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Mapping the ‘Space of Flows’: The Geography of Global Business Telecommunications and Employment Specialization in the London Mega-City-Region

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READES J. and SMITH D. A. Mapping the ‘space of flows’: the geography of global business telecommunications and employment specialization in the London mega-city-region, *Regional Studies*. Telecommunications has radically reshaped the way that firms organize industrial activity. And yet, because much of this technology – and the interactions that it enables – is invisible, the corporate ‘space of flows’ remains poorly mapped. This article combines detailed employment and telecoms usage data for the South-east of England to build a sector-by-sector profile of globalization at the mega-city-region scale. The intersection of these two datasets allows a new empirical perspective on industrial geography and regional structure to be developed.

Globalization telecommunications Firm location Land use patterns Distribution of economic activity England

READES J. and SMITH D. A. “流动空间” 制图：伦敦巨型城市区域中的全球商业电信地理与雇用专门化，*区域研究*。电信通讯已剧烈地重塑了企业组织产业活动的方式。但此般技术及其所促成的互动多半是不可见的，因此整体的“流动空间” 制图仍相当贫乏。本文结合英格兰东南部详细的雇用与电信使用数据，用以在巨型城市区域尺度上建构一个按各类别的全球化图谱。上述两类数据集的交汇，使得产业地理与区域结构的崭新经验视角得以被建构。

全球化电信 厂商区位 土地使用模式 经济活动的分布 英格兰

READES J. et SMITH D. A. Tracer ‘l’espace des flux’: la géographie des télécommunications d’affaires mondiales et de la spécialisation de l’emploi dans la mégapole de Londres, *Regional Studies*. Les télécommunications ont radicalement transformé la manière dont les entreprises organisent l’activité industrielle. Toujours est-il que ‘l’espace des flux’ des entreprises s’avère mal tracé parce que la technologie – ainsi que les interactions qui en résultent – est en grande partie invisible. Ce présent article combine des données détaillées sur l’emploi et sur l’utilisation des télécommunications pour le sud-est de l’Angleterre afin de créer, secteur par secteur, un profil de la mondialisation à l’échelle de la mégapole. L’intersection de ces deux ensembles de données permet le développement d’une nouvelle perspective empirique de la géographie industrielle et de la structure régionale.

Mondialisation des télécommunications Localisation des entreprises Plans d’occupation des sols Distribution de l’activité économique Angleterre

READES J. und SMITH D. A. Kartierung des ‘Raums von Strömen’: Geografie der weltweiten geschäftlichen Telekommunikation und Spezialisierung des Arbeitsmarkts in der Megastadtregion von London, *Regional Studies*. Die Methoden von Firmen zur Organisation industrieller Aktivitäten hat sich durch die Telekommunikation radikal verändert. Doch weil ein Großteil dieser Technik – und der durch sie ermöglichten Wechselwirkungen – unsichtbar ist, wurde der ‘Raum von Strömen’ in Unternehmen bisher nur wenig kartiert. In diesem Beitrag erarbeiten wir anhand von detaillierten Daten über das Beschäftigungsniveau und die Nutzung von Telekommunikationsdiensten im Südosten Englands ein nach Sektoren gegliedertes Profil der Globalisierung auf der Ebene der Megastadtregion. Die Schnittflächen dieser beiden Datensätze ermöglichen die Entwicklung einer neuen empirischen Perspektive der industriellen Geografie und regionalen Struktur.

Telekommunikation der Globalisierung Firmenstandort Muster der Landnutzung Verteilung der Wirtschaftstätigkeit England

READES J. y SMITH D. A. Cartografía del ‘espacio de flujos’: geografía de las telecomunicaciones comerciales globales y la especialización del empleo en la región mega-ciudad de Londres, *Regional Studies*. Las telecomunicaciones han cambiado radicalmente los métodos de las empresas para organizar la actividad industrial. Y sin embargo, debido a que gran parte de esta tecnología —y las interacciones que permite— es invisible, el ‘espacio de flujos’ corporativo sigue sin estar bien localizado. En este artículo combinamos los datos detallados del empleo y el uso de las telecomunicaciones en el sureste de Inglaterra para construir un perfil en función de los sectores de la globalización a escala de la región mega-ciudad. La intersección de estos dos grupos de datos permite desarrollar una nueva perspectiva empírica de la geografía industrial y la estructura regional.

Telecomunicaciones de globalización Ubicación de empresas Patrones del uso del suelo Distribución de la actividad económica Inglaterra

JEL classifications: C89, L29, L96, R14

INTRODUCTION

Over the past 20 years, the study of globalization processes has shifted outwards: from SASSEN’s (1991) ‘global city’ to SCOTT’s (2001) ‘global city region’ and, ultimately, HALL’s (2001) ‘polycentric Mega-City-Region’, which has been defined as ‘a cluster of towns and cities that is increasingly functionally interconnected across geographical space through virtual communications and travel’ (HALBERT *et al.*, 2006, p. 206). Yet in spite of this increasing geographical breadth, the ability to validate empirically key hypotheses relating to these globally oriented regions has remained limited because the underlying interactions across digital networks are largely invisible (BATTY, 1990), and because so many of the basic indicators can only be coarsely or indirectly measured.

In this study, the availability of large calling and employment datasets allows a spatially and sectorally disaggregate analysis of international telecommunications usage to be performed across the entire London Mega-City-Region (MCR). With these two datasets it becomes possible to address the analytical challenges of piecemeal email or telephone usage data noted by PAIN and HALL (2008), as well as the resolution constraints of previous work on both network infrastructure deployment (RUTHERFORD, 2004) and aggregate call flows (HALBERT, 2004, 2008).

Similarly, because the interactions are being directly captured from the network itself, we can also address the limitations of inferred informational flows from either citation and patent networks (e.g., SONN and STORPER, 2007) or director- and senior-level staffing within multinational enterprises (MNEs). The latter is assumed to reflect a kind of ‘communicative potential’ that allows the importance of individual offices in a global hierarchy to be deduced (e.g., TAYLOR and WALKER, 2001). And although the work of the Globalisation and World Cities (GaWC) group has extended this approach to encompass the entire United Kingdom (TAYLOR *et al.*, 2009), the nature of the process is necessarily limited in its ability to capture both fine-grained and comprehensive data.

Do the constraints on the ability to measure global flows to and from MCRs matter? The treatment of these complex, polycentric regions in the literature

suggests that they do: ‘Given the current concern about the competitiveness of areas, more attention should be paid to the interregional and international links of the [polycentric urban region] and the firms within it [...]’ (PARR, 2004, p. 238). Where administrative boundaries align with functional self-containment, superior economic growth is the result (CHESHIRE and MAGRINI, 2009), and so the dearth of data on international flows may significantly affect an understanding of the extent of this process and its relevance to urban and regional governance.

Defining the mega-city-region

The results of the POLYNET study (HALL and PAIN, 2006), reported in a special issue of this journal (HOYLER *et al.*, 2008), represent one of the most comprehensive attempts to tackle this interrelated set of challenges. The research focused on the activities of advanced producer services (APS) firms, reasoning that a globalized, information-intensive economy would have ‘its most significant expression’ (HALL and PAIN, 2006, p. 4) in the services offered by these firms. Table 1 offers the full sectoral list devised by these authors, together with complementary specifications

Table 1. *Advanced producer services (APS) sectors associated with globalization*

Sector	TAYLOR and		
	PAIN and HALL (2008)	WALKER (2001)	DERUDDER <i>et al.</i> (2010)
Accountancy	Yes	Yes	Yes
Advertising	Yes	Yes	Yes
Finance	Yes	Yes	Yes
Design	Yes		
Information and communication technology (ICT)	Yes		
Insurance	Yes	Yes	(Yes) ^a
Law	Yes	Yes	Yes
Logistics	Yes		
Management consultancy	Yes	Yes	Yes
Real estate		Yes	

Note: ^aInsurance is included in Finance.

developed by other globalization researchers in previous work on this topic.

The results obtained by HALL and PAIN (2006) indicated the existence of a London-dominated MCR bounded by Peterborough to the north, Colchester and Margate in the east, Brighton in the south, and Bournemouth and Swindon the west. The importance of London to the MCR is reflected in the standardized 'Urban Audit' process (EUROSTAT/GISCO, 2012): Fig. 1a shows the full extent of urbanization in this part of Britain, but London remains by far the largest centre in terms of area, population and economy over the past ten years. Activity within the Greater London Authority (GLA) boundary alone has created more jobs than the next ten largest British cities combined (WEBBER and SWINNEY, 2010, pp. 6–7)!

However, alongside this, HALL and PAIN (2006, esp. ch. 3) also identified significant orbital flows connecting Cambridge, Oxford, Reading and Milton Keynes, and other cities of the Greater South East of England (GSE), suggesting a less hierarchical structure than a casual survey would suggest. In fact, these smaller cities *also* have very high levels of APS employment (CENTRE FOR CITIES, 2010, p. 53) and they have kept pace with, or even exceeded, London's growth over the past few decades (CENTRE FOR CITIES, 2010, p. 18). Collectively, the cities of this mega-region have accounted for over 70% of gross value added and 55.5% of private sector jobs created in Britain in the past decade (WEBBER and SWINNEY, 2010, pp. 6–7).

So whereas, historically, the pre-eminence of Central London as a commuting destination has led to a focus on districts such as the City of London and the West End, the true picture is more complex. Nonetheless, a crude regionalization with this area at its heart would allow the extent to which APS activity is centralized within, or dispersed across, the GSE to be quickly gauged. Helpfully, the GLA employs just such a geography and it contains: the 'Central Activity Zone' of the 2004 London Plan (which is, in essence, the City, West End and Canary Wharf); an Inner London containing those parts of the inner 12 boroughs not incorporated in the Central Activity Zone; an Outer London incorporating the remaining 12 boroughs of the GLA; and a less-used Outer Metropolitan Area that extends into the adjacent regions of the East of England and South-east England and contains areas understood to interact heavily with Greater London.

The addition of a 'rest of the GSE' zone – incorporating those parts of the adjoining regions not already assigned to one of the four existing zones – takes us nearly out to the boundary employed in POLYNET. Fig. 1b shows the superposition of the three regional boundaries on the five concentric sub-regions introduced above. These sub-regions will be used together with a fine-scale geography of telecommunications

and employment activity in the Results and Analysis section to highlight significant variations in the distribution of globalized APS employment at the sectoral level once the data and methodology have been discussed.

DATA

Some important constraints on the study of global information flows were noted in the Introduction; however, the mediation of everyday life by digital networks and the increasing willingness of network operators to make anonymised data available for academic research allows the internationalization of firm networks to be approached in a new way. With access to communications data it becomes possible to examine informational flows at multiple scales *simultaneously*. And in conjunction with small area employment data, it becomes possible to explore spatial and interaction preferences in a systematic fashion.

Telecommunications data

For present purposes, the value of communications data therefore lies in the extent to which they allow the internationalization of firms to be analysed through direct measurement instead of analytically sophisticated inference. The results reported here draw on one month's domestic and international calling from August of 2005: the dataset consists of more than 8 billion unique records and covers 95% of landlines in Britain.

For domestic calling, the parts of the call originating or terminating from a landline could be localized to an area containing, on average, some 3000 numbers, ensuring that no one caller could be inadvertently identified while preserving the capacity for fine-grained spatial analysis (for a fuller explanation, see RATTI *et al.*, 2010). International calls could only be localized on the UK side but, crucially, they were flagged by the operator to make it possible to narrow the analysis to only this type of behaviour.

