Renewing Industrial Regions? Advanced Manufacturing and Industrial Policy in Britain

WORKING PAPER

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The UK's new industrial strategy, with local variants, is aiming to support manufacturing industries and return growth to traditional industrial regions (TIRs) and thereby contributing to a more rebalanced or 'levelled-up' spatial economy (Christopherson et al, 2014; Bailey et al, 2015). A key goal of this strategy is to develop research-based technology collaborations between public and private sectors, and advanced manufacturing (AM) industries. However, little is known about geographical changes in AM, and hence whether strategies will be working with, or against, the grain of established trends. Theoretical ideas are ambivalent about whether dispersal or concentration prevails in AM.

The paper considers three assumptions that have shaped recent policy thinking on the spatial potential of industrial strategy. The first is that AM is widely dispersed across a wide range of regions and offers potential for further regional dispersal. The second is that Traditional Industrial regions include significant reservoirs of assets and capabilities on AM that provide the basis for a potential revival of these industries. The third, is that the best way to encourage and support this revival and growth of AM is to increase research spending activity in urban innovation districts.

Using novel data on GVA and employment by NUTS 2 regions and Local Authority Districts, for eight advanced manufacturing industries over several decades, the paper finds that regional concentration fell in the majority of AM industries up until 2000, but it has risen since as these industries have consolidated and retrenched. Despite this, AM output has continued to shift away from dense, large cities to semi-urban and smaller cities. The findings reveal that LADS in TIRs have lost ground relative to those in other regions, although there are variations both between regions and industries. In AM industries with a more 'synthetic' knowledge base there has been some growth and expansion in some TIRs. In contrast, AM industries with more 'analytical' and science-based knowledge bases TIRs have shown a poorer relative performance.

Analysis of a long-term micro-level dataset on firms in these eight industries shows how dependent the growth of AM has been on inward FDI, which has produced greater output growth outside of TIRs. The majority of growth has been driven by FDI which has tended to prefer non-TIR locations.

The paper finds that AM industries have not shifted decisively towards R and D intensive regions, nor to regions with high levels of University research activity. There is no evidence of a return of AM to large urban regions. Historically, research centres in the UK do not appear to have been a key factor shaping AM location, which implies that future policy initiatives to 'spark' and support AM clusters around innovation districts will need to be re-thought and re-designed in several ways. The conclusions discuss some of the significant policy implications and challenges which these trends pose for place-based industrial strategy in a post-Brexit context.

Acknowledgment

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1. Introduction: Spatial Rebalancing Ambitions and Industrial Policy

It is well known that Britain suffers from a severe problem of regional imbalance which stems from the decline of manufacturing, and especially tradeable export industries in northern regions, and the uneven growth of service industries (Martin et al, 2013; Martin, 2015; Martin and Gardiner, 2018; McCann, 2016). Regional and local economic disparities have been intensified by the global financial crash and its aftermath, and emerging evidence suggests that the current COVID-19 recession is further widening these spatial disparities (Hughes e al, 2020). The plight of formerly industrial regions is central to the recent rise of populist discontent and growing concern with 'left behind places' experienced in the UK, western Europe and the USA (Hendrikson et al, 2018; Rodríguez Pose 2017). In mature industrialised countries, such as Britain, "former industrial regions have presented a persistent problem for public policy across the developed world for several decades" (Tomaney and Pike 2018, p. 140).

Partly in response to these problems, recent Governments have emphasised the need for an industrial policy to rebuild and reinvigorate the country's manufacturing base (BIS, 2010; HM Government, 2017; 2018). The current government has emphasised the priority of 'levelling-up' opportunity across the country and 'unleashing growth' in the post-Brexit era (The Economist, 2020). Mirroring other advanced economies internationally, after decades of indifference, manufacturing in the UK is also undergoing something of a 'policy renaissance' (Christopherson et al, 2014; Bailey et al, 2015; and see Lowe and Wolf-Powers, 2018, on the US). The substantive content of industrial policy in Britain has yet to match the strength and resources of industrial policies in other countries, and its development has been constrained by the shortcomings of longstanding political-economic paradigms and institutional frameworks (Berry 2016; Berry and Hay, 2016). Nevertheless, the UK government now has a national industrial strategy with local variants that aims to support manufacturing industries and return growth to manufacturing areas.

Mirroring other countries and attempting to address its productivity gaps (Rhodes, 2016), the UK's industrial policy renaissance has placed more emphasis on the more advanced or knowledge intensive parts of manufacturing. The new industrial strategy contains a mixture of different types of initiatives. Some are horizontal and industry-wide, while others are centred on key innovation challenges and 'missions', and a third set are focused on particular sectors where public investment in R&D has been increased (House of Commons, 2018). The latter two types of initiative connect most strongly with the more knowledge intensive parts of manufacturing. Indeed, the central goal of the industrial strategy is to develop research-based partnerships and collaborations between public and private sectors, and thereby deliver new technologies that meet the key challenges or missions. Its Catapult centres are designed to engage with advanced manufacturing (AM) industries in order to translate and commercialise innovations thereby seeding new firms and industries (Edmonds, 2019). University research facilities, in close conjunction with their industry partners, have been given a leading role in meeting innovation missions and in creating new clusters.

Despite the rhetoric and policy endeavour, however, the fusion of sector *and* geography is fuzzy and unclear. Uneasily for a policy seeking spatial rebalancing, geography has been neglected. There has been little explanation of how these policies relate to the differing needs and capabilities of the UK's regions (Bowman et al., 2015; Bernick et al, 2017), nor how the focus on innovation and high-technology will benefit regions specialised in more mundane and lower-skilled manufacturing activities (Fothergill et al, 2017). Whether the industrial strategy will deliver benefits for lagging traditionally industrial cities and regions and match the current government's 'levelling-up' ambitions is, therefore, a difficult and contentious question.

Despite the lack of explicit discussion of geography, the current policy approach is underlain by several assumptions about the geography of AM. The first is that it is widespread across cities and regions. The apparent hope is that AM can be further regionally dispersed, so in some ways it offers a geographical opportunity. While AM is certainly more regionally dispersed than other leading sectors such as finance (Sandbu, 2019), there has been very little detailed analysis of the geographies of the kinds of industry that policy is seeking to target. The second assumption is that AM has significant presence in traditional industrial regions (TIRs) in the Midlands and Northern England, Scotland and Wales, and there is potential for further growth based on their assets and skills. Third, it is also now widely accepted that the best way to encourage and support this regional dispersal is by developing University and research institute innovation clusters in each region. There is a growing policy belief in the potential of 'urban innovation districts' (see Katz and Wagner; 2014; Grodach and Gibson, 2018) which in the UK has given some hope to the view that northern cities can be regenerated by geographically concentrating investments in localised innovation hotspots. The policy ambition is to develop innovation centres linked to clusters of AM in traditional industrial regions, or what might rather paradoxically called 'regional dispersal through cluster development'.

The aim of this paper is to consider these three assumptions by comparing them with historical evidence on spatial changes in AM industries in order to assess whether such assumptions, and policies based on them, are working 'with or against the grain' of long-term trends. We start by examining long term trends in AM output and employment to assess whether AM is becoming more spatially concentrated or dispersed, and highlight some of the important differences between different sectors and industries that have emerged over the last few decades. We examine how these changes have affected TIRs in particular. We then discuss the assumption that AM industries can be supported through the promotion and growth of innovation districts and associated clusters. We highlight some reasons why the development of innovation hotspots with AM clusters will be much harder than often assumed. We argue that the scope for regional rebuilding varies strongly across different industries and we identify those types of AM industry that have performed relatively well in TIRs. While there are important differences between industries, we find less evidence that supports the importance of clustering around innovation centres, however, and argue that attempts to use innovation centres will need to be re-directed and strengthened if they are to be effective. The 'place pillar' of the industrial strategy will undoubtedly need to be strengthened to allow regions to design and implement local industrial strategies that respond to the varying needs of their economies (Bailey et al, 2015).

