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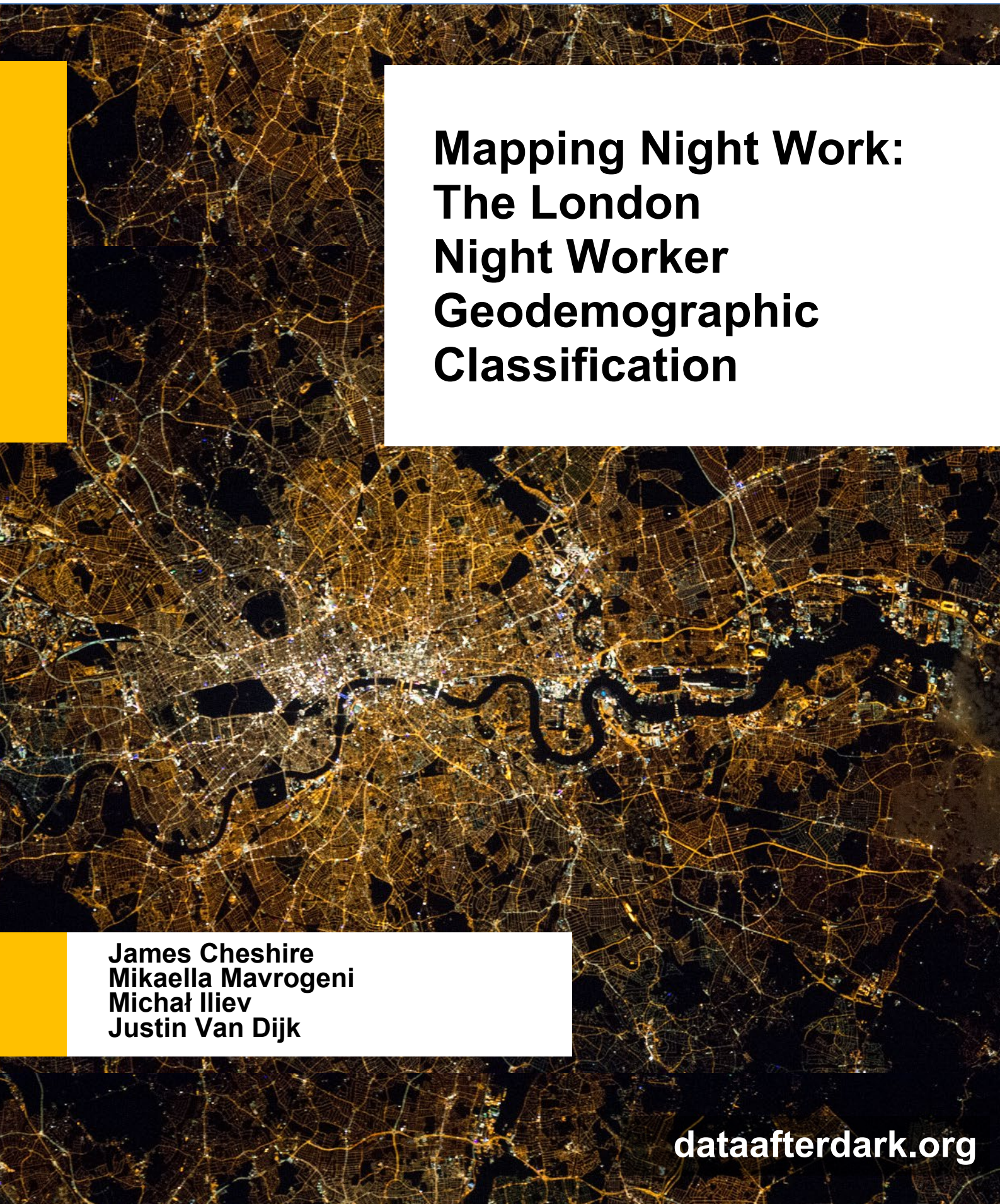

Mapping Night Work: The London Night Worker Geodemographic Classification

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dataafterdark.org

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Abstract

In this paper we strive for a more comprehensive picture of the geography of night working in London (UK). Approximately a quarter of London's workforce is employed in the evening and night-time economy, working between the hours of 6pm and 6am. Compared to those people who work during the day, there is little public information on where they work, how they travel to work, and what amenities they use during work hours. By combining official employment statistics with mobile phone mobility footfall data we construct the London Night Worker Classification, which is a novel small area geodemographic classification based on night-working characteristics.