Fig. 2a makes it clear that international telecommunications usage in Britain is utterly dominated by London, which accounts for nearly 50% of all time spent on the telephone to people abroad. For this reason, the simple 'percentage of all flows' approach employed by GRAHAM and MARVIN (1996, pp. 133–134) or by DE GOEI *et al.* (2009) is largely meaningless in this context, though it is clear that global cities do 'dominate phone, mobile phone, media communications, and Internet use outside the corporate and financial sectors' (GRAHAM, 2002, p. 77).

The distribution therefore establishes a requirement to normalize the raw data in some way to yield more nuanced insights into APS globalization. To address this, Fig. 2b divides international minutes by population

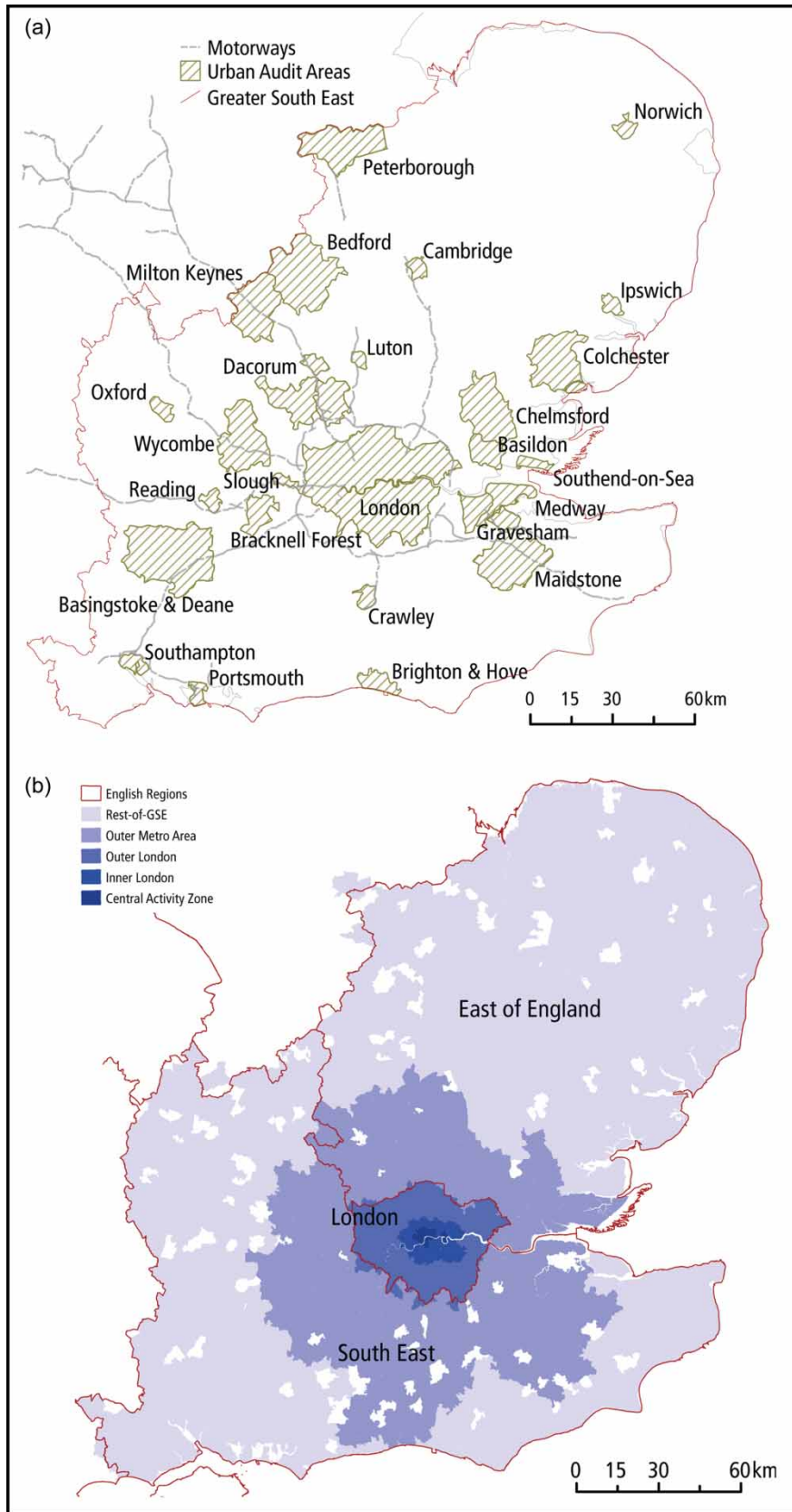


Fig. 1. Overview of the Greater South East of England (GSE) by region, sub-region and urban area: (a) urban audit areas; and (b) analytical regions within the GSE

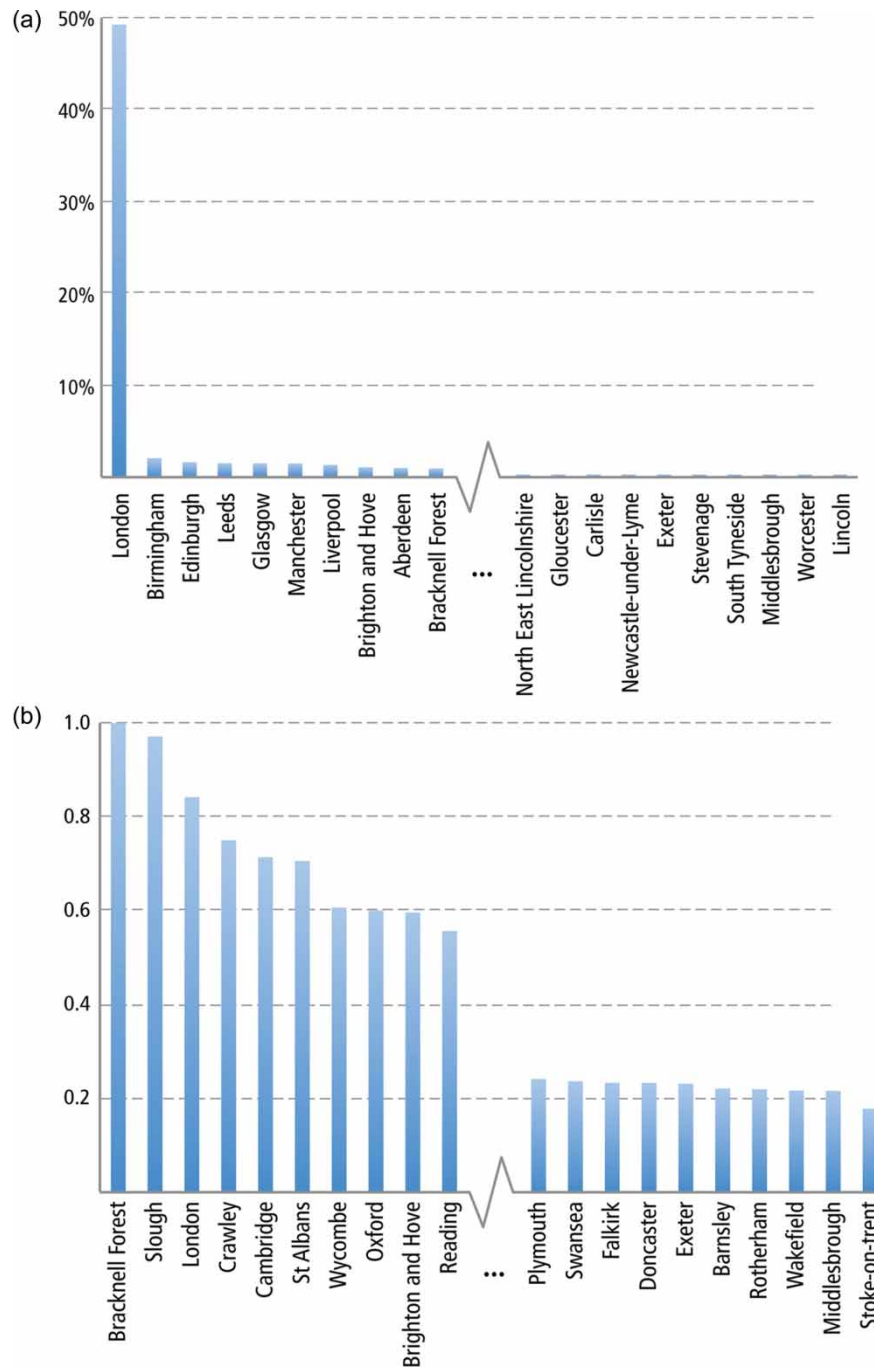


Fig. 2. Ten highest and lowest levels of international calling by British city: (a) percentage of all minutes; and (b) normalized minutes per telephone

(using the Urban Audit geography of Fig. 1a), substantially revising the picture presented in Fig. 2a in the process. Significantly, all of the ten most international cities are within the GSE; Liverpool, in 15th place, is the first city not found in the South of England. There is a very strong correspondence between the cities listed at the top-end of Fig. 2b and those obtained via qualitative investigation of MCR networks by PAIN (2008), already suggesting that telecoms data are an appropriate tool for the study of globalization and city-region formation.

Communications network research has typically tended to ignore business activity, either by attempting to remove it from the dataset entirely (e.g., RATTI *et al.*, 2010), or by subsuming it under a generic 'social interaction' label when it cannot be filtered (e.g., ONNELA *et al.*, 2007). Normally, this would be the desired outcome, but for MCR research a view of firm activity is essential. Because of the way that the underlying technology works, landline data allow the aggregate volume of communications by identifier to be used to segment callers into different

usage groups so as to get at the behaviour of firms directly. In this case, 97% of callers in the dataset averaged less than one hour of telephone use per day, and 0.002% accounted for more than 256 hours each. Removing these two extremes leaves just 3% of all callers, but the scale of the dataset is such that this represents more than 2 million unique numbers, each of which plausibly represents at least a mid-sized business or an MNE.

Employment data

To narrow the analysis to just those areas containing high levels of APS employment, standard labour statistics were then used as a spatial filter. Employment data for Britain are supplied by the Annual Business Inquiry (now superseded by the Business Register and Employment Survey) using the Standard Industrial Classification (SIC) to categorize workers according to the type of firm for which they work. The survey employs a random sampling approach at the ward scale for data collection, and the expectation is that 10% of businesses in a ward will be questioned about their staffing levels each year. Because of this, the level of employment for a given sector may appear to vary significantly from year to year and sectoral employment was averaged here across a five-year window – centred on the year of interest – to obtain a less biased picture.

To align this analysis better with that of HALL and PAIN (2006), industries defined at the three- and four-digit SIC level can be amalgamated into compound groups that reflect the basic divisions identified in Table 1. Table 2 shows the six resulting super-categories, together with the component sectors upon which the analysis will be based.¹ This is not a perfect fit: the authors in HALL and PAIN (2006) use a survey and face-to-face interviews to obtain data on senior executives and managers alone, whereas the employment data simply count all employees in a firm regardless of their role in delivering ‘advanced services’. So, although the present definition of APS is not a perfect match for what has gone before, telecommunications provides the crucial behavioural dimension that has often been missing from MCR research (PAIN and HALL, 2008).