2. Advanced Manufacturing in Britain

High-technology and more knowledge-intensive and 'advanced' manufacturing activities are attractive to policy makers as they offer the promise of raising productivity, as well as generating more skilled jobs, export-earnings, and innovation and knowledge spillovers (BIS, 2010; 2013). It is argued that firms need to upgrade to products and processes with higher value-added content including tangibles such as innovative technology and integration with intangible services such as branding, product support, after-care and disposal (described as 'manu-services' or 'servitization') (Pike, 2015; Sissons 2011). Although varied, AM is usually defined as manufacturing that is capital and knowledge intensive, using a high level of technology, elements of service provision, and requiring a workforce with specialist skills (BIS, 2010; Livesey, 2015). It is a broad label but includes activities that make use of cutting-edge materials and scientific advances, and involves the creation, utilisation and co-ordination of information, computation and software. In this paper, we use a widely used definition of advanced manufacturing (Table 1). We also separate these into high-technology and medium technology groups after the distinction proposed by Helper et al. (2012).

Table 1: Definition of Advanced Manufacturing Industries

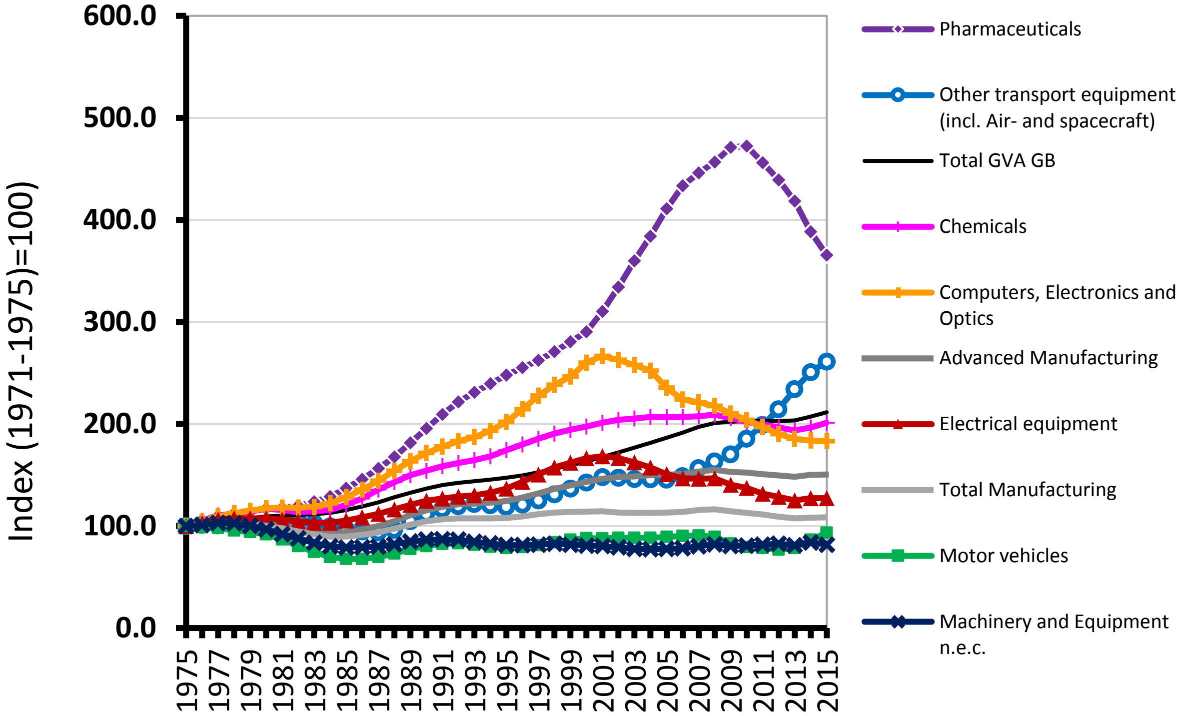
Very High Technology*
Computers, electronic and optical products (SIC 2007: C26) Pharmaceuticals (SIC 2007: C21) Air- and spacecraft (SIC 2007: C30.3)
Moderately High Technology*
Other transport equipment, other than Air and spacecraft (SIC 2007: C30 excl. C30.3)
Manufacture of chemicals and chemical products (SIC 2007: C20)
Motor vehicles, trailers and semi-trailers (SIC 2007: C29) Machinery and equipment n.e.c. (SIC 2007: C28) Electrical equipment (SIC 2007: C27)

*Based on shares of science and engineering occupations in industry employment, Helper et al, 2012, Table 1, page 7.

Source: XXXX

Government reviews of manufacturing in Britain have highlighted areas of comparative advantage in AM such as aerospace, automobilies and pharmaceuticals which are seen to have "important local economy and rebalancing effects" (Department for Business, Innovation and Skills (BIS) (2012, p. 32). Productivity in these higher knowledge-intensive parts of manufacturing has certainly grown faster than in medium and low technology manufacturing industries, although employment decline has also tended to be faster in higher value manufacturing industries (Green et al., 2016). These comparative strengths should be qualified in important ways, however. First, AM has been strongly and negatively affected by the 2008 recession and productivity growth in these industries appears to have stalled. Investment has been negatively affected by prolonged uncertainty amidst Brexit (Rhodes, 2018) and AM industries have been severely impacted by the COVID-19 recession. Second, there is considerable heterogeneity in experience and performance even within the AM category. Figure 1 shows the marked differences in trends in output by value for our selected industries. While the value of output in motor vehicles and machinery has been level since 1971, most other sectors grew until the early 2000s but have since declined (see Appendix A for a note on data sources). With the exception of the electrical sectors, output grew at a moderate rate in many of these industries prior to the 2008 crash. It appears that the effects of recession have compounded the longer-term difficulties facing the innovation model in pharmaceuticals (Rafols et la, 2014; Malerba and Orsenigo, 2015). In contrast, the partial revival of the automobile industry since the early 1990s is evident in the sense that the level of GVA has been maintained, and increased between 2010 and 2015 (see Bailey and DePropris, 2014; 2017). The strongest performing sector has been transport equipment including aerospace and shipbuilding which has shown strong growth from around 2002 (House of Commons, 2018). In fact, output growth in AM in the past decade has been dominated by this sector so that the country's manufacturing base is heavily exposed to its fortunes, which is a real concern given the impact of COVID-19 crisis on aviation.

Figure 1: GVA in Selected Advanced Manufacturing Industries in Britain, 1971-2015



Source: Cambridge Econometrics Data

3. The Changing Geographies of Advanced Manufacturing in Britain: Concentration or Dispersal?

There is little consensus about the dominant trends in the geographies of these AM industries, as theoretical ideas on the issue are ambivalent and vary in their predictions (Table 2). The de-agglomeration and movement of AM away from cities have been widely reported (Helper et al, 2012). There is strong evidence of a long-term dispersal of manufacturing industry due to an 'urban-rural shift', and firms' rising needs for space, modern premises and accessible locations, and the move of mature sectors to lower cost locations (Crafts and Klein, 2017; Dauth et al, 2015; Norton and Rees, 2007). Moreover, where leading foreign direct investors have higher productivity and are assured of having access to 'frontier' techniques, technologies and knowledge, they have little incentive to cluster, and may deliberately avoid existing clusters in order to minimise unwanted knowledge spill-overs and leakages (Shaver and Flyer, 2000).

On the other hand, there has been increasing emphasis on the benefits of clustering in AM. Some (conventional) versions of New Economic Geography (NEG) predict the increasing concentration of firms to realise local externalities and spill-overs as transport costs fall (up to a certain level) (Krugman, 1993; Brülhart, 2001). Later versions of NEG argue that such concentration effects are becoming weaker in the advanced economics as a result of technological, functional and organisational changes that permit the delocalisation of production and spatial dispersal of supply chains and production networks (Krugman, 2008; Baldwin, 2017). However, much recent research on knowledge-intensive industries has argued that local knowledge spill-overs, face-to-face networks and the formation of deep local pools of skilled labour ('brain-hubs') are increasingly significant (Moretti, 2013; see also Agtmael and Bakker, 2016). Localised 'ecosystems' are argued to be important to such firms as they allow the sharing and mixing of collective capabilities. Thus, localised 'industrial commons' are seen as essential for advanced supply chains (Helper et al, 2012). In some cases, foreign direct investment is attracted by such agglomerations, usually to access reservoirs of skilled labour (Barrell and Pain, 1999; Jones, 2017).