Keywords

night workers, night-time economy, geodemographic classification, cluster analysis

Research Questions

1. How can a geodemographic classification be constructed to identify spatial patterns of night working in London?

2. What are the key characteristics and typologies of night working geographies across the capital?

3. How can such a classification inform policy interventions in transport, economic planning, and worker welfare?

By integrating mobile phone data with industry-level employment statistics, the London Night Worker Classification (LNWC) offers an empirically grounded and policy-relevant representation of the night-time workforce. The paper proceeds by reviewing relevant literature, outlining the methodological framework, presenting the classification results, and reflecting on their implications.

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1. Introduction

Approximately 1.32 million individuals, representing a quarter of London's workforce, regularly work during evening and night-time hours between 6pm and 6am (GLA Economics, 2024). Additionally, between 2017 and 2023, the number of business sites operating within London's night-time industries grew by 11.3%, reaching 135,700. The significance of the night-time economy is further highlighted by the appointment in 2016 by the Greater London Authority (GLA) of a "Night Czar"; a role dedicated to representing and developing the city's nightlife, which is similar to initiatives in over 40 cities worldwide (Seijas and Gelders, 2021). Recent years have also seen increasing policy attention to night-time strategies, exemplified by the GLA's 24-hour Vision introduced in 2017 (GLA, 2017) and the recently established Nightlife Taskforce (Mayor of London, 2025). Despite these initiatives, there remains a significant gap in research on the spatial distribution of night workers, their workplaces, and commuting patterns. In addition, the night-time economy challenges conventional worker classification frameworks, as night-time employment differs significantly from daytime work. Night workers often have less predictable activity patterns, and distinct mobility behaviours, making them harder to capture through standard employment surveys (see, for instance, Kolioulis et al., 2021; Acuto et al., 2025).

In this paper we detail a geodemographic classification (cf. Vickers and Rees, 2007; Gale et al., 2016; Cockings et al., 2020; Wyszomierski et al., 2024) tailored to night workers in the Greater London (UK) area. This classification is an outcome from a policy-led research project that was commissioned by the Mayor of London to contribute to the evidence base informing the city's night-time economy. Funding was provided for three strands of activity: the first being a comprehensive survey of both night workers and their employers; the second being a series of long table discussions to gather detailed experiences of a select group of key and often underrepresented night workers; and the third strand, which is the focus of this paper, was the development of an area-based quantitative classification of night workers.

We first set out the methodological approach taken to the classification, which blends both commercial mobile phone activity data with more traditional employment statistics. The input variables to the classification were selected based on findings from the commissioned survey of night workers and their employers and the outcomes were tested by consultation with key policymakers within the Greater London area. We argue that integrating open and commercial datasets presents a valuable opportunity to develop a granular and transparent data resource. In addition, we believe that this approach offers a means to reconcile the limitations of both open survey data and commercial mobile phone location data, thereby generating timely, data-

rich outputs that remain sufficiently detailed and open to peer scrutiny to offer a more comprehensive understanding of night-time employment in London.

Whilst the geographic extent of this research is London, we have developed an approach that could be scaled to other cities not just in the UK but globally. For that reason, we regard this research as a useful basis for a much-needed expansion in the availability of detailed policy relevant data for the significant proportion of the population who work during the night-time hours.

2. Literature Review

2.1. Scholarly attention to the night-time economy

Scholarly interest in the night-time economy emerged in the mid-1990s (e.g. Hollands, 1995; Bianchini, 1995), with an initial focus on entertainment, cultural events, and the hospitality industry, particularly in British cities (Shaw, 2010). Shaw (2014) argues that early studies on the night-time economy drew attention to the development of the alcohol and leisure industries and their economic benefits for inner cities. This focus aligned well with policy initiatives targeted to restructuring city centres around consumer-driven activities (Lovatt & O'Connor, 1995; Hobbs et al., 2001). As a result, the night-time economy in the academic literature before 2010 was framed through an economic and commercial lens, alongside concerns about its negative externalities, such as anti-social behaviour (e.g. Moore et al., 2007; Crawford & Flint, 2009).