Furthermore, the marriage between employment and communications geographies is not seamless, and the small white gaps in Fig. 1b indicate telecommunications areas for which no corresponding employment geography is available. The operator’s commercially sensitive network exchange areas were masked through a mapping onto the standard statistical Output Area geography employed by the Office for National Statistics (ONS). However, the employment survey’s use of wards for its labour statistics meant that in approximately 8% of cases no ward centroids fell within a telecommunications zone when an attempt

Table 2. *Advanced producer services (APS) to Standard Industrial Classification (SIC) mapping*

Name	Details
Professional services	741 (Legal, Accounting, etc.), 742 (Architectural & Engineering), 744 (Advertising)
Cultural production	9211 (Motion & Video Production), 9212 (Motion & Video Distribution), 9220 (Radio & Television), 9231 (Artistic & Literary Creation), 7440 (Advertising)
Financial services	651 (Monetary Intermediation), 652 (Other Financial Intermediation), 660 (Insurance & Pension Funding), 671 (Auxiliary to Financial Intermediation), 672 (Auxiliary to Insurance & Pension Funding)
Information and communication technology (ICT)	7210 (Hardware Consultancy), 7221 (Publishing of Software), 7222 (Other Software Consultancy), 7240 (Data Base Activities)
Logistics	6311 (Cargo Handling), 6312 (Storage & Warehousing), 6321 (Other Support Land Transport), 6322 (Other Support Water Transport), 6323 (Other Support Air Transport), 6210 (Scheduled Air Transport), 6220 (Non-Scheduled Air Transport), 6110 (Sea & Coastal Water Transport), 6120 (Inland Water Transport), 6010 (Transport via Railways), 6024 (Freight Transport by Road)
Research and development (R&D)	7310 (Natural Sciences Research)

was made to join the three sets of data. Fortunately, this issue arises only at the wider outer metro area (OMA) and GSE scales and does not appear to have had a significant impact on the analysis.

METHODS

To map out the corporate geography of the London MCR, a two-stage analysis was employed: first, the small area employment data from the Annual Business Inquiry is used to identify locations with statistically significant levels of specialization in one or more of the six categories of APS activity; then for each of these areas a novel, normalized measure of international telecommunications intensity is derived to enable us to distinguish between areas where medium and large businesses are more – or less – engaged in global communications. Each of the six firm categories set out in Table 2 is treated separately, building a disaggregate and detailed picture of the MCR and its overall spatial and communicational dynamics.

Many comparative studies of regional employment – including recent work by POLÈSE *et al.* (2007) – have used HALL's (1962) 'local' adaptation of FLORENCE's (1948) location quotient (LQ), which measures the relative concentration of employment in one area to the average concentration across the sample. However, detailed work on localization economies within metropolitan London (GODDARD, 1973; READES, 2011; SMITH, 2011) had already suggested that the localization of firms would vary at a finer scale than the city-unit typically employed in this type of research (e.g., HALL and PAIN, 2006; TAYLOR *et al.*, 2010). Fortunately, even with smaller unit geographies, it is nonetheless still possible to measure industrial concentration using LQ.

More formally, LQ is the ratio of local employment (E) in a given area (A) to employment in the region as a whole (R). To determine whether there is a relative concentration of employment in a particular industry (i), one has only to compare the local employment ratio with the regional one using the formula:

$$(E_{iA}/E_A)/(E_{iR}/E_R)$$

The result is essentially a ratio that indicates the degree to which an area is relatively more specialized in a given sector than the region as whole, but there is no general agreement as to what constitutes a significant level of specialization.

Typically, an arbitrary threshold is selected by the researcher for analytical tractability (e.g., DE PROPRIIS, 2005); however, in cases where LQs are normally or log-normally distributed, the standard deviation (SD) can be a useful guide to whether the over- or under-representation of an industry in a given area is statistically significant (for a discussion of

this, and related issues, see MARTIN and SUNLEY, 2003). At the regional scale, the distribution of LQs for small areal units often follows a quasi-normal distribution once zero-values are removed. Normality enables us to work with z -scores, establishing what O'DONOGHUE and GLEAVE (2004) proposed calling a standardized location quotient. The choice was to work with two thresholds – ± 1.5 , corresponding to a two-tailed 87% confidence interval, and ± 1.98 , which corresponds to a 95% confidence interval – since it allowed more marginal concentrations to be incorporated when searching for statistically significant concentrations of employment in each sector.

The standardized LQ was paired with a novel concentration/specialization metric for international calling. Deliberately modelled on the LQ, the telecommunications quotient (TQ) enables the share of international communications traffic for which a given area is responsible to be compared with the regional average as follows:

$$(T_{IA}/T_A)/(T_{IR}/T_R)$$

where I is a foreign location of interest (e.g., Los Angeles, Japan, or all countries together) to which calls have been placed or from which calls have been received; and A is an area of interest within region R . This approach has several advantages for MCR work: first, much like LQ, it controls for widely varying absolute levels of telecoms usage; second, it yields a singular metric that can be compared with the figures calculated for employment; and third, its simplicity makes it possible to test for a variety of relationships quickly and easily.

So it can be anticipated that the City of London, known for its global financial services industry, will have a very large value for international calling (T_{IA} , where A is the City of London) relative to that of the GSE region as a whole (T_{IR}). But if the total amount of calling – including domestic – from the City (T_A) is also very high, then a more modest TQ than expected may well be found. This result would indicate that the relative share of international calling from Central London is not substantially different from the region as a whole.

It is worth noting that there are actually two types of flow data: calls and minutes. In theory, either one could be used in the TQ calculation and the appropriate choice will be considered in the following section. However, regardless of the input data selected, the analysis can proceed in the same way: first, employment data are used to select only those areas with statistically significant levels of specialization – here determined by an LQ value falling more than 1.5 SDs from the log-normal mean – in one of the APS sectors of interest; then, the relative level of international calling by medium and large firms for these significant areas is

examined for an insight into the degree to which industry is, or is not, operating in a global context with substantive cross-border informational flows.

It is also important to note that LQ and the proposed TQ are essentially aspatial statistics that treat zones independently. As spatial clustering is a defining feature of employment geography (particularly APS employment), alternative spatial statistical measures of employment clustering have been developed that consider relationships between neighbouring zones and account for spatial autocorrelation (e.g., GUILLAIN and LE GALLO, 2010, ARBIA, 2001). However, this analysis is not attempting to measure clustering, and is using LQ data only to identify zones with high concentrations of employment relative to the MCR as a whole. This process acts as a filter, enabling the analysis of telecommunications usage subsequently to be focused in only those zones where the concentration is greatest. The authors believe this treatment to be appropriate, but would nonetheless note that going beyond this level of analysis would require addressing the existence of spatial autocorrelation – indicated by the centralization measures and maps below – and its relationship to the zonal configuration used.

RESULTS AND ANALYSIS

Although Fig. 2b has already demonstrated that sorting British cities on the basis of the intensity of international communications usage yields the geography of the London MCR, it is theoretically possible that the results are a by-product of global migration flows and not APS activity. Perhaps immigration to the GSE accounts for higher levels of international calling, and the levels are not tied to the working practices of highly skilled employees in APS firms? To test for this possibility, several proxies for highly skilled work of the type assumed to occur within APS firms were considered: the rateable value of the premises in which the business is based (BRUHNS *et al.*, 2000); the proportion of employees who self-report as being in a management role; the

proportion of employees in managerial and professional roles; and total employment.

It is clear from Table 3 that calling is connected to highly skilled work since every single variable is positively correlated with communications quotients derived from either calls or minutes. However, total employment is notable for being much *less* correlated, implying that the processes measured by international telecommunications intensity are more weakly connected to employment in general. Without wishing to overstate the importance of the correlations, it should be clear that the relationship between the TQ and indirect measures of high-value work are extremely significant in terms of establishing the suitability of telecoms usage as a measure of APS-led globalization.

Additional testing of TQ using a regression model weighted by total employment yielded an adjusted R^2 value for 0.589 for the rateable value for premises alone, and 0.662 for rateable value and the proportion of managerial and professional employees, reinforcing the idea of a strong relationship between high-value, knowledge-intensive industries and telecommunications usage. Table 3 clearly establishes that the precondition for the rest of this work – that international telecommunications usage is intrinsically connected to APS work – has been met. With this relationship in mind, one can now turn to the individual sectoral groupings to explore MCR geography in more detail since it is anticipated that significant differences in the use of space and of international telecommunications will be found at this level.

Financial services

Perhaps no single industry is more closely associated with economic activity – and with the deployment of its associated telecommunications infrastructure (RUTHERFORD, 2004) – in London and the South East than financial services. The role of ‘the City’ has been widely studied as a model of globalization and specialization (e.g., KYNASTON, 2001; SASSEN, 1991) and is presumed to demonstrate how physical proximity, a strong institutional and social culture, and favourable regulatory environment can yield sustained

Table 3. Bivariate Pearson correlations between communications and employment

	TQ (min)	TQ (calls)	Rateable value	Proportion of managers	Proportion of managers and professionals	Total employment
TQ (min)	1.000	0.893**	0.592**	0.489**	0.571**	0.281
TQ (calls)	0.893**	1.000	0.599**	0.463**	0.517**	0.296**
Rateable value	0.592**	0.599**	1.000	0.429**	0.557**	0.506**
Proportion of managers	0.489**	0.463**	0.429**	1.000	0.714**	0.183**
Proportion of managers and professionals	0.571**	0.517**	0.557**	0.714**	1.000	0.264**
Total employment	0.281**	0.296**	0.506**	0.183**	0.264**	1.000

Notes: All correlations have $n = 1344$ and two-tailed significance test results of 0.000. **Correlation significant at the 0.01 level (two-tailed). TQ, telecommunications quotient.

growth. However, what Table 4 makes clear is that two distinct locational dynamics are at work within the sector: the 'intermediation' industry – which includes merchant banking – is highly concentrated in the Square Mile, while the insurance and pension industries are more widely distributed, though still with an important central component.

The natural implication of this distribution is that the insurance sector does not, on the whole, have the same locational requirements as the other financial sectors. With the exception of TAYLOR *et al.* (2003), the financial services industry is sometimes seen as an undifferentiated whole, but these results make it clear that they should be examined separately. This difference can be understood in terms of the industry's dominant consumers: with the exception of specialist insurers such as Lloyds or reinsurers such as Swiss Re, the majority of insurance is sold directly to consumers as largely standardized products, while a good deal of investment activity entails more complex cross-sectoral interactions between analysts of investment banks or hedge funds and lawyers, accountants, clients, as well as firms in which they hold, or are taking, positions. In other words, home contents insurance is readily purchased online or over the telephone, but collateralized debt obligations are not.

The distributions shown in Table 4 suggest that insurers have been able to retain or expand activity in lower-cost areas, while 'high finance' has not. And yet, a more fine-grained analysis problematizes this simple dichotomy: Fig. 3a highlights the fact that statistically significant levels of activity are quite widely distributed. Fig. 3b clarifies the implications for an understanding of globalization within the MCR: proximity to London is a clear predictor of international communications intensity. Insurance sites to the North East are much less international in outlook, while Central London is amongst the most global locations in the entire dataset. Rather more surprising, however, was the high level of activity around the orbital M25 motorway; research suggests that this is the mark of supporting infrastructure for

large, American-owned firms (also PAIN, 2008, p. 1167), indicating that 'back office' work can entail a great deal of cross-border communications.

Cultural production

The second sectoral grouping associated with 'first cities' (HALL and PAIN, 2006, p. 9) is that of cultural production: the advertising and film industries that are closely tied to the literature on image production and 'signifying location' (e.g., CURRID and WILLIAMS, 2010; SCOTT, 1997). In these sectors, more than 50% of activity is concentrated within the Central Activity Zone and Inner London areas, and there is very little work being undertaken across the OMA and GSE areas, but the distribution is nonetheless log-normal and compatible with z -score cut-offs (Table 5).