Table 2: Some Alternative Theoretical Perspectives on the Locational Dynamics of Advanced Manufacturing

Theoretical Perspective	Main Arguments
'First Generation' New Economic Geography Models	Increasing geographical concentration of manufacturing industry driven by exploitation of increasing returns effects of spatial agglomeration that confer competitive advantage in trade
'Second Generation' New Economic Geography Models	Technological and organisational advances are weakening the increasing returns effects of spatial agglomeration and allowing manufacturing to delocalise geographically
'Brain Hub' Theory	Knowledge-intensive industries increasing attracted to places that contain deep pools of highly skilled and technical labour that are key to innovation – so-called 'brain hubs'
Localised Industrial Ecosystems Theory	Advanced and knowledge-based manufacturing attracted to local ecosystems which enjoy well developed 'industrial commons' of shared knowledges, capabilities and assets
Regional Product Cycle Theory	As industries move through their product cycle they deconcentrate geographically and relocate to cheaper cost locations

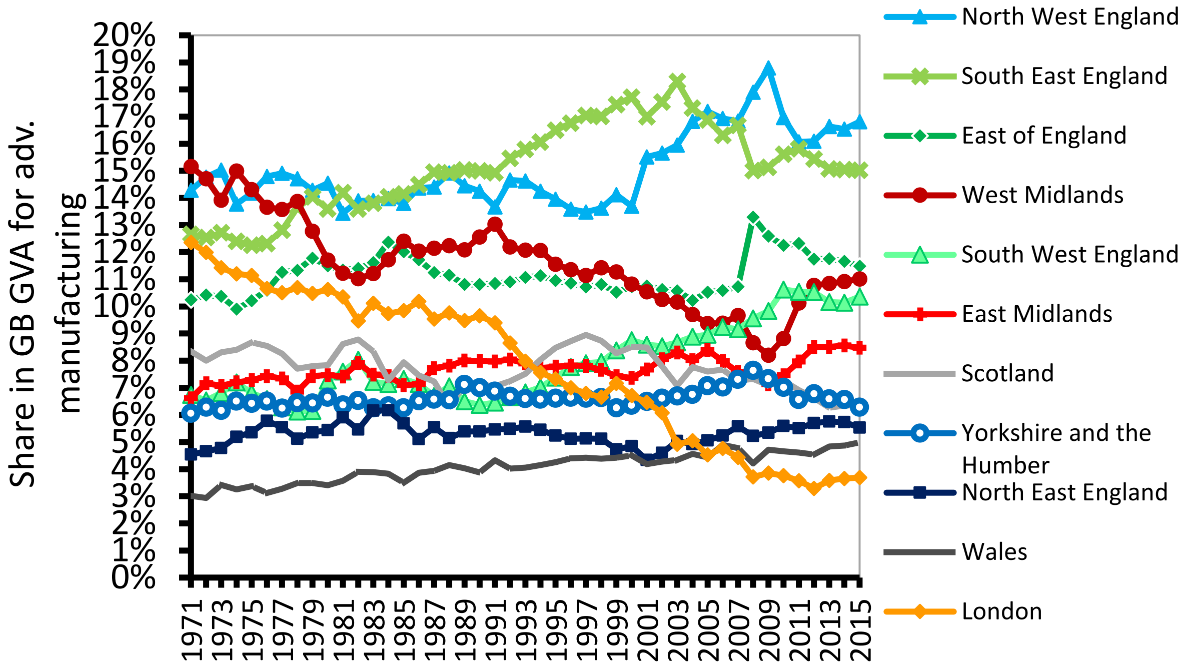
Spatial Production Network Theory	Advances in technology and production methods allow a spatially dispersed network structure to production, with different locations specialised in different function or stages of production and component supplies
'Phoenix Industry' Theory	Revival of old manufacturing locations around new often related sectors and types of activity, using upgraded, adapted, and transferred skill, technological and other inherited assets

Source: Collated by authors

AM is, of course, also being restructured by radical changes such as the so-called '4th Industrial Revolution' or 'Industry 4.0', AI, digitisation and the growth of cyber-physical systems. There is much uncertainty about the ways in which these changes will reshape its geography, possibly leading to a more decentralised and networked form of production requiring close proximity to markets (Bailey and De Propris, 2018). These new types of specialisation could feasibly produce both greater concentration *and* dispersal, and these two may be complementary rather than alternatives. It plausible then, that AM in Britain is undergoing both regional dispersal *and* localised clustering at the same.

There have been important shifts in the geography of these industries across the country. **Figure 2** shows the shares of output in AM by region. It indicates that there has been something of a drift to the South outside London, as regions such as the South East and South West (and East and East Midlands to a lesser extent) have seen their shares of output increase. The outcomes for Northern regions appear strongly divergent. The North West has increased its share strongly since the end of the 1990s, while Wales, the East Midlands, Yorkshire-Humberside and the North East have experienced only slight increases in their shares. In Scotland and the West Midlands, shares of output have fallen. The fall in the West Midlands, of course, reflects the severe decline of its automotive sector from the 1970s up until 2009 (see Donnelly et al, 2017). The most dramatic decline has been in London.

Figure 2: Regional Shares of Advanced Manufacturing GVA



Source: Cambridge Econometrics Data

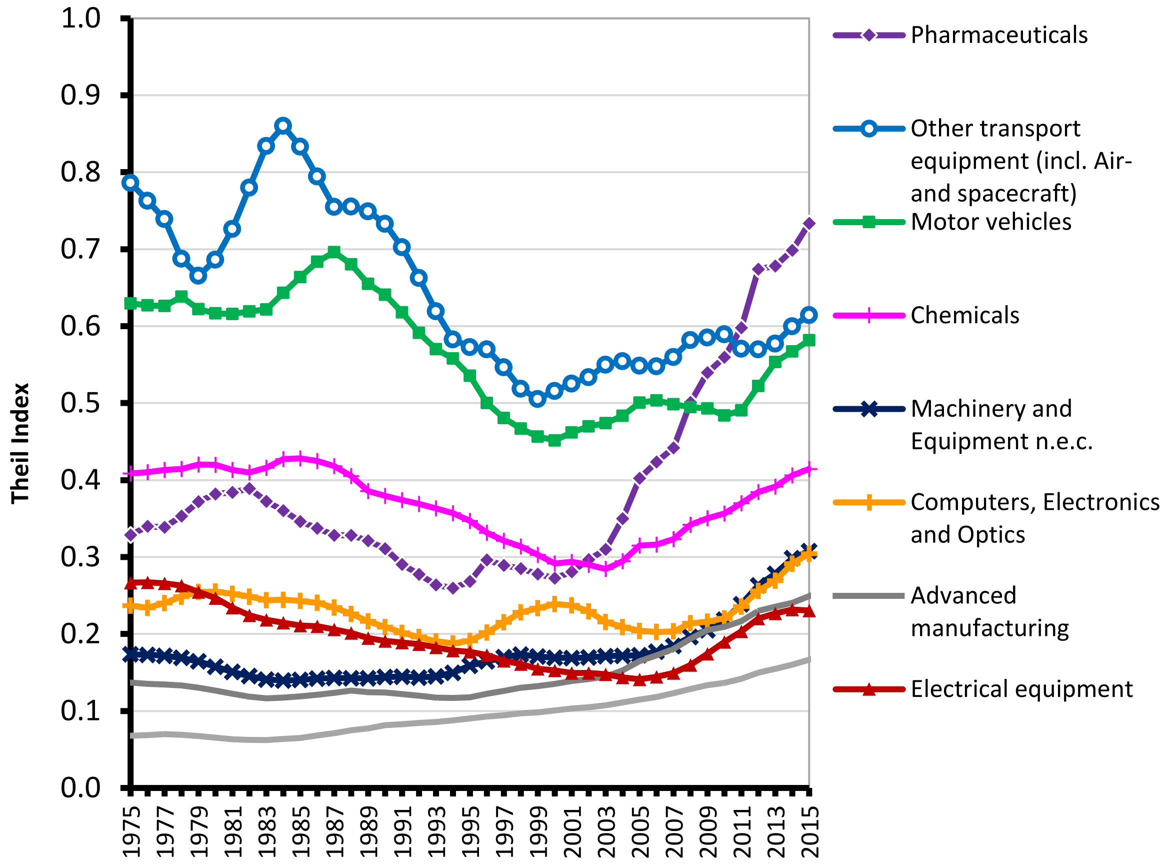
In order to examine whether the spatial distribution of AM industries -is becoming more concentrated or more dispersed, indices of relative concentration have been calculated using the Theil index (see Cutrini, 2010; Gardiner and Martin, 2019), given for industry *i* as

$$\sum_{r=1}^{R} \frac{GVA_{ri}}{GVA_i} \ln\left(\frac{GVA_{ri}/GVA_i}{GVA_r/GVA}\right)$$

and the summation is across all regions, r.