It was not until the 2010s that studies on the night-time economy became connected with the field of 'nocturnal research' (see Shaw, 2015; Gwiazdzinski et al., 2018). This has broadened scholarship to examine issues such as health (Bushell 2023), tourism (Zmyslony and Pawlusiński, 2019), racial/ethnic inequalities (Schwanen et al., 2012), queer geographies (Campkin and Marshall, 2018), precarious work (Kolioulis et al., 2021), culture (Rowe and Bavinton, 2011), governance (Roberts & Eldridge, 2009), and transportation equity (McArthur et al., 2019; Smeds et al., 2020). In parallel, policymaking has evolved, with cities adopting more holistic and inclusive strategies for managing the night-time economy. This shift reflects a growing recognition that the night-time economy extends beyond leisure and consumption, representing a dimension of urban economies.

Despite the growing body of research on social, environmental, and cultural dimensions of the night-time economy, there remains an urgent need for improved night-time evidence, as current strategies often rely on daytime-centric assumptions and frameworks (Acuto et al., 2022). To generate more

accurate insights into the night-time economy in particular, it is critical to ensure that both research and policymaking consider the experiences not only of night-time consumers but, more importantly, “of those who are busy producing and sustaining this economy” (Acuto et al., 2022: 109).

2.2. Past approaches to estimating the number of night workers in the UK and London

Home to approximately 8.9 million people (approximately 13% of the total UK population), Greater London is a major employment hub (ONS, 2024a). With an economy valued at nearly £520 billion ($655 billion), many sectors operate beyond standard working hours, and late-night activity is prevalent across various industries. In 2023, the size of London’s workforce was approximately 5.3 million people, including both residents and commuters from outside the city. Of these, 1.32 million were classified as night-time workers, constituting 16% of the UK’s night workforce (GLA Economics, 2024). Despite its high absolute number of night workers, the city's night-working rate (25%) remains comparable to the national average (26%). Notwithstanding this, like the rest of the UK, the city has seen a decline in night-time employment in recent years, falling from 1.60 million in 2017 and remaining below this pre-pandemic level (ONS, 2023; GLA Economics, 2024).

London’s night workers are spread across the city, with 544,000 residing in Inner London boroughs, 553,000 in Outer London boroughs, and 222,000 living outside the capital.[1] However, more night workers are employed in Inner London (791,000) than in Outer London (528,000). The sectors with the highest shares of night workers in London include Professional Services, Health, and Transport & Storage, which together employ 40% of the city’s night workforce (GLA Economics, 2024).

Where these statistics provide an idea of the overall number of people involved in the night-time economy, a fundamental challenge in accurately estimating the number of night workers lies in defining what constitutes ‘night’ and ‘work’ (Acuto et al., 2025). Where in the US, for instance, the night-time economy is often referred to as the ‘other 9-to-5’ (e.g. Dentel-Post et al., 2017), UK studies have adopted broader time frames. The GLA and Office for National Statistics (ONS) define the night-time economy as encompassing all

[1] London boroughs are divided into Inner and Outer London, a distinction set out in the *London Plan* (GLA, 2021). *The London Plan 2021* is the Spatial Development Strategy for Greater London, setting out a framework for how the city will develop over the next 20–25 years.

economic activities occurring between 6pm and 6am (see Wickham, 2012, for one of the earliest uses). Based on this definition, night workers are those who typically work during these hours. However, due to the complex and often informal nature of night-time work, accurately counting night workers nonetheless presents significant methodological challenges, making it difficult to determine their distribution across the city (see Acuto et al., 2025 for an overview).