This distribution is therefore entirely consistent with the findings from detailed research undertaken by NACHUM and KEEBLE (1999) and FAULCONBRIDGE (2007) on the Soho media cluster. But this overall structure is what makes part of the pattern observed in Advertising (SIC 7440) industry so interesting: while there is a dominant tendency towards a central business district (CBD) location, there are major concentrations of employment much further out in the GSE. The particularly prominent site in Thame (the outlying high-TQ near Oxford in Fig. 4b) highlights what may be an emerging strategy in the advertising sector: this area appears to focus employment in some of the less intensively creative aspects of the industry, suggesting that what might be seen here are the first signs of an emerging front/back-office division in a cultural industry.

The 20% of Motion and Video Production employment in the OMA or rest of the GSE also merits further investigation since it is impossible to determine whether it is functionally connected to activity in Soho or is of a different nature entirely. In contrast, the 36% of employment in Radio & Television in Inner London

Table 4. Financial services

Sector	Standard Industrial Classification (SIC)	Central London (%)	Inner London (%)	Outer London (%)	Outer metro area (%)	Rest of Greater South East of England (GSE) (%)
Monetary Intermediation	651	48.01	5.49	11.81	15.30	19.39
Other Financial Intermediation	652	54.99	3.45	6.80	16.59	18.18
Insurance & Pension Funding	660	24.59	1.11	13.32	25.48	35.50
Auxiliary to Financial Intermediation	671	67.61	5.55	5.32	14.79	6.73
Auxiliary to Insurance & Pension Funding	672	38.67	1.78	12.41	23.16	23.99
All financial services		47.56	4.05	10.29	18.04	20.07
All sectors		14.23	8.99	17.77	26.64	32.37

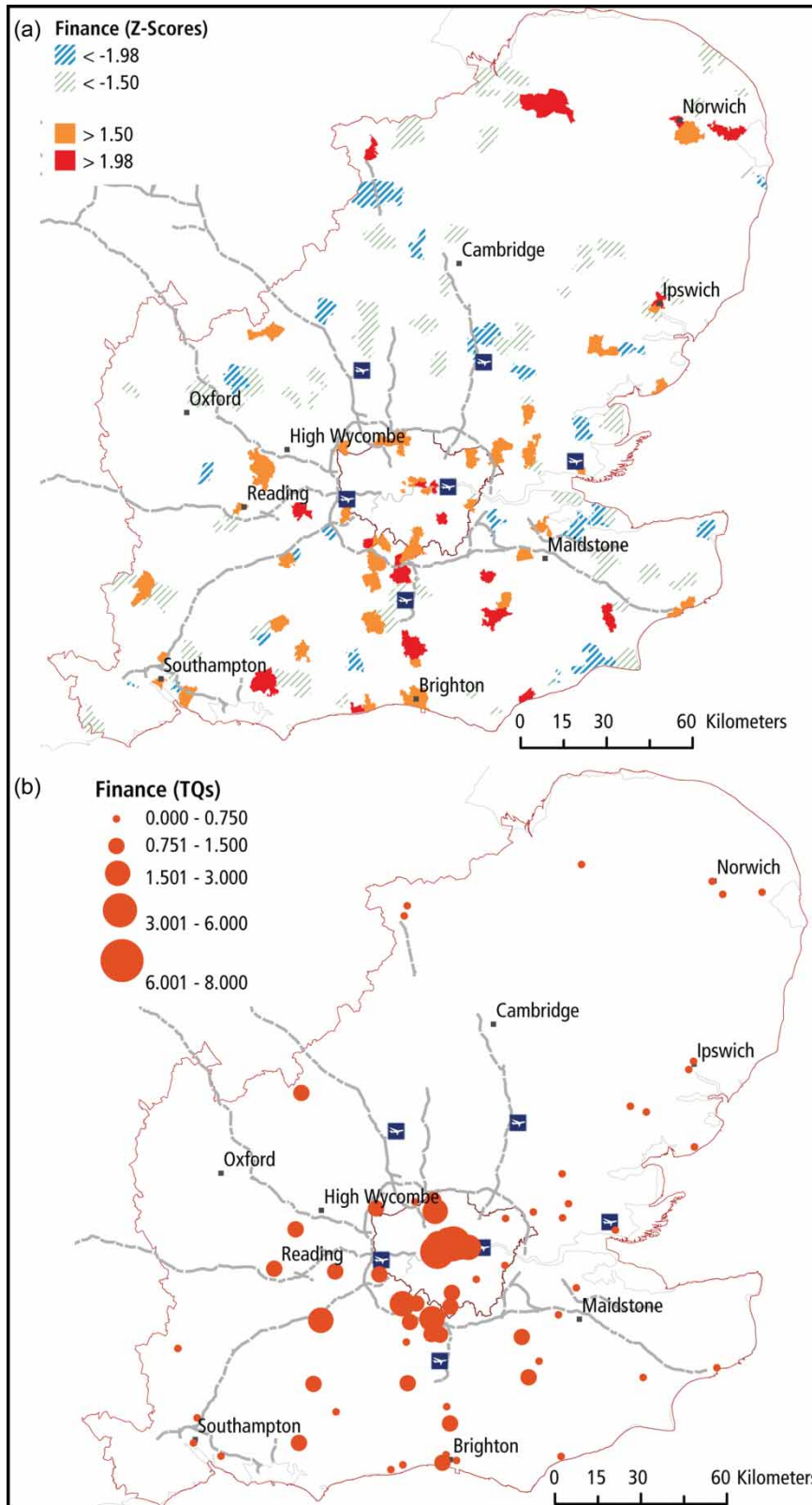


Fig. 3. Financial services employment and communications activity: (a) location quotient (LQ); and (b) telecommunications quotient (TQ)

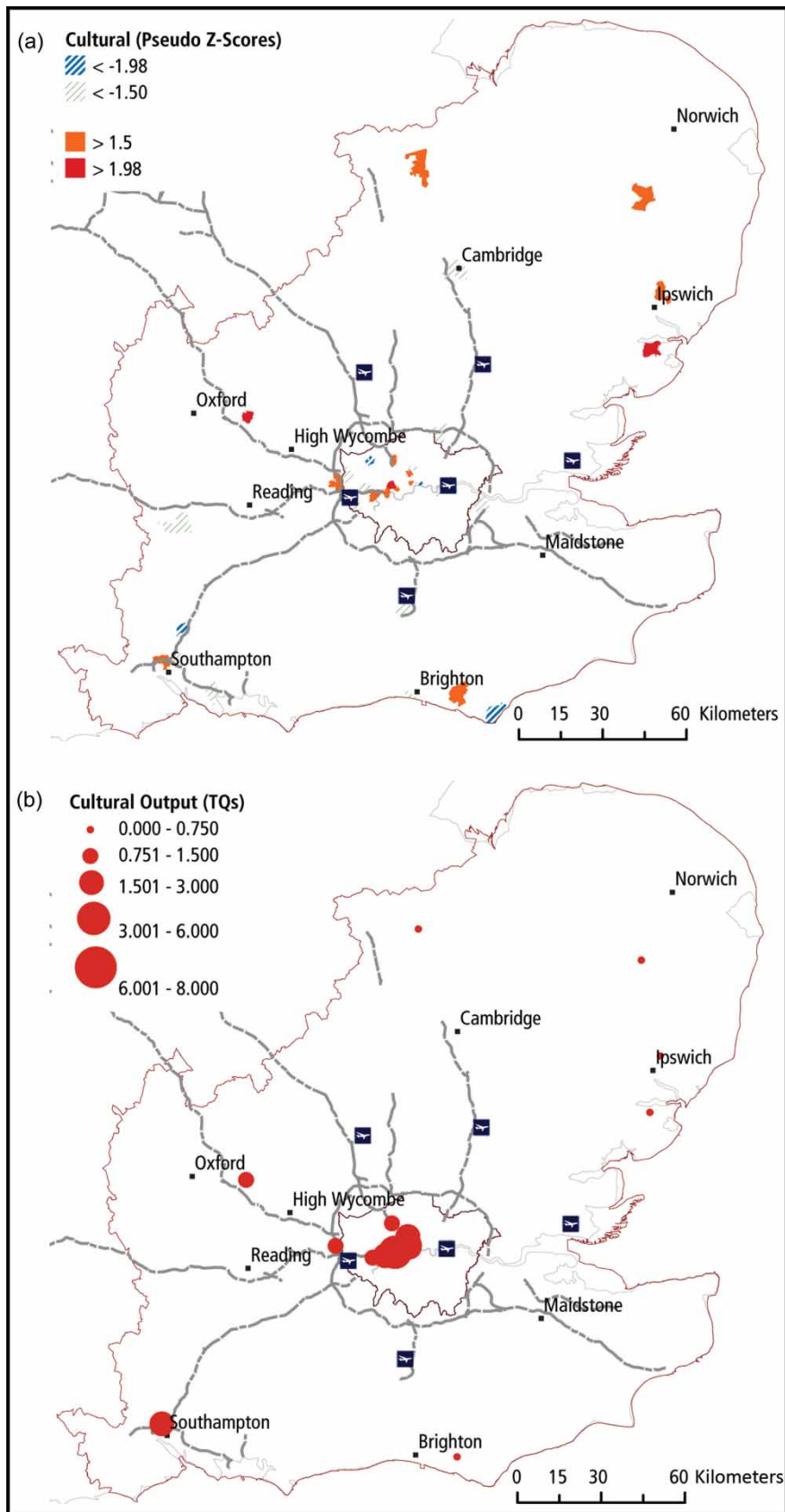


Fig. 4. Cultural production employment and communications activity: (a) LQ; and (b) TQ

Table 5. Cultural production

Sector	Standard Industrial Classification (SIC)	Central London (%)	Inner London (%)	Outer London (%)	Outer metro area (%)	Rest of Greater South East of England (GSE) (%)
Motion & Video Production	9211	57.96	12.46	8.65	10.55	10.38
Motion & Video Distribution	9212	49.71	34.10	7.51	2.31	6.36
Radio & Television	9220	37.38	35.48	17.87	4.07	5.20
Artistic & Literary Creation	9231	42.31	29.63	14.51	4.26	9.30
Advertising	7440	46.47	11.75	11.36	13.17	17.24
All cultural production		43.88	23.80	13.74	7.85	10.72
All sectors		14.23	8.99	17.77	26.64	32.37

is readily explained by the presence of the BBC (British Broadcasting Service) at White City/Shepherd's Bush (now relocated to Salford and Central London). Moreover, the imprint of this world-renowned brand on the use of international telecommunications is readily visible in the high TQ scores for Southwest London, an effect not really seen outside of Greater London.

Professional services

It might be expected that the Professional Services group – consisting principally of consultancy activity delivered by a mix of global services firm and small, local providers – would demonstrate some level of overall consistency in its spatial preferences. Instead, there is wide variation: the Legal industry is the most highly concentrated sector in the entire sample and the highest LQs are in the area around the Inns of Court, while Accounting offers evidence of significant presence near the GSE's largest cities, likely reflecting the sector's oligopolistic structure and MNE subsidiary servicing approach (PAIN, 2008). Architecture, Engineering and, more surprisingly, Management Consulting showed evidence of regional dispersal: the first two in particular seem to have little tendency towards concentrating employment in areas outside of London in general, and Bloomsbury in particular (Table 6).