A higher Theil index *i* indicates greater relative regional concentration. **Figure 3** shows that at a NUTS2 regional scale, and using five-year means, geographical concentration fell in the majority of industries up until around 2000 but has risen since. The degree of regional concentration has increased particularly strongly in pharmaceuticals. Figure 3 also reveals that there are substantial and persistent differences in concentration across industries, with pharmaceuticals, motor vehicles and other transport equipment being much more strongly concentrated. Chemicals occupies an intermediate position, while computing, electronics and machinery are much more dispersed.

Figure 3: Theil Indices for AM industries based on Shares of GVA in NUTS2 regions



Source: Authors' Analysis, Cambridge Econometrics Data

that after the turn of the century relative concentration in most industries increased and, again, there was a weak positive relationship with the growth of output. Overall, both growing and stalling AM industries were tending to become more regionally concentrated during this period.

In summary, there has been a slight tendency towards geographical concentration in most AM industries since around 2000, but there is no strong relationship with the rate of output growth. Regional concentration is most likely due to a mixture of forces and processes. In some cases, it reflects the strengthening of regional clusters and 'ecosystems', especially around some significant foreign direct investors (Beverland et al., 2015). More generally however, we have seen that AM industries in Britain have struggled in a highly competitive global environment in this period, and, have shown different types of temporal trend. In general, concentration appears more likely to be the result of selective consolidation, firm rationalisation and disappearance of some sites (see Hannon 2016, on pharmaceuticals, for example).

AM industries show very different and consistent patterns of distribution across Britain. Some industries (specifically aerospace, motor vehicles, pharmaceuticals, and other transport equipment) show a high level of concentration at a local authority district scale, whereas others are much more dispersed, particularly computers, electronics and optics. Employment has consolidated in some established centres of production which have seen their output grow. The appearance of new concentrations has been important in some industries but, in general, it has been a more unusual process. The geography of computers, optics and electronics is distinctive and much more dispersed. The following section focuses more closely on the consequences of these processes for traditional industrial regions.

4. Advanced Manufacturing in Traditional Industrial Regions

The second assumption under debate is that traditional manufacturing regions provide a conducive context for advanced and high-technology manufacturing. Once again there are conflicting views. Peter Hall's (1985) view that "tomorrow's industries will not be born in yesterday's regions" was advanced on the assumption that the strong legacies of old industries in an area can inhibit the transition to or emergence of new, more advanced industries. Early accounts of de-industrialisation tended to be pessimistic about the future of traditional industrial cities and regions. It was argued that such places suffer from constraining forms of 'canonical' path dependence in which they are locked into outmoded activities, technologies, and infrastructures, and burdened by ageing workforces, dated (even obsolete) skills, and unable to develop new industrial growth paths (Hall, 1988; Martin and Sunley, 2006; Glaeser, 2011).

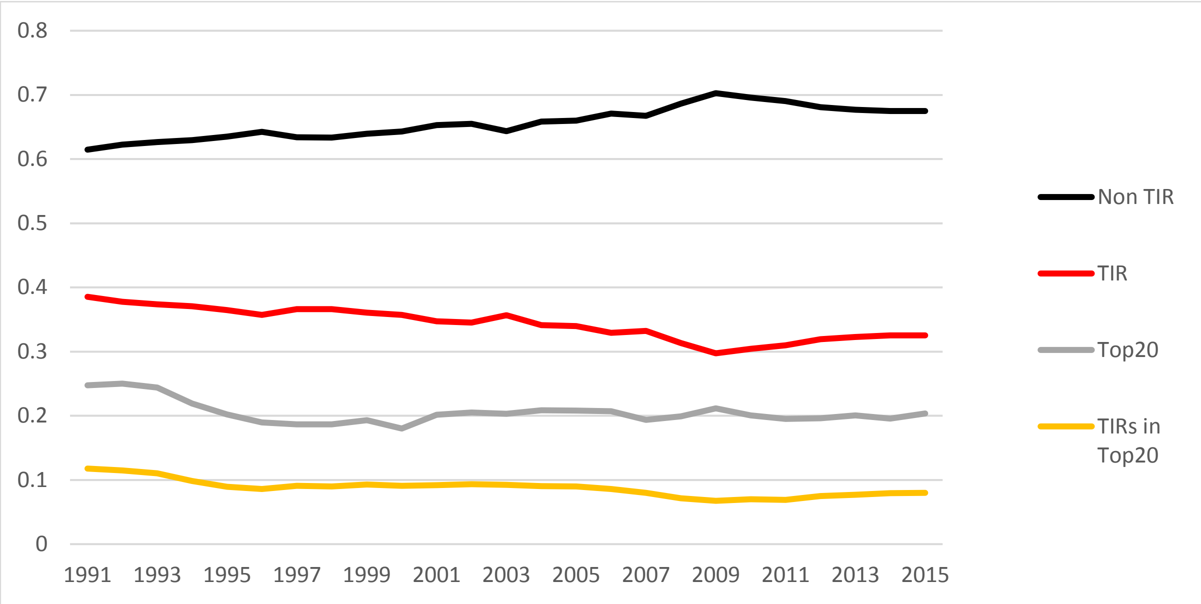
However, empirical research has found a more complex and mixed picture in traditional industrial cities and regions. Some, such as America's Midwest, have recovered as firms have adopted new production organization methods and showed more evolutionary and adaptive types of path dependence (Florida, 1996; Cowell, 2015; Moretti, 2013; Hobor, 2012; Christopherson, 2009). According to Christopherson's (2009) 'phoenix industry' view, manufacturing has been revived in TIRs by networks of small firms. Industrial legacies and skilled labour have been re-used, recombined and re-worked in networks of small firms that have often found more design-intensive roles (Bryson *et al.*, 2013; Doussard and Shrock, 2015). Often these have been facilitated by collective intermediary institutions rather than by investments in high-technology centres (Clark, 2014). Industrial regions can be reinvigorated by diversification and branching as new sectors appear at the interfaces between existing sectors (Boschma and Iammarino, 2009).

So how do these contrasting views relate to the geographies of advanced manufacturing across Britain? TIRs are defined as those where in 1971 manufacturing and mining employment was more than one standard deviation above the national mean (ie above 33.8 percent of total employment) This definition identifies a total of 12 NUTS 2 regions[1]. In the analysis that follows, those Local Authority Districts (LADs) within these 12 regions are defined as traditionally industrial.[2] The study concentrates on the period since 1991 because the LAD data by three digit SIC class are only available from that date. Figure 4 shows the shares of GVA in the traditionally industrial LADs and the twenty LADs with the largest shares of GVA in 1971. It shows that LADS in TIRs have lost ground relative to other LADs in terms of their share of output. LADS in TIRs do not appear to have benefited from a strong phoenix effects, and output has shifted away from them. However, these aggregate findings obviously mask important variations both between regions and industries.