To estimate the number of people that work between 6pm and 6am in the UK, researchers rely heavily on the UK's Labour Force Survey (LFS). The LFS is the UK's largest quarterly household survey, covering approximately 38,000 households in each wave. More importantly, it is the only nationwide survey conducted by the ONS that collects data on individuals' working hours. However, questions regarding usual working patterns are asked only once per year, in the second quarter. These questions assess whether respondents typically work during the day, evening, or night, with individuals able to select all applicable categories. Based on LFS responses, a person is classified as a night-time worker if they "usually" work either in the evening or at night, regardless of whether they also work during the day. Under this definition, it was estimated that approximately 8.4 million people in the UK could be considered night-time workers in 2023 (GLA Economics, 2024). A major shortcoming is that the LFS does not specify timeframes for 'day', 'evening' or 'night', leaving respondents to interpret these terms subjectively. As a result, individuals with identical working patterns may respond differently.

Due to the limited number of respondents, the LFS only provides insights at the UK-wide and city-wide level. To refine these estimates, the GLA collaborated with the ONS in 2018 to develop a more granular analysis, as outlined in *London at Night: An Evidence Base for a 24-Hour City* (GLA Economics, 2018). The methodology involved first identifying "night-time industries" based on LFS responses and then using the total number of workers in these industries as a proxy for the overall size of the night-time workforce. Each LFS respondent provides a three-digit Standard Industrial Classification (SIC)[2] code for the industry they work in. Industries were classified as night-time if they had a higher-than-average proportion of night-time workers (29%) and a sample size of at least 30. The selected industries (see **Appendix A**) were grouped into four categories: (1) night-time cultural and leisure activities, (2) activities supporting night-time cultural and leisure activities, (3) 24-hour health and personal social services, and (4) activities supporting broader social and economic functions (ONS, 2023). Finally, the

[2] The SIC system categorises business establishments and other statistical units by the type of economic activity in which they are engaged. Each digit of the SIC code provides a progressively more granular industry classification: section (first letter), division (two digits), major group (three digits), class (four digits) and subclass (five digits).

total number of employees in the selected industries, as recorded in the Inter-Departmental Business Register (IDBR)[3], was counted as the number of night-time workers at the local level.

While the approach allows for the estimates of the size of the night-time workforce to be broken down for different parts of the city, there are some limitations. A report by the ONS (2023b), for example, indicated that only 60% of night workers identified in the LFS survey were employed in these selected industries. This means that 40% of night workers, along with an uncounted number of informal workers, are not accounted for at a local level. Conversely, some individuals may be classified as night workers simply because they are employed in these industries, even if they do not primarily work at night. The limitation of this approach is evident from the 2022 estimate of night-time industry employees in London (1.84 million), which significantly exceeds the LFS figure (GLA Economics, 2024). Furthermore, while both city-wide and local estimates provide a broad measure of the scale of the night-time economy, they do not account for specific working hours or seasonal variations, nor do they offer a detailed spatial distribution of workers and workplaces.

2.3. New approaches to considering night workers activities

Given the limitations of the data sources detailed above, it is important to turn to new forms of data to create a richer spatial depiction of night workers in London. Alongside business trading information, mobile phone location data has been identified as one of the most effective tools for measuring the size and spatio-temporal distribution of the night-time workforce (GLA Economics, 2018). Given that most adults possess a mobile phone and Call Detail Records (CDRs) are passively generated by them, mobile phone operators now routinely offer data products that detail both the ambient population of an area as well as the flows of people to and from it in a highly granular way, both spatially and temporally.

Although these products are limited by the demographic biases of their subscriber base (resulting in the under/over representation of certain population groups) and geographic biases (uneven sampling of locations per individual), they have seen widespread use within research, policy and commercial contexts (Panczak et al., 2020). A common application is the inference of home and work locations based on the frequency and timing of a

[3] The Inter-Departmental Business Records (IDBR) is a comprehensive list of UK businesses used by the government for statistical purposes.

user's presence in particular areas (Yang et al., 2021). The analytical methods deployed to do this range from simple frequency counts to more sophisticated heuristics that incorporate time-of-day patterns and activity trends (Verma et al., 2024). Since the activity patterns of night workers are reversed compared to the general population (i.e., they are present at their workplaces during night-time hours), the group is more prone to misclassification and requires particular consideration from data suppliers. The resulting footfall data offer significant advantages over traditional surveys by accurately identifying night-work activity hotspots and the specific times of day and week when such activity occurs.