Fig. 5b suggests that for this group as a whole there is a much stronger dichotomy between firms operating in highly globalized environments in Central London and around the M25, and those operating in second- or

third-tier cities and towns elsewhere in the GSE. In the latter case, levels of international calling are only slightly higher than the regional norm. It should also be noted that there is a clear suggestion of a concentration of professional services activity in the vicinity of Cambridge where no less than four zones have statistically significant levels of employment in these industries.

Combining the LQ and TQ analyses yields several important conclusions, the first of which is that the City of London remains the absolutely critical site for global Professional Services activity in the GSE. There is strong, direct evidence of clustering here: not only is the City a statistically significant site for one sector, but also it is often the most significant site in the entire sample for *many* specialties within the sector. The general locational and communication pattern would be consistent with a distinction between firms that operate in highly competitive, global environments around the CBD and those that operate across a regional 'periphery'.

Information and communication technology (ICT)

In the original POYNET research (HALL and PAIN, 2006, p. 55), ICT and Consultancy activity were folded into a single category; however, Table 7 suggests a markedly different distribution of employment for this group and the results below indicate that this distinction is crucial. Here there is just one sector with high levels of employment in Central London, and none has

Table 6. Professional services

Sector	Standard Industrial Classification (SIC)	Central London (%)	Inner London (%)	Outer London (%)	Outer metro area (%)	Rest of Greater South East of England (GSE) (%)
Legal, Accounting, etc.	741	35.60	8.16	12.46	23.64	20.14
Legal Activities	7411	60.13	4.15	7.19	11.30	17.23
Accounting	7412	43.45	9.35	11.35	17.20	18.65
Market Research	7413	31.63	7.05	17.88	31.46	11.98
Business Consultancy	7414	35.14	11.11	13.34	24.18	16.24
Architectural & Engineering	742	21.07	8.45	13.29	28.39	28.80
Advertising	744	36.00	11.48	12.98	18.90	20.64
Professional services		32.60	8.47	12.67	24.24	21.95
All sectors		14.23	8.99	17.77	26.64	32.37

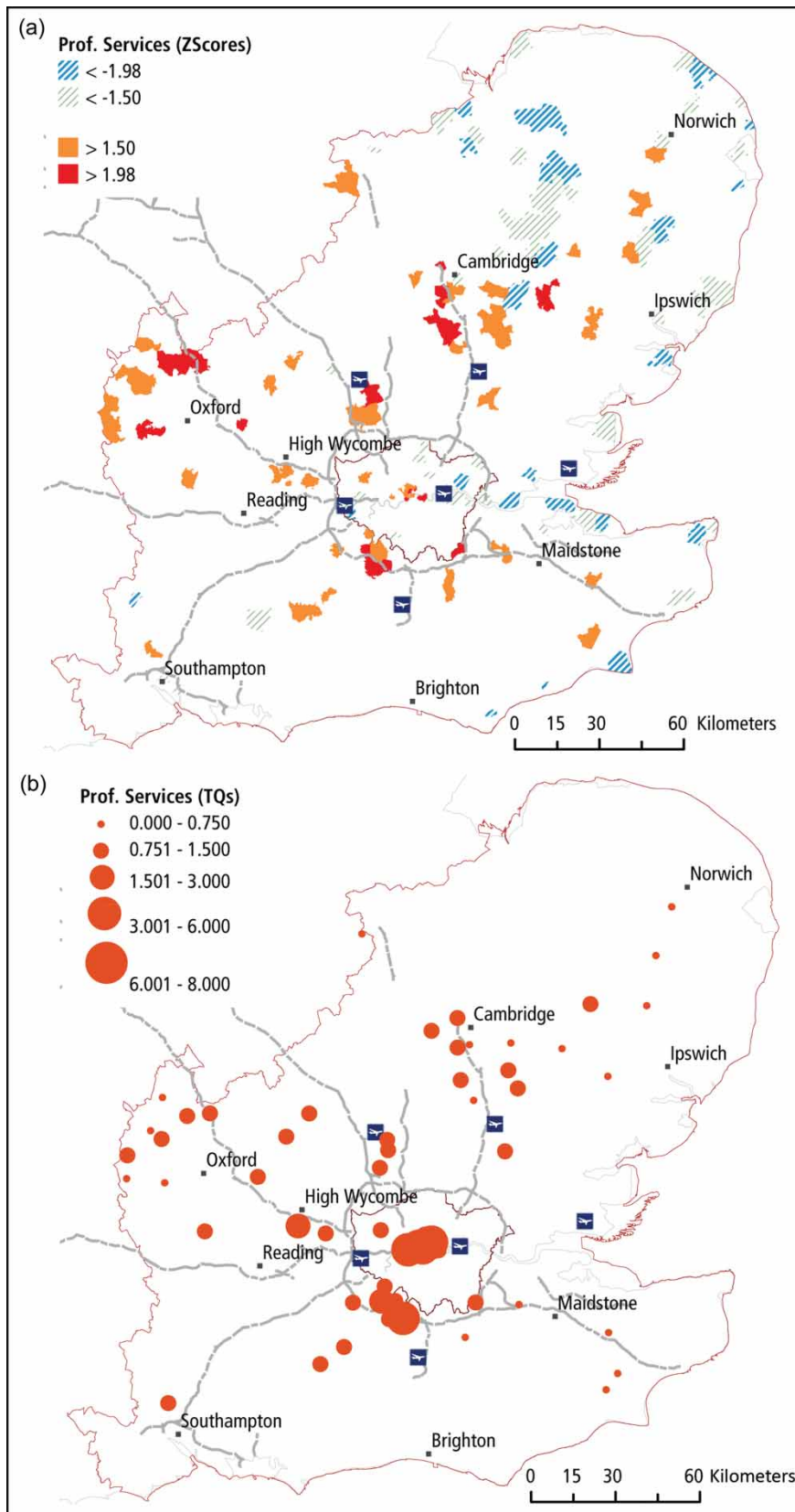


Fig. 5. Professional services employment and communications activity: (a) LQ; and (b) TQ

Table 7. Information and communication technology (ICT)

Sector	Standard Industrial Classification (SIC)	Central London (%)	Inner London (%)	Outer London (%)	Outer metro area (%)	Rest of Greater South East of England (GSE) (%)
Hardware Consultancy	7210	16.93	6.69	7.87	61.02	7.48
Publishing of Software	7221	9.76	5.37	19.02	51.22	14.63
Other Software Consultancy	7222	18.49	7.42	13.66	39.51	20.92
Data Base Activities	7240	53.78	0.89	7.11	25.78	12.44
All ICT		19.20	7.16	13.44	40.10	20.10
All sectors		14.23	8.99	17.77	26.64	32.37

employment of note within Inner London. Instead, ICT workers are far more abundant in the OMA region and beyond: nearly all SIC categories have more than 60% of staff ‘concentrated’ in the two outer-most rings.

The distribution of ICT consultancy and ‘publishing’ in the Central Activity Zone might seem indicative of a front/back-office structure, but the staffing levels are such that this is unlikely. It seems that many firms have no presence at all in Central London and that only a fairly small number of specialized suppliers are to be found there. In fact, the largest ICT firms have nearly the inverse office structure of their financial counterparts: small outposts in the CBD enable them to meet with clients and vendors (particularly on the creative side), while the bulk of the ‘real’ development work is done outside London in cities such as Reading and Slough (e.g., MICROSOFT, 2012; ORACLE, 2012). The notable exception in Table 7 is worth considering further: the increasing reliance of firms on the processing and management of data has created the need for firms in the area of ‘customer relationship management’. In many ways these are more like specialized business consultancies than standardized, product-driven software firms, and that is a reflection of the challenges of data mining (e.g., BECKER *et al.*, 2009).

Regardless, at the wider GSE scale it is the ‘Western Wedge’ posited by HALL (1987) that is most prominent: it runs in an arc that swings from the M3 in the south to the M40 in the north-west and is centred on Reading (Fig. 6a). In fact, in its preference for the ‘Thames Valley Corridor’, ICT betrays a bias towards international airports and amenity. The particularly strong use of telecommunications at a few sites is also suggestive of MNE activity, not smaller businesses. It should be noted too that ICT is one of just two sectors in which there appears to be a broadly negative relationship between proximity to Central London and international communications intensity.

Research and development (R&D)

Although natural sciences R&D and ICT both operate in ‘high-technology’ environments, Table 8 shows a key difference between the two groups: much higher levels of R&D activity in the rest of the GSE and

almost none – relative to all other sectors – within metropolitan London. Fig. 7a foregrounds the absence of any obvious locational strategy organized around proximity to other R&D sites or other APS sectors, and some of the highest concentrations of R&D activity occur in relatively less accessible areas such as Sandwich, Royal Tunbridge Wells and Sharnbrook.

Furthermore, comparison of Figs 6 and 7a makes it clear that the persistence of the ‘Western Wedge’ is very much a product of the ICT industry. In general, although some R&D locations are clearly connected to pre-existing research centres of excellence in places such as Cambridge, other facilities seem to have little obvious connection to anything at all. In fact, the ‘dispersed office park’ approach of firms operating in this sector may be a means of avoiding the leakage of intellectual property to competitors – firms might seek to reap returns to scale locally by concentrating their researchers in a single facility that also serves to minimize the risk of ‘knowledge spillovers’ to others (MCCANN *et al.*, 2002).

For instance, Fig. 7b picks out an extraordinarily high level of relative international calling activity in Sandwich, home (until recently) to a major pharmaceutical research centre. R&D therefore appears to be a large user of global telecoms, and distance from the CBD is no predictor of communications usage. At times, international call volumes even exceed domestic ones, a behaviour seen nowhere else. In fact, the majority of external links here seem to be uniquely global – most likely to the other offices of the same firm – and there is little regional or local interaction.

Logistics

Because contemporary firms increasingly rely on specialized logistics suppliers to keep them supplied with a variety of inputs on a just-in-time basis, PAIN and HALL (2008, p. 1068) include this sector in their examination of APS behaviour in MCRs. Whereas the other sectors considered are primarily concerned with the production and circulation of information and knowledge, Logistics staff are obviously involved in the storage and movement of physical objects. As such, the sector has far more extensive needs in terms of staff, space and transport infrastructure. Consequently, they would be