[1] These comprise: Tees Valley and Durham; Greater Manchester; Lancashire; South Yorkshire; West Yorkshire; Derbyshire and Nottinghamshire; Leicestershire, Rutland and Northamptonshire; Shropshire and Staffordshire; West Midlands; West Wales and the Valleys; and, South Western Scotland.

[2] We are not using this administrative unit term in the way it is usually employed in the neo-Marshallian literature on (typically) Italian industrial districts.

Figure 4: Shares of AM GVA by Type of Local Authority District

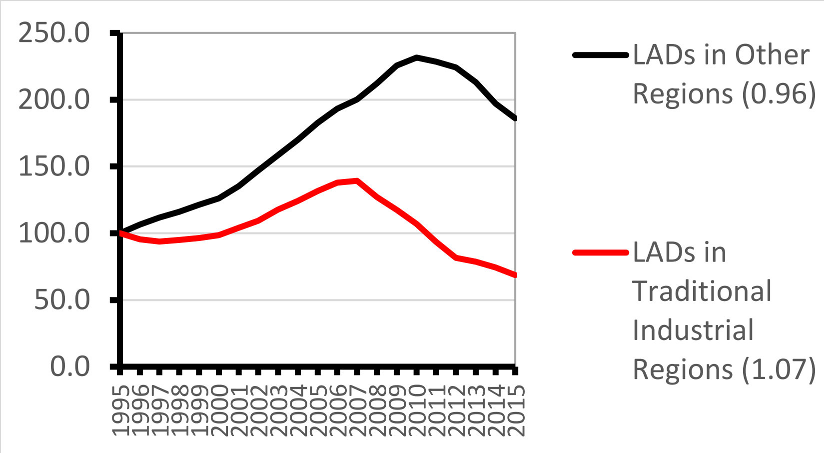


Source: Cambridge Economics Data, Authors' Analysis

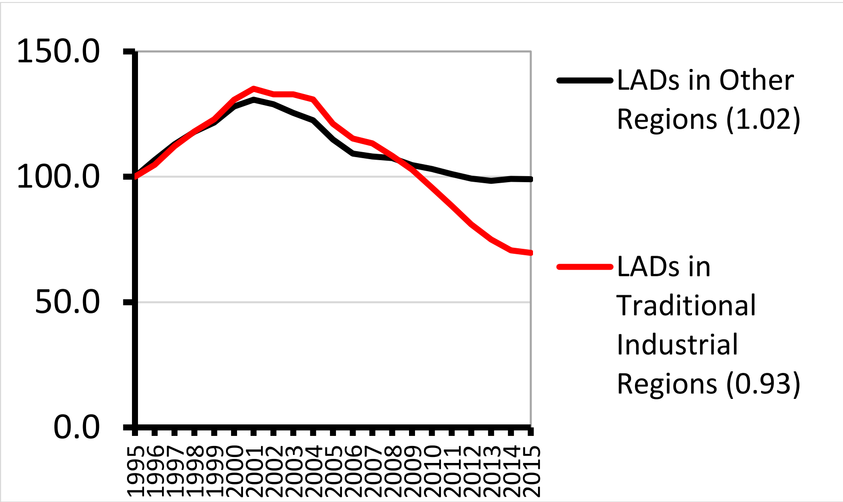
Figure 5 summarises the trends in output in different industries, comparing output in LADs in TIRs with those in other regions in each industry. There are evident differences between patterns seen in different industries. In pharmaceuticals, computers, optics and photo, and electrical equipment, output growth has shown a strong and widening divergence between industrial LADs and other centres. Motor vehicles also shows a switch of output growth away from traditionally industrial LADs in recent years. In contrast, in aerospace and in machinery and equipment output growth in these LADs has been slightly stronger than in other LADs, and in chemicals the output performance in industrial LADs has been significantly stronger.

Figure 5: Change in GVA (relative to 1995 level) in LADS in TIRs, and in non TIRs across Sectors

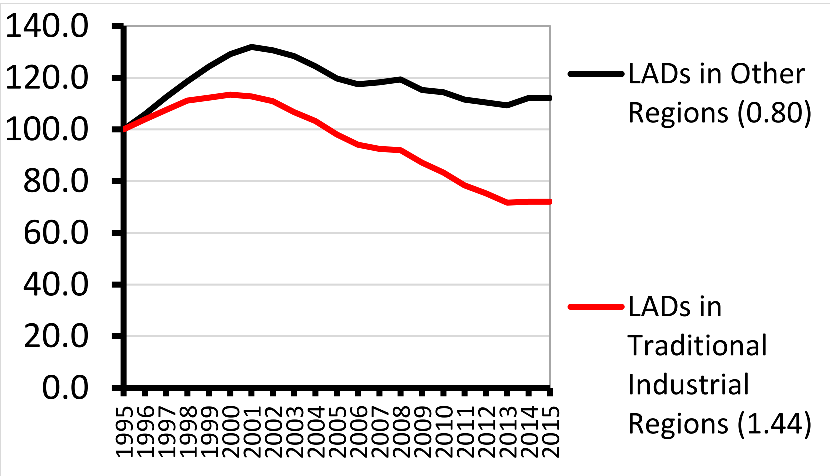
A. Change in GVA 1995-2015 in Pharmaceuticals



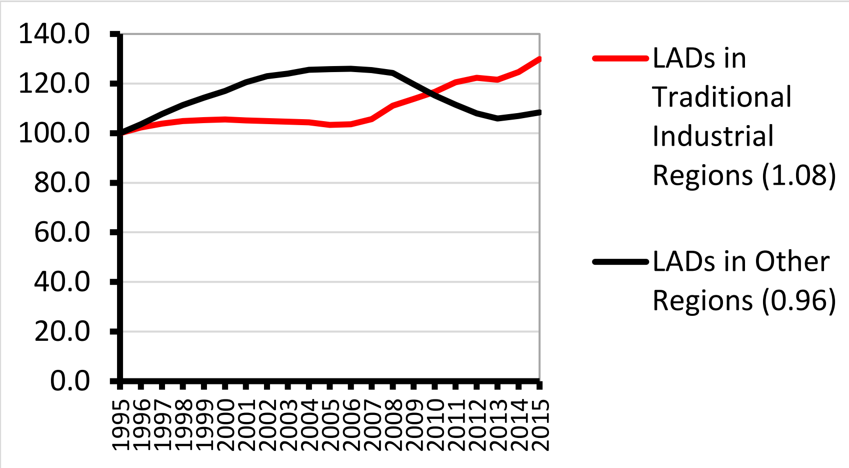
B. GVA in Computers, Electronics and Optics



