 Interpretation

Overall, a mixed picture has emerged of the nature of polycentricism in the Pennine region. Analysis along the morphological dimension is unequivocal. Indeed, the region is one of, if not the most morphologically-polycentric in Europe (e.g. when compared to the POLYNET regions).

However, the functional dimension is less clear. The result of the 'general functional polycentricity' analysis is relatively strong; but the containment analysis suggests the scale of flows between centres is unusually small. In this respect, the high 'general functional polycentricity' score could in fact be a function of the morphological

structure of the region. With four large cities quite tightly-spaced and interspersed by many large and medium-sized towns, it is perhaps inevitable that a relatively complex *pattern* of flows will emerge: there is no clear primate to dominate commuting patterns. Evidence for this is found by looking at commuting behaviour in centres such as Warrington: significant out-flows are observed both westwards to Liverpool, and eastwards to Manchester. The relatively weak *scale* of flows corroborates analysis by Overman et al (2009) who found that commuting between Leeds and Manchester was c.40% lower than would be typically expected for two cities of their size and proximity.

Along the industrial dimension, evidence of regional economic specialization is very low. Indeed it is remarkable that Greater Manchester and West Yorkshire (Leeds-Bradford) are the two most 'generic' regional economies in the UK. The historical specialisms of the region are not easily observed in the data, suggesting these roles have lapsed.

As a whole, therefore, the analysis suggests that multi-dimensional polycentricism is significantly *under*-developed given the high degree of morphological polycentricism. Considering the region's relatively poor economic performance (Section 4.1), this supports the analysis of Brezzi and Veneri (2014), Cervero (2001), and Vandermotten et al (2007). These studies found that morphologically-polycentric regions suffer an economic penalty compared to morphologically-monocentric regions, partly as a result of the constrained ability of the region's urban centres to generate agglomeration economies (see Section 3.2). The poor functional and industrial polycentricism in the Pennines would suggest that the region does not currently exploit its morphological polycentricity and overall size of population, and that therefore there could be material agglomerative benefits from increasing interdependence in the region.

Why is functional polycentricity and industrial specialization currently so low in the Pennine region, despite its morphological polycentricity? I suggest three hypotheses that could explain this result.

Inadequate transport infrastructure

The analysis suggests that the centres are less functionally interdependent than they should be given their physical proximity. Research by Overman et al (2009) found that a primary driver of this was the high cost, both in financial and temporal terms, of transport links between Pennine centres, particularly between Leeds and Manchester. These costs reflect both topographical constraints (the Pennines themselves) and the historic legacy of UK transportation infrastructure, particularly rail, as radial from London. Consequently an efficient transport network for the region is under-developed.

Governance and institutions

Marshall (2005) argues persuasively for the role of aligned economic and political boundaries in creating positive and sustainable economic development. Such alignment is often elusive; for example none of the POLYNET regions featured a governance arrangement that explicitly recognized the regional polycentric economic structure. Nevertheless, the local governance structure in the UK is particularly fractured, with local authorities often responsible for areas much smaller than metropolitan economic units. As a result, spatial economic policymaking can be overly parochial and narrowly-defined, rather than taking a more holistic regional view. This is acute in the Pennine region, where reforms in the 1980s abolished metropolitan-level authorities, leaving borough authorities that service territories far smaller than functional urban areas (Manchester, for example, has ten such authorities).

Changing roles in the global economy

Historically, the major centres of the Pennine region were *famously* specialized. Manchester and Leeds were centres of textile manufacturing (cotton and wool respectively). Sheffield was a centre of metalwork and heavy industry. Liverpool's port and associated industries serviced the region. However by the mid-20th century these functional specialisms were displaced by globalization and changing patterns of industrial supply and demand. One could therefore argue that today's lack of specialization reflects a failure to replace these historical specialisms with ones more suited to the requirements of the contemporary global economy, and the inability of the region's infrastructure (transport and governmental/institutional) to facilitate such a replacement.

5. Implications for policy

The fact that functional and industrial polycentricism in the Pennine region appears weak, relative both to other PURs and to its own morphological polycentricism, suggests that there could be significant gains from pursuing greater regional collaboration and integration. I suggest five areas for policymakers to consider.