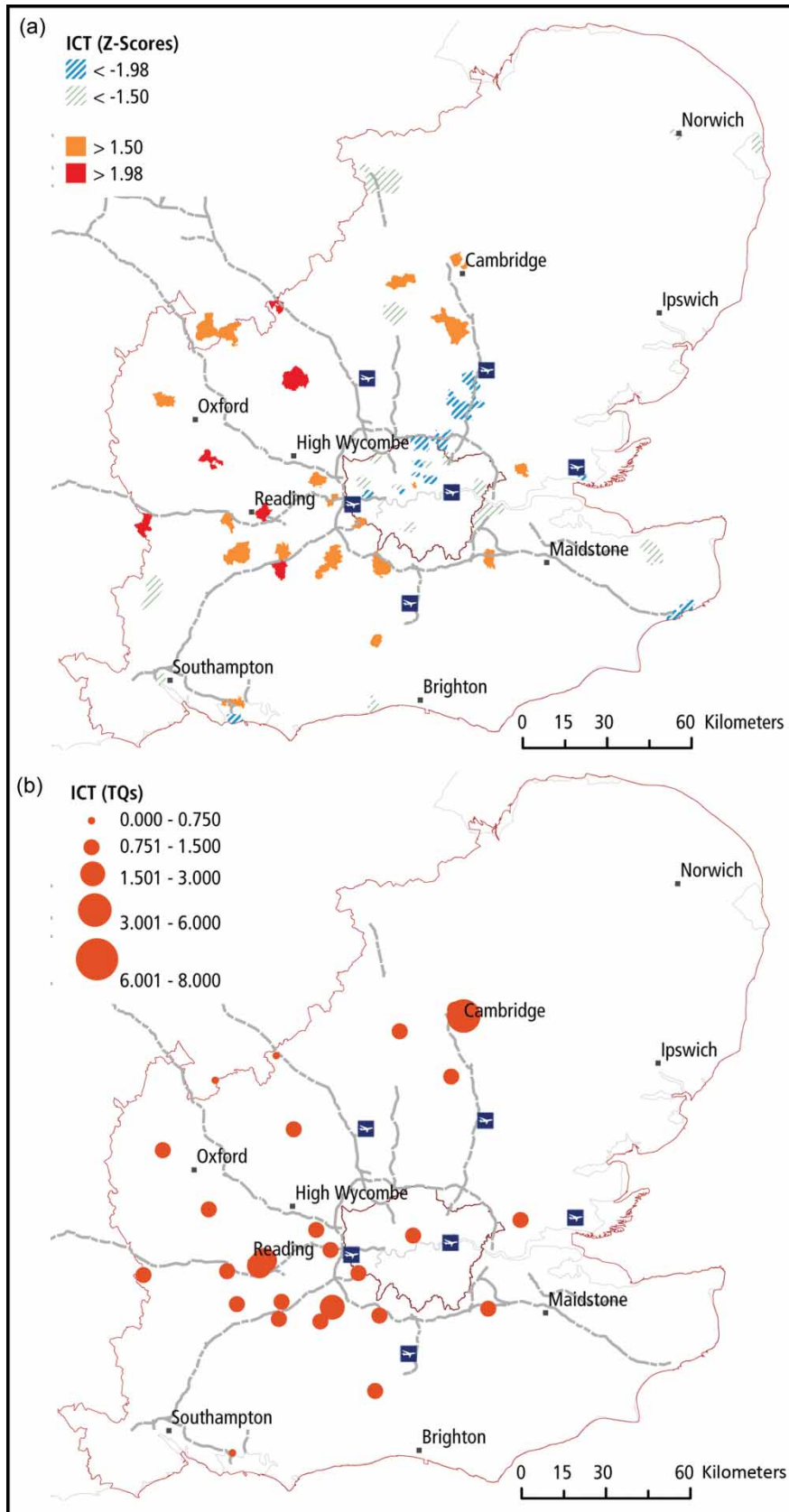


Fig. 6. Information and communication technology (ICT) employment and communications activity: (a) LQ; and (b) TQ

Table 8. Research and development (R&D)

Sector	Central London (%)	Inner London (%)	Outer London (%)	Outer metro area (%)	Rest of Greater South East of England (GSE) (%)
All R&D	9.54	3.93	8.53	38.86	39.14
All sectors	14.23	8.99	17.77	26.64	32.37

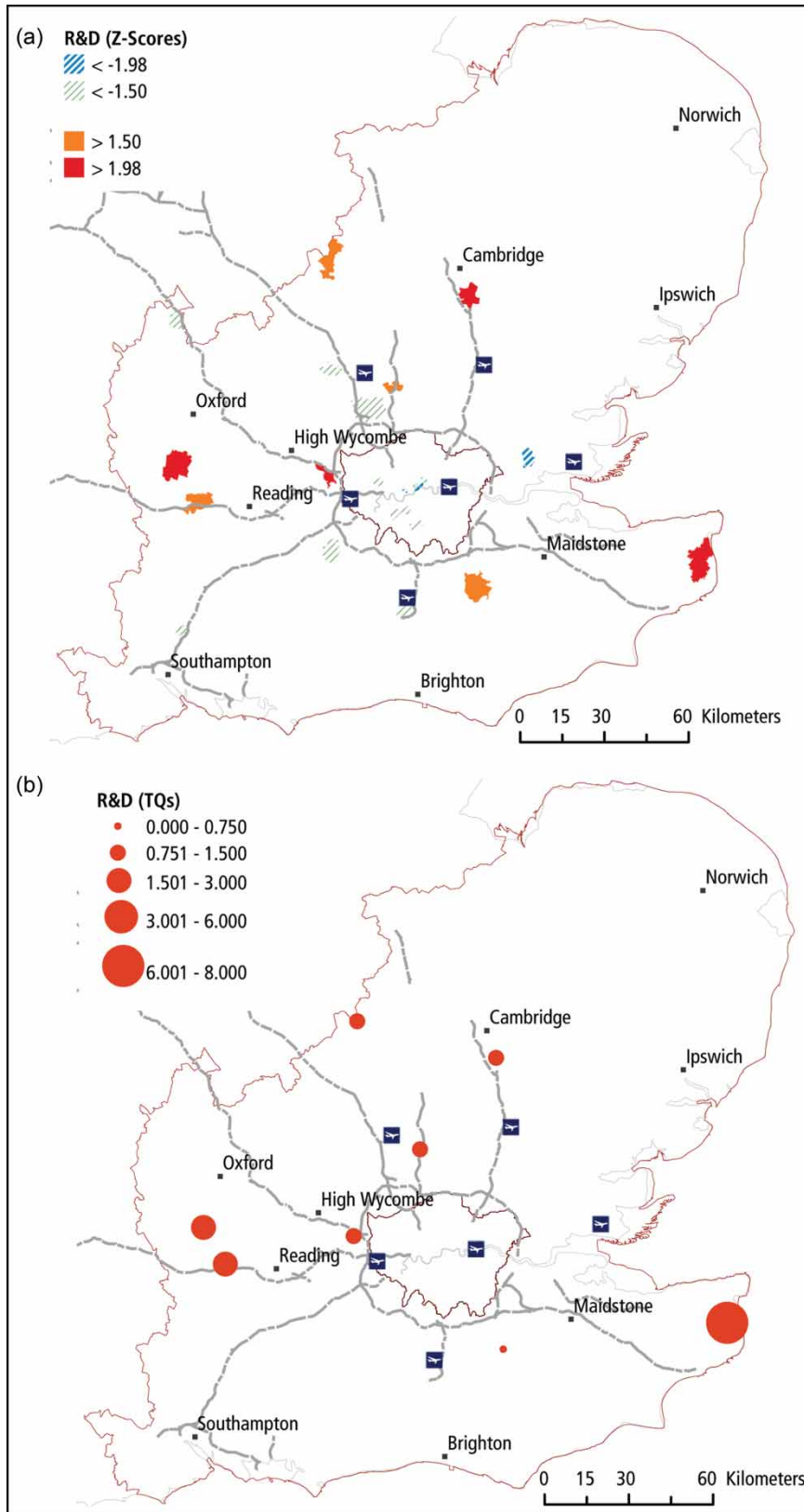


Fig. 7. Research and development (R&D) employment and communications activity: (a) LQ; and (b) TQ

expected to have a very different set of locational and information preferences.

At the highest level, Table 9 contains few surprises: with the exception of the much smaller City Airport, London's major airports are all in the Outer London or OMA regions and so air transport-related employment naturally follows this distribution. The 2.4% of centrally located Scheduled Air Transport workers are likely to be the employees of the Civil Aviation Authority (CAA), which is based in Holborn (Central London), but the location of the remaining 96.7% make it abundantly clear where the 'work' is done.

That said, some of the more unusual distributions require some explanation: the high proportion of Other Land Transport and Other Water Transport in Central London are connected to the provision of London's massive public transit system: the majority of Transport for London's employees are considered to be working 'from' London, and the water-based group is undoubtedly connected to activity in the Port of London. Similarly, the rail regulator has its headquarters at Euston (Central London), but mainline station and Railtrack maintenance staff probably account for the bulk of employment in this category.

Fig. 8a clearly connects significant logistics employment to major infrastructure such as airports (e.g., Luton, Stansted and Heathrow) and ports (e.g., Southampton, Harwich and Tilbury). Generally speaking, Logistics also shows a bias towards the Northeast of the GSE that would be consistent with a preference for cheap land and labour. However, the concentrations of employment around the M25 should also be noted, which indicate a strong set of interconnections between road, rail, air and sea; in spite of frequent congestion, the orbital appears to act as a staging area for metropolitan London.

Fig. 8b indicates, not surprisingly, that higher levels of international calling are associated with proximity to major international air transport entry/exit points for goods. Interestingly, major international ports do

not seem to have a correspondingly high level of international communications activity even though they handle much larger volumes of goods. Perhaps the speed and complexity of air transport entails additional communication and coordination tasks that lead to markedly higher levels of interaction?

LIMITATIONS

The preceding section emphasizes that what is being dealt with is an immensely complex system in which there is no such thing as a 'typical' sector with some normal distribution of activity that is representative of the whole. Indeed, one issue encountered with the use of the TQ – and with TQs derived from international calling in particular – is that as the base region *R* is broadened the distribution becomes less normal and so behaves very differently from the LQ. In this sense, directly equating the LQ to the TQ is problematic; however, the distribution underpinning this result lends empirical support to CASTELLS's (2009) claim that '[much] of the "global city" is actually quite local (e.g., Queens, Hampstead or Brixton) except for their immigrant populations' (p. 7). To this it may be added that much of economic activity is *also* 'actually quite local' from an information flows standpoint.

Also, because the TQ lacks a temporal aspect, it is not possible to use the timing of calls to distinguish between finer-scale variation such as, say, calls influenced by social relationships and those influenced by professional interactions. Since even the operator has only partial knowledge of which customers are using their telephones for business purposes, an approach that filtered callers on the basis of total talk time seemed the best method by which to identify business users. Overall, these initial results suggest that the TQ has real analytical value but that more work will be needed to understand the particular domains in which its outputs are most

Table 9. Logistics

Sector	Standard Industrial Classification (SIC)	Central London (%)	Inner London (%)	Outer London (%)	Outer metro area (%)	Rest of Greater South East of England (GSE) (%)
Cargo Handling	6311	0.53	0.00	39.36	41.49	18.62
Storage & Warehousing	6312	1.24	3.42	16.77	35.71	42.86
Other Support (Land Transport)	6321	47.76	12.67	15.20	12.22	12.15
Other Support (Water Transport)	6322	4.57	2.88	2.88	14.66	75.00
Other Support (Air Transport)	6323	0.36	2.17	43.81	31.71	21.95
Scheduled Air Transport	6210	1.92	1.11	70.40	22.83	3.74
Non-Scheduled Air Transport	6220	3.00	0.60	15.62	66.97	13.81
Sea & Coastal Water Transport	6110	20.78	0.30	2.11	9.04	67.77
Inland Water Transport	6120	62.50	18.75	0.00	0.00	18.75
Transport via Railways	6010	43.44	7.05	12.07	10.40	27.05
Freight Transport by Road	6024	1.01	2.10	18.59	32.36	45.94
Logistics		11.73	3.74	31.31	25.71	27.50
All Sectors		14.23	8.99	17.77	26.64	32.37