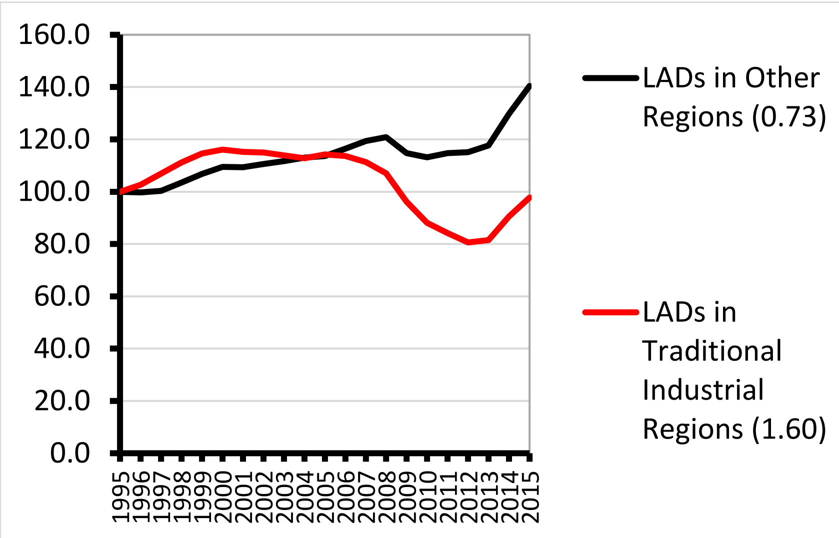
C. GVA in Electrical Equipment



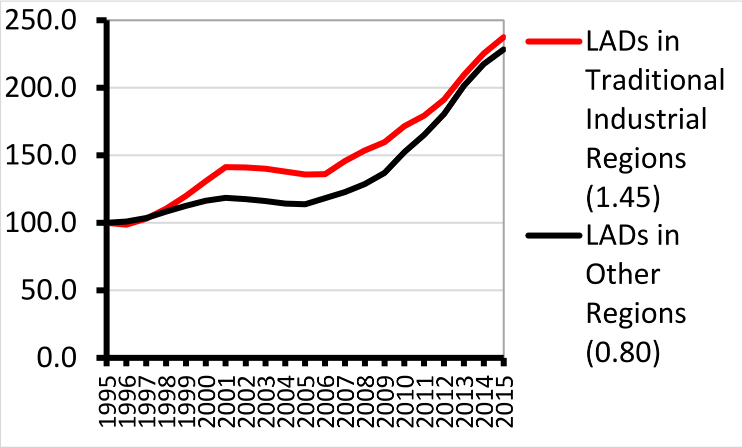
D. GVA in Chemicals



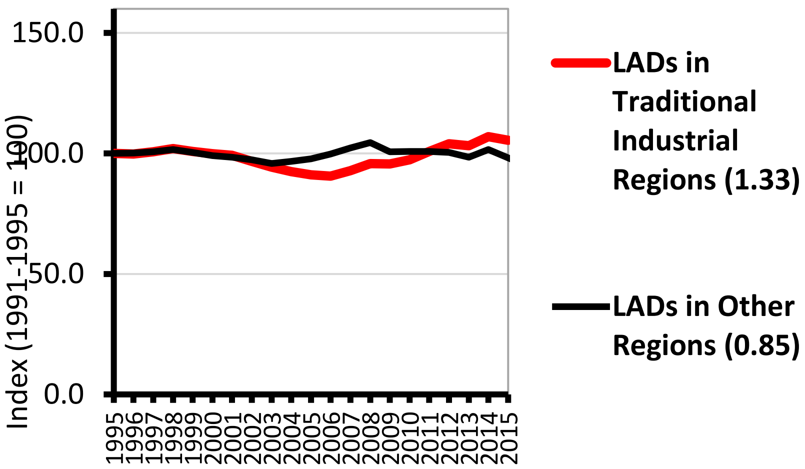
E. GVA in Motor Vehicles and Trailers



F. GVA in Air and Spacecraft



G. GVA in Machinery and Equipment (NEC)



Source: Cambridge Econometrics GVA data

In summary, Table 3 compares AM industries on two key dimensions. While some relatively concentrated sectors appear to perform relatively well in TIRs, others appear to have struggled in these kinds of regions. Similarly, among more geographically dispersed industries there also appears to have been a difference between industries that typically perform better in TIRs and those that have performed relatively less well in these regions. In general, those that do relatively well appear to have stronger connections with predecessor and related industries, while those that do less well appear to be based on newer and science-based capabilities. This key point is explored further in the next section.

Table 3: Regional Concentration and Relative Performance in TIRS

	Concentrated sector	**Dispersed sector**
Relatively stronger performance in (some) TIRs	• Aerospace • Motor vehicles • Other transport equipment (excl. aerospace • Chemicals	• Machinery and equipment
Relatively weaker performance in TIRs	• Pharmaceuticals	• Computers, Electronics and Optics • Electrical equipment

The shift in AM away from TIRs reflects trends in Foreign Direct Investment. It is well known that FDI in manufacturing has been strong in Britain (until recently) since the late 1980s (Driffield and Munday, 2000). However, manufacturing FDI has tended to shift its location away from peripheral regions towards the South and East (Wren and Jones, 2012). Table 4 is based on a micro-analysis of firms in seven AM sectors to examine the contributions of firm openings and closures. This exercise subdivides manufacturing plants into those that were open both in 1973 and 2016, those that were open in 1973 but not in 2016 (labelled closed before 2016) and those that were open in 2016 but not in 1973 (labelled opened after 1973). Each of these subgroups is then divided into GB-owned and foreign-owned (note many plants that were GB owned in 1973 were foreign owned in 2016). Columns (1) and (2) divide total 1973/2016 real gross output into the 8 subgroups and column (3) is the change that occurred across the subgroups. The final column gives the percentage of the total change attributed to each group. For AM between 1973-2016, real gross output increased by £81.2 billion. This increase was mostly (44.1%) due to foreign-owned plants that were opened post-1973 in areas outside of TIRs (some of these would have been brownfield plants that were acquired by inward FDI). Of next importance (26.6%) is foreign plants that were opened after 1973 within TIRs. The loss of capacity in AM sectors primarily due to GB-owned plants opened after 1973 (-8.2%) and those that operated throughout (-4.9%).

Table 4: (Weighted) Real Gross output (£m 2000 prices) in GB Manufacturing, 1973 and 2016*

			(1) 1973				(2) 2016	(3) Change	% change
Advanced manufacturing									
Not in TIR	open throughout	(i) GB-owned	5310.8	not in TIR	open throughout	(i) GB-owned	3870.7	-1440.1	-1.8
		(ii) foreign-owned	1100.6			(ii) foreign-owned	14871.8	13771.2	17.0
	closed before 2016	(i) GB-owned	27742.5		opened after 1973	(i) GB-owned	40808.3	13065.8	16.1
		(ii) foreign-owned	16546.8			(ii) foreign-owned	52384.7	35837.9	44.1
In TIR	open throughout	(i) GB-owned	7562.3	TIR	open throughout	(i) GB-owned	3598.2	-3964.1	-4.9
		(ii) foreign-owned	665.7			(ii) foreign-owned	9640.9	8975.2	11.1
	closed before 2016	(i) GB-owned	25992.1		opened after 1973	(i) GB-owned	19358.3	-6633.8	-8.2
		(ii) foreign-owned	4974.5			(ii) foreign-owned	26573.5	21599.0	26.6
Totals			89895.2				171106.3	81211.1	100.0

***Column (3) is difference between columns (1) and (2). TIR defined in Table 9**

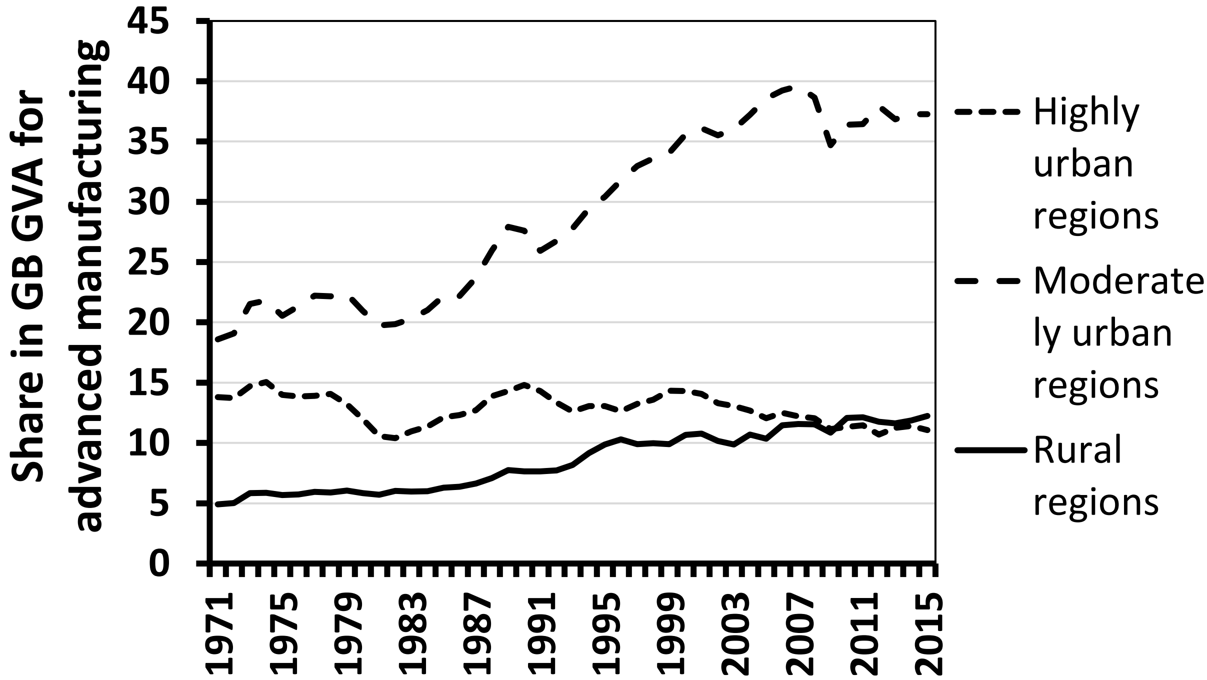
Source: Office for National Statistics (2018) Annual Business Survey, 2008-16: Secure Access. [data collection]. 9th Edition. UK Data Service. SN: 7451 http://doi.org/10.5255/UKDA-SN-7451-9 Office for National Statistics (2012) Annual Respondents Database, 1973-2008: Secure Access. [data collection]. 3rd Edition. UK Data Service. SN: 6644 http://doi.org/10.5255/UKDA-SN-6644-5