2.4. Towards a classification of night workers in London

Mobile phone derived population data can be combined with additional data sources and clustered to create a geodemographic classification (see Singleton et al., 2020). Such classifications have typically involved the grouping of small geographic areas with similar socioeconomic characteristics and are a long-established approach to data reduction, which has found common applications in a range ofpolicy contexts (Singleton and Spielman, 2014). Traditional classifications, such as the “Output Area Classification” (OAC) (see Gale et al., 2016), emphasise the grouping of populations based on a broad range of variables collected through official statistics (such as censuses and administrative data) to provide a comprehensive representation of a given area. However, there has been a growing shift towards the development of classifications tailored to specific policy objectives or contextual applications. These purpose-driven classifications employ a more selective set of variables, often informed by policy consultations or survey data. Singleton and Longley (2019) illustrate this shift by demonstrating how stakeholder consultations influenced the design of the London Workplace Zone Classification (LWZC). By incorporating policymakers’ recommendations on variable selection and testing the practical utility of the resulting classification with end users, the authors ensured its relevance and applicability in practice.

Where the LWZC includes a variable on night-time businesses, this factor did not emerge in the final classification groups. It is against this background that we propose a specialised classification to help policymakers better understand the complex landscape of night-work in London. This includes identifying which work zones are active at different times and the predominant industries within them. In common with Singleton and Longley (2019), we adopt a hybrid geodemographic classification that integrates standard open datasets with new forms of data. Moreover, the process of integrating multiple

activity layers, each potentially sensitive on its own, helps mitigate disclosure risks and ethical challenges arising from the mapping of mobile phone location data (see Sieg et al., 2023). This policy-driven focus represents a key strength of geodemographic classification, which we aim to exploit in this study by incorporating insights from consultations with the GLA and outcomes of the night workers survey.

3. Data and Methods

The London Night Worker Classification (LNC) draws on two main sources of data: employment statistics and mobile phone activity. Employment structure data highlights industries where night workers are more prevalent, while mobile phone data contains granular spatial and temporal insights that are unlikely to be published in their raw form. To align with the London policy context and definitions used by the GLA and ONS, we explicitly define evening and night workers, hereinafter collectively referred to as night-time workers, as those who “usually” work between 6pm and 6am.

3.1 Employment structure data

Employment structure relates to the composition of the night-time economy in terms of businesses that operate during night hours. Similar to the approach taken by the GLA and ONS (GLA Economics, 2018), we use this as a proxy for the demand for night workers and to identify potential key night-worker locations. For this, we use the Directory of London Businesses, available through the London Datastore. The dataset includes a comprehensive list of businesses with detailed information on business locations and their Standard Industrial Classification (SIC) codes, which allows for aggregation. Alternative data sources such as the Inter-Departmental Business Register (IDBR) published by the Office for National Statistics, and the Business Census available through the Consumer Data Research Centre, were also considered (ONS, 2025; CDRC, 2024). However, since the IDBR is sold as a commercial product and access to the Business Census is restricted and requires an application, the Directory of London Businesses was selected for its accessibility as a publicly available dataset.

Rather than following the GLA and ONS framework, we use a more specific subset of SIC categories to define night-time industries. These categories were informed by the comprehensive survey of both night workers and their employers, conducted over a five-month period as part of the broader programme of work of which this research is part (see **Appendix B**). The

survey consisted of two online questionnaires hosted on the Commonplace survey platform (see commonplace.is) and was designed to capture the views of night workers and the businesses that employ them. The survey was promoted through University College London (UCL) and the GLA, along with a wide range of networks, including Business Improvement Districts (BIDs), trade unions, trade bodies, and organisations such as Citizens UK. The survey captured 584 responses from night workers and a further 64 responses from businesses. These responses were further supplemented by interviews with a range of night workers across several London boroughs, as well as two focus groups held on 10th June and 24th July. The interviews included cleaners, hospitality workers, and on-demand delivery drivers.

The final employment structure variables record the total number of businesses in each relevant industry sector by square kilometre at the Lower Layer Super Output Area (LSOA) level. LSOAs are commonly geographic units used in the UK for statistical analysis and are popular with policy makers. Each LSOA typically contains between 400 to 1,200 households and encapsulate between 1,000 and 3,000 residents (ONS, 2024b). For 2021 London LSOAs, this range is slightly higher, consisting between 1,000 to 4,300 residents. Table 1 provides an overview of the employment structure variables used in the classification.