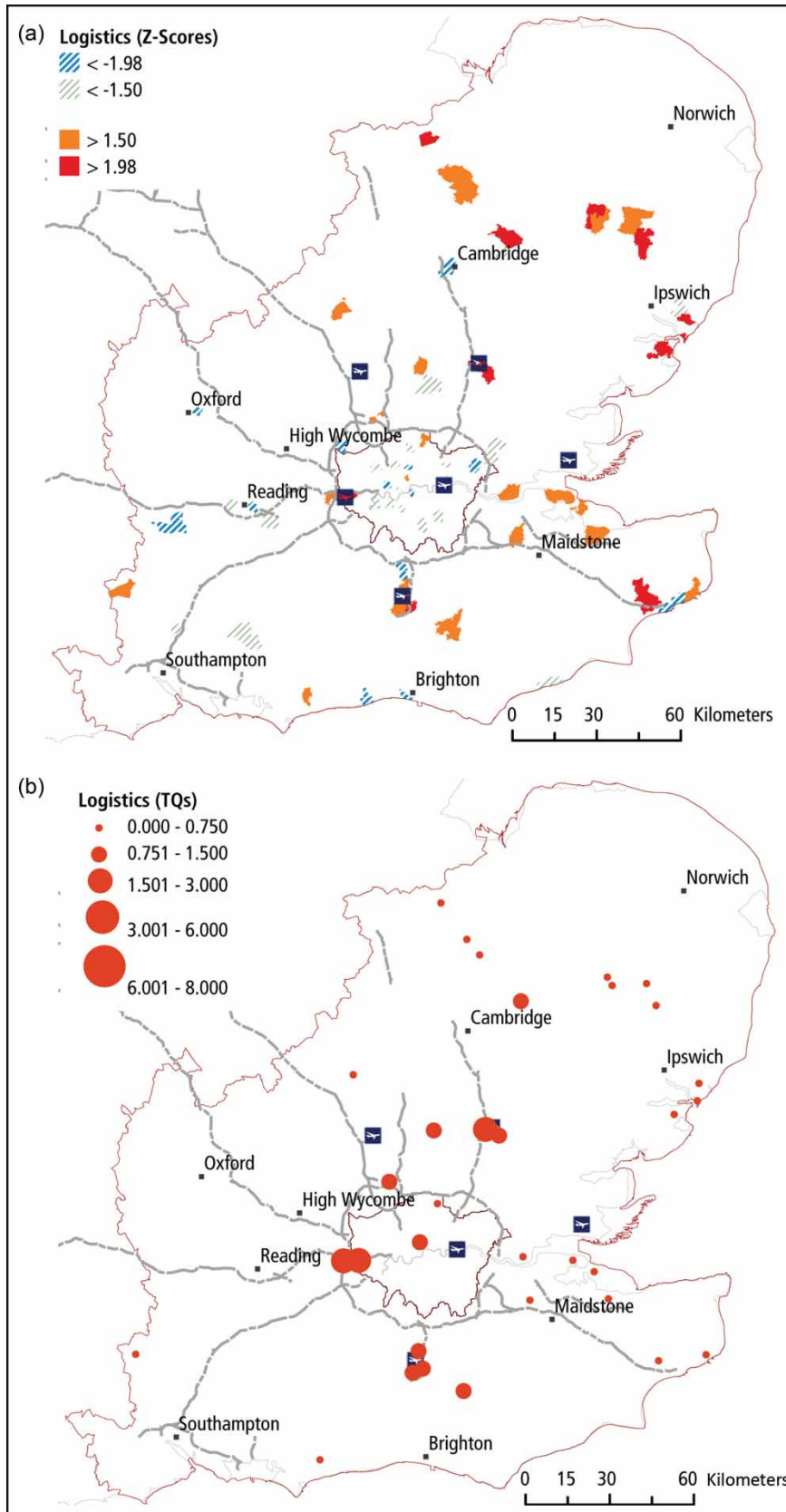


Fig. 8. Logistics employment and communications activity: (a) LQ; and (b) TQ

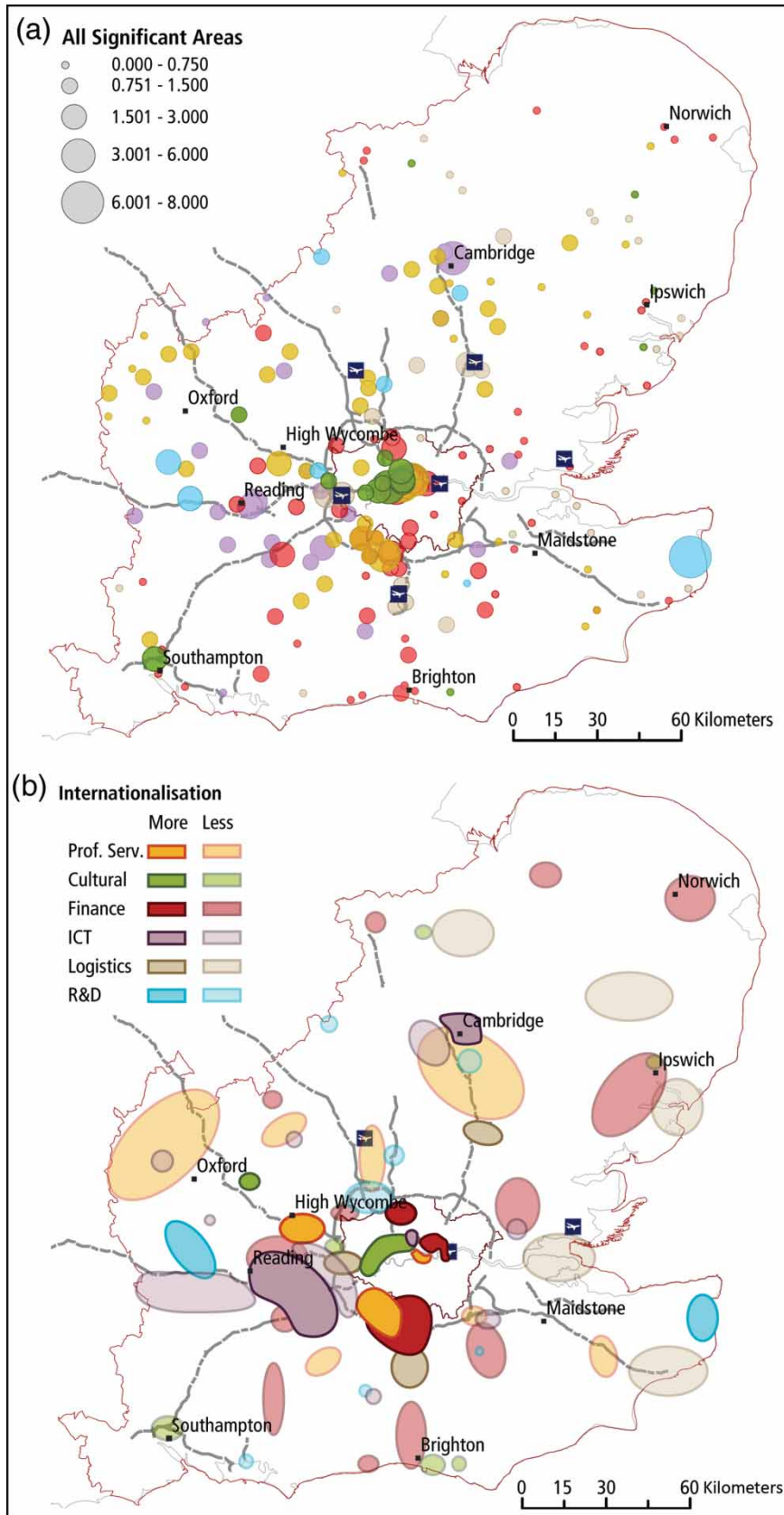


Fig. 9. Significant locations and summary results: (a) TQ summary; and (b) schematic sectoral distribution
 Note: The colour legend for the locations shown in (b) also relates to those shown in (a)

relevant and the constraints under which it can be employed as a research or policy-making tool.

Another more important limitation that was briefly noted above is inherent in the use of employment counts. As is common in most data of this type, all employees of a firm – regardless of role – are categorized according to the classification of the firm for which they work. So all employees of a firm such as Tesco are recorded as retail staff and coded accordingly, even though Tesco's operations in Britain are underpinned a highly sophisticated logistics and store planning function that could and should be considered an APS operation.

This issue cannot be addressed using quantitative methods since the limitation is inherent in the data. Consequently, more intensive approaches are called for to verify these findings at the level of one or more individual firms (for instance, see the report in PAIN and HALL, 2008). The present authors do, however, feel very strongly that these results demonstrate the promise of 'big data' approaches for complementary investigations of processes hitherto difficult to examine systematically at the regional scale.

CONCLUSIONS

SASSEN (2002, p. 15) has argued that 'cities that are strategic sites in the global economy tend, in part, to disconnect from their region', but these results suggest the reverse: that the complexity of economic activity and the competition for space means that the pre-eminent cities of the global economy are deeply connected to their 'hinterlands'. Using calling and employment data, it can be seen that although there is a marked tendency for more central businesses to be more international in terms of their communications patterns, there is a range of APS activity across the wider MCR that is equally global in outlook. In short, it is essential that research into the 'signifying locations' that are at the heart of globalization and clustering work does not neglect the wider regional context. Indeed, in some cases internationalization appears to coincide with a preference for accessible, high-amenity areas in the vicinity of 'second tier' cities such as Reading and Cambridge.

This result problematizes simpler conceptions of the concentration/deconcentration dynamic thought to characterize global cities and it rounds out the detailed investigation of TAYLOR *et al.* (2003, pp. 91–105) into the sectoral clustering of firms in Central London. The dynamic becomes clear if the totality of statistically significant employment locations is taken and combined with the TQ classification. The combined results in Fig. 9a emphasize the extent to which high international call volumes are disproportionately concentrated in the 'Western Wedge' – notably along the M4 corridor – identified by HALL (1987) as the heart of Britain's 'high-technology' economy. More surprising, however, is the emergence of a major APS grouping around the M25 at

Epsom/Redhill, and a secondary clustering at Cambridge that has no counterpart in the other cities of the Southeast. One should also take note of the general decline in international call volumes heading into East Anglia and in the vicinity of Milton Keynes, the latter being consistent with previous work suggesting that it is a relatively modest node in the global APS network (PAIN and WALKER, 2005; TAYLOR *et al.*, 2009).

Taken together, these various trends suggest a clear boundary for the globalization of APS firms, even if it is not the one that might initially have been expected. This dynamic is shown in a schematic, if impressionistic, form in Fig. 9b so as to emphasize the areas where internationally oriented business appears to be happening. Fig. 9 suggests that metropolitan London's contemporary dominance arises from its particularly high concentrations of knowledge work in conjunction with high levels of diversity amongst knowledge workers. On this basis it is clear that London is, and will remain, a key axis of research into globalization and APS networks, but that it should not be the only one.

As TOWNSEND and MOSS (2008, p. 28) put it, businesses in world cities act as 'importers of raw information and exporters of ideas, decisions and new services', and it is reasonable to suppose that where this information is at its most diverse businesses will be found that are particularly large users of ideas and innovation. However, the situation does become more complicated when ICT and R&D are considered, both of which were found to be pursuing more flexible locational strategies than their colleagues in Finance, Professional Services and Cultural Outputs: the former tend to show higher levels of dispersion and they actually seem to be more international when in proximity to transport-rich sites – especially airports – than to other globalized industries. In this there is substantial, if indirect, evidence of the power of codification in 'analytical' industries (ASHEIM *et al.*, 2007; STORPER and VENABLES, 2004).

It also bears repetition that not all APS firms are actively seeking to participate in and benefit from knowledge spillovers; in fact, the patterns observed in R&D are suggestive of businesses where this is to be avoided through an 'industrial complex' organization (MCCANN *et al.*, 2002) and where spillovers are few and far between because of ultra-specialization (ATHEY *et al.*, 2007, pp. 31–32). The greatest observed contrast in calling activity came from logistics firms linked to inter- and multi-modal hubs – where ships dock, aeroplanes land, and rail and road meet. This is an area where the increased spatial resolution of telecommunications data allows the regional dynamics to be examined in greater detail than appears possible in, for instance, the results reported by TAYLOR *et al.* (2010).