Table 4 reveals just how dependent the growth of AM has been on inward FDI, but also underlines that in these industries it has produced greater output growth outside of TIRs. This suggests that foreign investors have preferred non-TIR and less-industrialised locations. Nevertheless, the analysis confirms the centrality of foreign-owned firms to the presence of AM in TIRs. AM in TIRs is highly dependent on strategic decisions by anchor firms and foreign investors, echoing longstanding concerns with external control and branch plant economies (Firn 1975). Moreover, in the context of Brexit, the strength of couplings with foreign investors will prove critical to the prospects and survival of AM in such TIRs.

5. Urban Innovation Districts and Clusters?

The third question we intend to discuss in the light of historical evidence is whether research spending in innovation centres is likely to attract AM industries and generate growth in AM in proximity to these centres. There are several anecdotal stories about the success of particular urban innovation districts (especially the AMRC in Sheffield, see Breach, 2019), however wider reviews of the relationships between innovation spending in Britain and AM production systems have suggested a lack of connection and co-ordination. Our evidence does not show a return of AM to large urban conurbations or a concentration of AM in innovative districts in large cities. AM remains located primarily outside dense centres of large cities in semi-urban and smaller cities and the shift of these industries away from the densest conurbations and large cities (as measured by population density) has continued (Figure 6). The areas gaining AM have tended to be smaller cities and moderately urban areas rather than rural locations. This is not so much of an 'urban-rural shift' as a 'conurbation core-moderate urban' shift.

Figure 6: Shares of Advanced Manufacturing Output (GVA) by Type of Region (NUTS2)

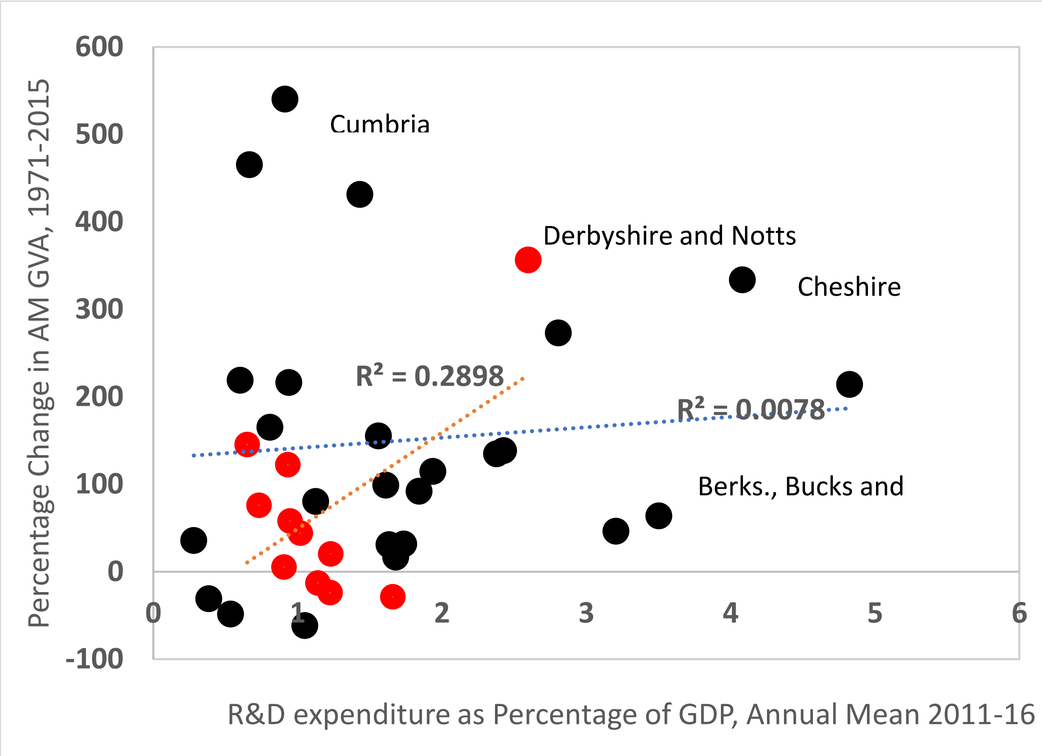


Source: Cambridge Econometrics data, Authors' Analysis

A further point is that the complex outcomes seen across TIRs also appear to arise, in part, from differences between the high and medium-technology parts of AM. As evident in computing, optics and electronics, and pharmaceuticals, the performance of TIRs in these high-technology sectors has been worse than in other types of areas. Of the three high-technology sectors, only aerospace has effectively offered some potential for growth in industrial regions. The relatively poorer performance of these high-technology sectors in TIRs appears to be partly due to the longer-term loss of competitiveness in these sectors and its exposure by economic crises and recessions. There is, then, apparent differences between industries with synthetic and analytical knowledge bases (Asheim et al., 2011). In AM industries with a more 'synthetic' knowledge base, there is some evidence of adaptive path dependence and 'phoenix industry' effects. In industries such as aerospace, motor vehicles, and other transport equipment, concentrations in TIRs continue to do well; and there has been some new expansion into other TIRs, especially in the Midlands and North West. Many of these sectors are to a greater degree based an engineering and synthetic, metals-related knowledge base and pools of skilled labour where TIRs typically have more advantages. However, it is likely that research-driven innovation districts may find it harder to connect with these synthetic sectors, than with high-technology sectors based more on analytical and scientific knowledge.

In general the co-location between AM and R and D appears to have been fairly weak. Figure 7 shows the relationship between R&D intensity and the growth of AM value across NUTS2 regions over the period. In general, it reveals only a very weak positive relationship between research intensity and AM growth. The relationship is somewhat stronger in TIRs where AM has grown faster, but largely because of the performance of Derbyshire and Nottinghamshire. The concentration of pharmaceuticals in Cheshire underlies the growth of AM in this research-intensive region. Many parts of AM have not been located in high R&D expenditure regions which suggests that production location decisions by AM firms, and especially foreign investors, have been influenced by other factors apart from close proximity to other high research-intensive firms and institutions. Foreign direct investments in production sites often do not require geographical proximity to regional innovation systems but are based on other factors such as distance and access to markets and labour (Wren and Jones, 2012). Furthermore, the presence of a strong regional research system does not by itself deliver strong AM growth as many SMEs and suppliers struggle to absorb the innovations produced by such systems (Beverland et al., 2015; Harris et al, 2020).