Transport infrastructure

Intra-regional transportation is poor in the Pennines. Winch (2015) argues that transport can be a primary driver of the 'Northern Powerhouse' agenda; this is recognized to an extent by existing policy such as the 'Northern Hub' project (DfT 2015). However, I believe policymakers should go further, for example by ensuring that the development of the HS2 rail link is done in a manner that leverages regional connections across the Pennines, instead of creating separate London-focussed corridors through the region. The 'HS3' proposal to improve rail links across the Pennines is encouraging but requires significant substantiation and investment.

Governance and institutions

An appropriate governance structure and apparatus has been lacking. Policymakers have recognized this and attempted to rectify through the creation of 'metro-mayors'; Manchester represents the first case of this policy (Topping 2014). However, a formalized, unified regional governance layer could add useful strategic direction. Davoudi (2007, p.15) has argued that polycentric regions require "a variable geometry of more informal and flexible intermunicipal collaborations for different functions and services." Busetti (2015) argues that modern institutions, particularly in areas such as transport, can help to play this role; Transport for London could be held up as a template for such a regional agency. The 2015 foundation of 'Transport for the North' is a positive development. Analogous institutions in other areas where regional decision-making would be valuable, for example health and education, should be investigated.

Balancing growth versus equity

Overman (2013) notes that there is a general tendency to "jam-spread" place-based development resources, rather than to target them in those smaller areas where they can generate the most return-on-investment. The recent development of the Randstad polycentric region in the Netherlands was accompanied by a change in national policy: to explicitly channel development resources to the country's most competitive region, rather than spreading them more equitably (but less efficiently) across regions on a per-capita basis (Zonneveld and Waterhout 2007). This suggests difficult decisions may need to be made over the allocation of development resources within the Pennine region. This in turn requires the existence of a governmental entity at the correct territorial level that can adjudicate these tradeoffs.

The role of 'first cities'

The growth-equity tradeoff then interacts with the requirements of a 'first city' in a polycentric region. As Hall and Pain (2006c) found in the POLYNET study, 'first cities' perform crucial gateway roles in their regions: the most skilled workers concentrate in them, especially in APS sectors; and communication flows and firm interactions within the first city were found to be more important than those in the rest of the region. Significant investment in the 'first city' is therefore an inherent requirement for a successful PUR model. The competition between Manchester and Leeds is therefore possibly inhibiting regional development as a whole. Manchester is the larger city, and enjoys a higher profile internationally. Yet Leeds is the UK's second centre for legal, accountancy, and banking services – archetypal APS industries (Leeds City Region 2017). A policy decision may therefore need to be made - either at a national level, or a regional one – to overtly prioritise the development of one of these cities over the other. The Manchester-focussed policy announced thus far suggests such a decision has already been made (Derbyshire 2014); policymakers should hesitate before indulging their 'jam-spreading' inclinations.

Industrial clusters

A final policy area for consideration should be the role of government in promoting industrial specialization via clusters. Clustering at the city-level has received significant attention from academics and policymakers since at least Porter's (1995) exposition. Some research, for example Martin et al (2008), has argued that policy promoting clustering is unnecessary and not welfare-improving,

because the agglomerative benefits of clustering are generally captured directly by the actors involved. Nevertheless, given the Pennine region's very low level of industrial specialization, regional cluster policy should be explored. The recent development of a media cluster in Manchester, driven by BBC relocation to Salford, suggests the potential for proactive approaches to cluster policy, particularly in sectors of comparative advantage and where there are limited risks of duplication within the region.

5.1 The limits of polycentricism

I have argued that there would be economic gains from encouraging polycentric interdependence in the Pennine region. However, the limits of polycentric planning and development must be acknowledged. Two areas are worth particular consideration.

Firstly, the implications of our conceptual foundations should be considered in relation to a Pennine PUR, existing as it does in a country which already hosts London, one of the most advanced and important 'Global Cities'. Can a country of the UK's size sustainably support two large APS hubs? I would argue it can, given the co-existence of several major continental European APS hubs in close proximity (the "blue banana" urban corridor running from South East England to northern Italy via the Netherlands and Bavaria). However, London's proximity and continued success makes the ar-

gument for a Pennine APS centre more complicated than in other POLYNET regions which almost always featured national primate centres.