The observed sectoral differences highlight the capacity of telecommunications to enable firms to optimize location based on *other* economic, social and spatial

considerations. In other words, in parallel with research into the global city network, there is a continued demand for research into the underlying 'space of places' embodied in the MCR region. And in spite of the very different methodologies, these findings echo those of RUTHERFORD (2004), who argued that there is a need to stop focusing only on 'the "metageography" of relations *between* cities' and overcome 'a certain ignorance of the original geography of complex relations *within* cities' (p. 289, original emphasis).

More specifically, CASTELLS (2009) has suggested that 'in terms of spatial networks [...] these global networks do not have the same geography [and] they usually do not share the same nodes. The network of innovation in ICT is not the same as the network of finance [...] (p. 10), and these results provide strong empirical support for his claims. So although the London MCR is clearly a 'complex network of functionally interconnected town and cities', there is evidence to indicate that the multitude of spaces *between* those sites are increasingly part of this global MCR

and that telecommunications is a key component of this regional expansion.

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NOTE

1. The Advertising category included in the Cultural Production and Professional Services subgroups to facilitate comparison is *not* the same (SIC 7440 versus 744, respectively).

REFERENCES

- ARBIA G. (2001) Modelling the geography of economic activities on a continuous space, *Papers in Regional Science* **80**, 411–424.
- ASHEIM B., COENEN L. and VANG J. (2007) Face-to-face, buzz, and knowledge bases: sociospatial implications for learning, innovation, and innovation policy, *Environment and Planning C* **25**, 655–670.
- ATHEY G., GLOSSOP C., HARRISSON B., NATHAN M. and WEBBER C. (2007) *Innovation and the City: How Innovation has Developed in Five City-Regions*. National Endowment for Science, Technology and the Arts (NESTA), London.
- BATTY M. (1990) Invisible cities, *Environment and Planning B* **17**, 127–130.
- BECKER J. U., GREVE G. and ALBERS S. (2009) The impact of technological and organizational implementation of CRM on customer acquisition, maintenance, and retention, *International Journal of Research in Marketing* **26**, 207–215.
- BRUHNS H., STEADMAN P., HERRING H., MOSS S. and RICKABY P. (2000) Types, numbers, and floor areas of nondomestic premises in England and Wales, classified by activity, *Environment and Planning B* **27**, 641–666.
- CASTELLS M. (2009) Globalization, networking, urbanization. Unpublished manuscript.
- CENTRE FOR CITIES (2010) *Cities Outlook 2010*. Technical Report. Centre for Cities, London.
- CHESHIRE P. and MAGRINI S. (2009) Urban growth drivers in a Europe of sticky people and implicit boundaries, *Journal of Economic Geography* **9**, 85–115.
- CURRIE E. and WILLIAMS S. (2010) The geography of buzz: art, culture and the social milieu in Los Angeles and New York, *Journal of Economic Geography* **10**, 423–451.
- DE GOEI B., BURGER M., VAN OORT F. and KITSON M. (2009) *GaWC Research Bulletin 268* (available at: <http://www.lboro.ac.uk/gawc/rb/rb268.html>).
- DE PROPRIIS L. (2005) Mapping local production systems in the UK: methodology and application, *Regional Studies* **39**, 197–211.
- DERUDDER B., TAYLOR P. J., NI P., DE VOS A., HOYLER M., HANSENS H., BASSENS D., HUANG J., WITLOX F., SHEN W. and YANG X. (2010) Pathways of change: shifting connectivities in the world city network, 2000–08, *Urban Studies* **47**, 1862–1878.
- EUROSTAT/GISCO (2012) *Administrative Units and Statistical Units* (available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/gisco_Geographical_information_maps/popups/references/administrative_units_statistical_units_1).
- FAULCONBRIDGE J. R. (2007) London's and New York's advertising and law clusters and their networks of learning: relational analyses with a politics of scale?, *Urban Studies* **44**, 1635–1656.
- FLORENCE P. S. (1948) *Investment, Location, and Size of Plant*. Cambridge University Press, Cambridge.
- GODDARD J. B. (1973) Office employment in Central London: a spatial analysis, *Progress in Planning* **1**, 111–232.
- GRAHAM S. (2002) Communication grids: cities and infrastructure, in SASSEN S. (Ed.) *Global Networks, Linked Cities*, pp. 71–92. Brunner-Routledge, Abingdon.
- GRAHAM S. and MARVIN S. (1996) *Telecommunications and the City: Electronic Spaces, Urban Places*. Routledge, London.
- GUILLAIN R. and LE GALLO J. (2010) Agglomeration and dispersion of economic activities in and around Paris: an exploratory spatial data analysis, *Environment and Planning. B, Planning and Design* **37**, 961–981.
- HALBERT L. (2004) Densité, desserrement, polycentrisme et transformation économique des aires métropolitaines. Interpréter la concentration des activités d'intermédiation dans la zone centrale de la région francilienne. PhD thesis. Université Panthéon-Sorbonne, Paris.

- HALBERT L. (2008) Examining the mega-city-region hypothesis: evidence from the Paris city-region/Bassin Parisien, *Regional Studies* **42**, 1147–1160.
- HALBERT L., PAIN K. and THIERSTEIN A. (2006) European polycentricity and emerging mega-city-regions – ‘one size fits all’ policy?, *Built Environment* **32**, 194–218.
- HALL P. (1962) *The Industries of London*. Hutchison University Library, London.
- HALL P. (1987) *Western Sunrise: The Genesis and Growth of Britain’s Major High Tech Corridor*. Allen & Unwin, London.
- HALL P. (2001) Global city-regions in the twenty-first century, in SCOTT A. J. (Ed.) *Global City-Regions: Trends, Theory, Policy*, pp. 79–97. Oxford University Press, Oxford.
- HALL P. and PAIN K. (Eds) (2006) *The Polycentric Metropolis: Learning from Mega-City Regions in Europe*. Earthscan, London.
- HOYLER M., KLOOSTERMAN R. C. and SOKOL M. (2008) Polycentric puzzles – emerging mega-city regions seen through the lens of advanced producer services, *Regional Studies* **42**, 1055–1064.
- KYNASTON D. (2001) *The City of London, Vol. IV: A Club No More, 1945–2000*. Chatto & Windus, London.
- MARTIN R. and SUNLEY P. (2003) Deconstructing clusters: chaotic concept or policy panacea?, *Journal of Economic Geography* **3**, 5–36.
- MCCANN P., ARITA T. and GORDON I. R. (2002) Industrial clusters, transactions costs and the institutional determinants of MNE location behaviour, *International Business Review* **11**, 647–663.
- MICROSOFT (2012) *Our Offices* (available at: <http://careers.microsoft.com/careers/en/gb/offices.aspx>).
- NACHUM L. and KEEBLE D. (1999) *Neo-Marshallian Nodes, Global Networks and Firm Competitiveness: The Media Cluster of Central London*. Working Paper Number 138. University of Cambridge, ESRC Centre for Business Research, Cambridge.
- O’DONOGHUE D. and GLEAVE B. (2004) A note on methods for measuring industrial agglomeration, *Regional Studies* **38**, 419–428.
- ONNELA J. P., SARAMÄKI J., HYVÖNEN J., SZABÓ G., LAZER D., KASKI K., KERTÉSZ J. and BARABÁSI A. L. (2007) Structure and tie strengths in mobile communication networks, *Proceedings of the National Academy of Sciences, USA* **104**, 7332–7336.
- ORACLE (2012) *United Kingdom Field Offices* (available at: <http://www.oracle.com/uk/corporate/contact/united-kingdom-offices-307766-en-gb.html>).
- PAIN K. (2008) Examining ‘core–periphery’ relationships in a global city-region: the case of London and South East England, *Regional Studies* **42**, 1161–1172.
- PAIN K. and HALL P. (2008) Informational quantity versus informational quality: the perils of navigating the space of flows, *Regional Studies* **42**, 1065–1077.
- PAIN K. and WALKER D. R. F. (2005) *POLYNET Action 1.2: Quantitative Analysis of Service Business Connections*. Technical Report. Institute of Community Studies/The Young Foundation (available at: http://www.polynet.org.uk/docs/1_2_see.pdf).
- PARR J. B. (2004) The polycentric urban region: a closer inspection, *Regional Studies* **38**, 231–240.
- POLÈSE M., RUBIERA-MOROLLÓN F. and SHEARMUR R. (2007) Observing regularities in location patterns an analysis of the spatial distribution of economic activity in Spain, *European Urban and Regional Studies* **14**, 157–180.
- RATTI C., SOBOLEVSKY S., CALABRESE F., ANDRIS C., READES J., MARTINO M., CLAXTON R. and STROGATZ S. H. (2010) Redrawing the map of Great Britain from a network of human interactions, *PLoS One* **5**, 1–6.
- READES J. (2011) The place of telecommunications: spatial decision-making by firms in the age of global communications. PhD thesis. University College London, London.
- RUTHERFORD J. (2004) *A Tale of Two Global Cities: Comparing the Territorialities of Telecommunications Developments in Paris and London*. Ashgate, Aldershot.
- SASSEN S. (1991) *The Global City: New York, London, and Tokyo*. Princeton University Press, Princeton, NJ.
- SASSEN S. (2002) Locating cities on global circuits, in SASSEN S. (Ed.) *Global Networks, Linked Cities*, pp. 1–36. Brunner-Routledge, Abingdon.
- SCOTT A. J. (1997) The cultural economy of cities, *International Journal of Urban and Regional Research* **21**, 323–340.
- SCOTT A. J. (Ed.) (2001) *Global City-Regions: Trends, Theory, Policy*. Oxford University Press, Oxford.
- SMITH D. (2011) Polycentricity and sustainable urban form. PhD thesis. University College London, London.
- SONN J. W. and STORPER M. (2007) The increasing importance of geographical proximity in knowledge production: an analysis of US patent citations, 1975–1997, *Environment and Planning A* **40**, 1020–1039.
- STORPER M. and VENABLES A. J. (2004) Buzz: face-to-face contact and the urban economy, *Journal of Economic Geography* **4**, 351–370.
- TAYLOR P. J., BEAVERSTOCK J. V., COOK G. A. S., PANDIT N. R., PAIN K. and GREENWOOD H. (2003) *Financial Services Clustering and its Significance for London*. Technical Report. Corporation of London, London.
- TAYLOR P. J., EVANS D. M., HOYLER M., DERUDDER B. and PAIN K. (2009) The U.K. space economy as practised by advanced producer service firms: identifying two distinctive polycentric city-regional processes in contemporary Britain, *International Journal of Urban and Regional Research* **33**, 700–718.
- TAYLOR P., HOYLER M., EVANS D. and HARRISON J. (2010) Balancing London? A preliminary investigation of the ‘Core Cities’ and ‘Northern Way’ spatial policy initiatives using multi-city corporate and commercial law firms, *European Planning Studies* **18**, 1285–1299.
- TAYLOR P. J. and WALKER D. R. F. (2001) World cities: a first multivariate analysis of their service complexes, *Urban Studies* **38**, 23–48.
- TOWNSEND A. M. and MOSS M. L. (2008) New York: the city of the telephone, in RATTI C. (Ed.) *New York Talk Exchange*, pp. 25–30. MIT Press, Cambridge, MA.
- WEBBER C. and SWINNEY P. (2010) *Private Sector Cities: A New Geography of Opportunity*. Technical Report. Centre for Cities, London.