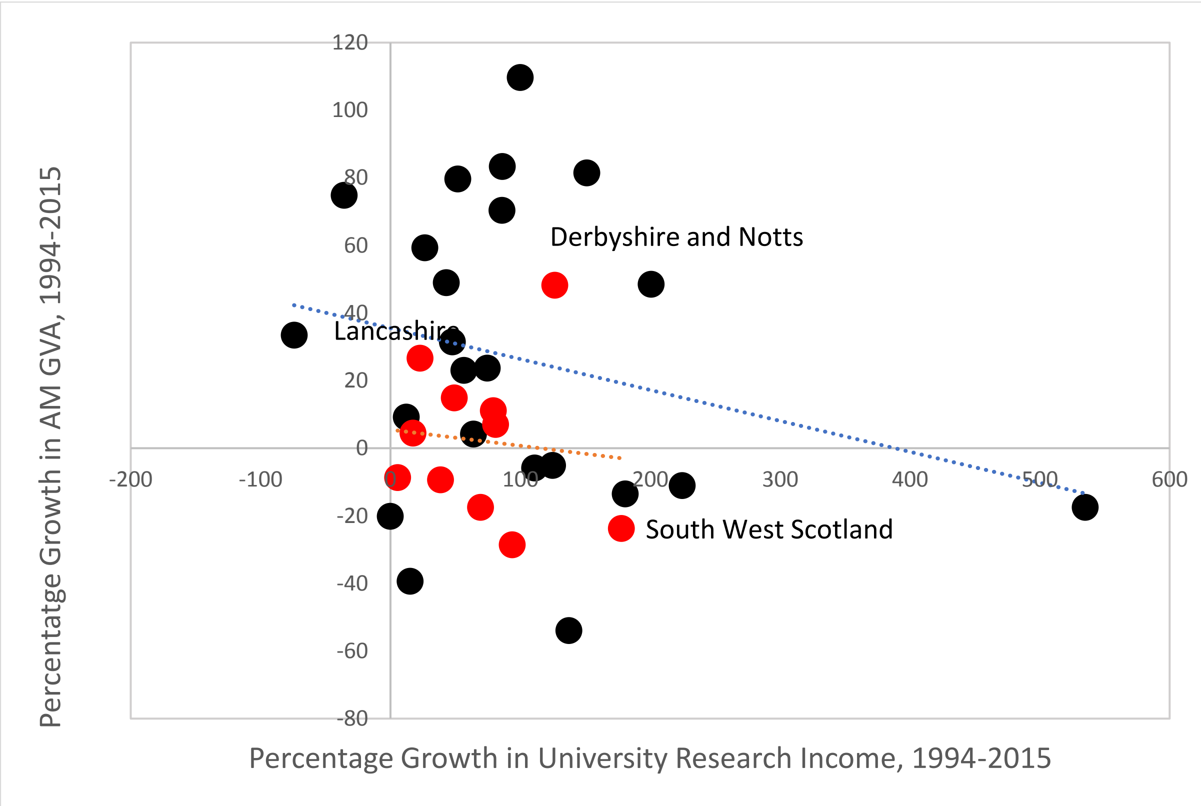
Figure 7: R&D intensity in Regional (NUTS2) GDP (2011-16) against Growth of AM GVA, 1971-2015



Source: Cambridge Econometics and ONS data on R&D

It is not surprising, then, that when the relationships between the growth in total university research expenditure is compared to the growth in AM output across NUTS2 regions there is no strong relationship (Figure 8). The analysis shows that despite that the fact that some parts of AM used analytical knowledge, its growth in general has not been closely co-located with the growth in university income and suggests that university research has not been a key driver of regional AM performance. Innovation research has in general taken a supply-side and place-blind approach that has not been key to procuring new technologies, nor in fostering regional innovation capacity (Jones, 2016). Public support for R&D spending in the UK has been heavily focused on bioscience and medical research (Jones and Wilsdon, 2018). This all suggests that, unless there is a radical departure from established trends, university research institutes and urban innovation districts are unlikely to provide a sufficient foundation for local industrial strategies capable of stimulating AM industries' growth, and the lack of connection between innovation and AM is a key problem. Mission-focused innovation centres aimed at meeting the 'grand challenges' risk neglecting the needs and priorities of the local economic context and diffusion processes (Brown, 2020), and thus may entrench this gap. Place-based local industrial strategies will require a more comprehensive attempt to build local innovation ecosystems that give more attention to commercialisation, skills development, firms' absorptive capacity and the translation of innovations into regional supply chains.

Figure 8: Change in University Research Income against Change in AM GVA, 1994-2015 by NUTS 2 Region



Source: Cambridge Econometrics and HESA data on University Research income

6. Conclusions

This paper has sought to investigate three assumptions underlying much of UK policy thinking on using AM-focused industrial strategies as a means of 'levelling up' and 'regional rebalancing'. Based on historical evidence, the analysis has revealed a complex picture of change with important variations across scales, between different TIRs and between different industries within AM. The results show continued dispersal of AM away from large and dense core cities but at a regional scale there has been some towards concentration since the turn of the century. However, it is likely that this is as much due to the consolidation and decline of some industries, as it is to the formation of stronger regional ecosystems and clusters in others. In sum, then, the overall association between AM industries' growth and regional concentration is relatively weak. In aerospace, other transport equipment, motor vehicles, and chemicals, concentrations in TIRs, especially in the East Midlands, North West and West Midlands, have continued to do well until recently, and there has been some new expansion into other TIRs (and also into non-TIRs). As Section 4 noted, while there has been scope for sectoral rebalancing in some of these medium and high technology, engineering-related sectors, their concentration at regional scales is relatively high and stable since the early 1990s. But the stronger performance of some TIRs in these sectors suggests that to some degree they may have benefited from types of adaptive path dependence in which older engineering legacies and skills have been beneficial to their evolution. In contrast, in other AM industries with more science-based 'analytical' knowledge, TIRs have provided a less conducive context and may well have suffered from constraining forms of path dependence and lock-in.

However, these relationships are by no means deterministic. One of the key complicating and driving forces has been the importance of FDI to AM in Britain. The majority of output growth in AM has been driven by foreign direct investors which have tended to prefer non-TIRs. Despite this preference, foreign investors have also invested significantly in TIRs and these plants have performed much better in output terms than domestically owned plants. Foreign investors appear to have been better at either breaking paths and diversifying TIR economies through transplants of knowledge and practice, or more adept at re-using old capabilities and assets by combining and fusing them with new ideas and managing these transfers of knowledge and ideas. Certainly the analysis confirms that the fortunes of TIRs have been radically different, depending on whether they can attract and sustain significant FDI. The clear policy implication here is that the more Brexit uncertainty and its eventual arrangements alienates, limits and/or deters foreign-owned manufacturing investors, then the harder it will be to support regional rebalancing through manufacturing. A key policy imperative should be to try to ensure that Brexit does not produce significant decoupling from foreign-owned AM firms.

This analysis and the picture of uneven regional growth and decline in AM underlines both the need for more place-specific, regional support for AM industries and the significant challenges facing any attempt to implement this support. Place-specific support will need to be carefully targeted on locations and industries with continuing growth potential. It appears that it will be especially difficult to build more concentrated scientific-analytical AM industries in TIRs. As a result, many of these regions would better advised to focus on those industries with more engineering and synthetic knowledge bases. This recommendation aligns with a related diversification or smart-specialisation policy approach (Ref?). In order to strengthen AM ecosystems and localised supply-chains then a place-specific strategy will need to be multidimensional and include services to firms, infrastructural investment, skills and education, and not simply rely on innovation and high-technology push. As the analysis demonstrated, while R&D spending has been associated in some places with AM growth, in others this growth has been driven by other factors. Given the highly varied nature of University research, it is not surprising that there appears to be been little correlation between regional university research spending and AM performance. This finding implies that knowledge spillovers are either occurring at wider geographical scales, or that the spillovers are not being generated by this research, or that those that are cannot be absorbed by much of AM. Based on experience to date which may well, of course, reflect a past disconnection between much university research and AM, a policy model of urban innovation districts based on University research will no doubt be highly valuable for some frontier AM firms, but is unlikely to be a major force for geographical rebalancing. Some of the hopes for urban innovation districts need to be tempered, and place-specific support for AM will need to integrate innovation and research efforts within broader programmes of support and firm services that aid knowledge transfer and skills development for AM SMEs, in order to reinforce and strengthen the resilience of manufacturing supply chains.

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