Secondly, whilst spatial structure and the built environment are undoubtedly factors that influence economic outcomes, they are by no means the only or even the most important. Overman (2015) compares the contrasting fortunes of the Randstad and Ruhr polycentric regions, noting that both exhibit strong functional polycentricism. What differentiates them, however, is the skills-base in their populations: the Randstad employs a very highly skilled population, whereas the Ruhr does not. Skills or education levels are a far more significant driver of economic performance than spatial structure; Gibbons et al (2010) find that regional wage disparities in the UK are almost wholly driven by 'sorting' variables (i.e. 'people characteristics') rather than 'area characteristics'. Any policy that focuses on infrastructure rather than the skills-base of the population will therefore be significantly limited.

A possible response to this criticism could note the ability for investment in a Pennine polycentric region to induce *structural change* in its economy, for example by persuading skilled workers to relocate away from the South East. This could represent a Pareto-improvement for the UK as a whole if it enables the growth of a self-sustaining APS cluster in the north whilst simultaneously reducing congestion in the south east.

6. Conclusions

This paper has argued that polycentric regions must be considered through a multi-dimensional perspective. Whereas traditional analysis has focused on morphological polycentricism, there is increasing emphasis being placed on the nature of functional and industrial dimensions. Unfortunately, this has not yet resulted in in-depth analysis of the links between economic outcomes, and functional and industrial polycentricism. Nevertheless, the conceptual foundations in this area – including agglomeration economies, Castell's 'space of flows', and the role of advanced knowledge-workers in the modern urban economy – are persuasive. Improving the nature of interactions between centres in a polycentric region is therefore likely to have positive economic outcomes. This would come via the leveraging of agglomeration economies, which are contingent on urban *scale*. Through such interactions, some agglomeration economies can operate over regional scales rather than on individual urban centres.

Applying this multidimensional framework to northern England, I find evidence of a highly morphologically-polycentric urban region straddling the Pennine hills. The fragmented spatial structure of this region is unusual and results in a complex pattern of inter-centre flows; however, the economic links between regional centres are under-developed, with less functional interdependence and far less industrial specialization than would be expected given the morphological structure.

What does this mean for the 'Northern Powerhouse'? Overall, this paper concludes that there could be significant value in pursuing a regional development policy based on polycentricism, perhaps framed under the 'Powerhouse' slogan. My analysis suggests that the Pennine region's highly-fractured morphology has hindered its economic development. Morphological structure is largely fixed; therefore, acknowledging this and working to proactively leverage the opportunities polycentricism can offer appears sensible as a policy approach. Further research should be conducted to examine the micro nature of both industrial clustering and communication flows in the region to better target policy measures.

Policy measures that address the current lack of functional interdependence and specialization should be prioritized. These include transport investments, particularly those which encourage and leverage Manchester as a 'hub' for the region, and the establishment of governmental institutions that are geographically aligned to the Pennine polycentric region. A coordinated approach to cluster policy that aims to leverage comparative advantages without intra-regional duplication would also be beneficial. These measures may well catalyze economic growth, both through unlocking regional-level agglomeration economies, and by stimulating structural change.

Nevertheless, whilst polycentricism under the 'Powerhouse' banner may *support* and *improve* economic development in northern England, at least versus its historic trajectory, it is highly unlikely to redress the UK's overall North-South economic imbalance. London and the South East benefit from agglomeration economies generated by major scale advantage; capital accumulated over centuries; a highly-skilled workforce; and a sector mix, aligned to these properties, better-positioned for growth in the modern global economy. These facts explain why London was one of Sassen's original 'global cities'. The championing of polycentric development in northern England is unlikely to change the fundamental economic geography of the UK. Nor is it likely to directly improve the skills-base of the Pennine's labour market, a primary cause of its lower competitiveness.

More broadly, this paper has identified significant gaps in the empirical literature. In particular, research that purports to quantify the relationship between regional spatial structures and economic outcomes do not currently apply a multi-dimensional understanding of polycentricism. Furthermore, recommendations from these analyses should recognize that urban morphology is a largely fixed dimension, especially where urban development zoning or planning constraints exist. Regions therefore have to look for the tools that promise the best societal return on investment. Only when such research is undertaken will we know unequivocally the power of regional polycentricism.

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