Table 1: Employment structure variables

Industry sector	Variable	Spatial scale
Arts and recreation	Number of arts and recreation businesses by km^2	LSOA
Health	Number of health businesses by km^2	LSOA
Hospitality	Number of hospitality businesses by km^2	LSOA
Manufacturing	Number of manufacturing businesses by km^2	LSOA
Public services	Number of public administration and defence businesses by km^2	LSOA
Retail	Number of retail businesses by km^2	LSOA
Security	Number of businesses operating in the security sector by km^2	LSOA
Transport	Number of businesses operating in the transport and storage sector by km^2	LSOA

3.2 Mobile phone activity data

To capture night-worker activity, we utilise BT footfall data licensed through the GLA High Streets Data Service. This dataset is derived from mobile phone data gathered from EE – the UK's largest mobile network (owned by BT) - with a 30% market share as of 2022 (Statista, 2022). The data are collected by continuously tracking all devices on the network, using signal triangulation. According to BT's documentation, this method offers greater location accuracy than traditional mobile network data. For data validation, BT compared its footfall counts to official match-day attendance figures at two London football stadiums – Craven Cottage and Emirates Stadium – finding only a 0.3% and 4.6% difference, respectively. In addition, the data are scaled to the UK's population using age band and gender from census data to mitigate potential biases arising from variations in BT's market share across different regions. As a result, the provided counts represent estimates of the true footfall, rather than just BT users.

Home and work locations are inferred according to the first most visited and second most visited locations. In personal communication, BT representatives outlined that points are clustered using DBSCAN if they fall within a spatial proximity of 150 metres, indicating they belong to the same location. The device needs to appear at a location for at least 10 minutes and be present for two-thirds of the month to be recorded in the dataset. For reasons of statistical disclosure control, the final processed dataset is aggregated to a 350-metre hexagonal grid resolution, recording total footfall counts of workers, residents, and visitors by day, across three-hour intervals for January 2024. Table 2 summarises the 'BT footfall' variables, which represent average worker activity across three-hour windows between 6pm and 6am. Acknowledging that activity patterns may fluctuate throughout the week, the data were also categorised into weekday, weekend, and Sunday types.

Table 2: BT mobile phone activity variables

Activity type	Variable	Spatial scale
Weekday activity	Night-worker density between 6pm and 9pm Monday-Thursday	350-metre hexagonal grid
Weekday activity	Night-worker density between 9pm and 12am Monday-Thursday	350-metre hexagonal grid
Weekday activity	Night-worker density between 12am and 3am Monday-Thursday	350-metre hexagonal grid
Weekday activity	Night-worker density between 3am and 6am Monday-Thursday	350-metre hexagonal grid
Weekend activity	Night-worker density between 6pm and 9pm Friday-Saturday	350-metre hexagonal grid
Weekend activity	Night-worker density between 9pm and 12am Friday-Saturday	350-metre hexagonal grid
Weekend activity	Night-worker density between 12am and 3am Friday-Saturday	350-metre hexagonal grid
Weekend activity	Night-worker density between 3am and 6am Friday-Saturday	350-metre hexagonal grid
Sunday activity	Night-worker density between 6pm and 9pm Sunday	350-metre hexagonal grid
Sunday activity	Night-worker density between 9pm and 12am Sunday	350-metre hexagonal grid
Sunday activity	Night-worker density between 12am and 3am Sunday	350-metre hexagonal grid
Sunday activity	Night-worker density between 3am and 6am Sunday	350-metre hexagonal grid

Figure 1 presents the average number of workers within each 350-metre hexagonal grid. Similar spatial patterns are observed across the time windows, although the volume of night workers declines throughout the night, with the lowest numbers recorded between 3am and 6am. Central London emerges as the major hotspot for night-worker activity. However, high levels of activity are also evident in employment clusters located outside of Central London. Notably, during the 12am to 6am time windows, worker activity is higher in the eastern parts of the city compared to the western parts, suggesting potential regional differences in night-time working patterns.

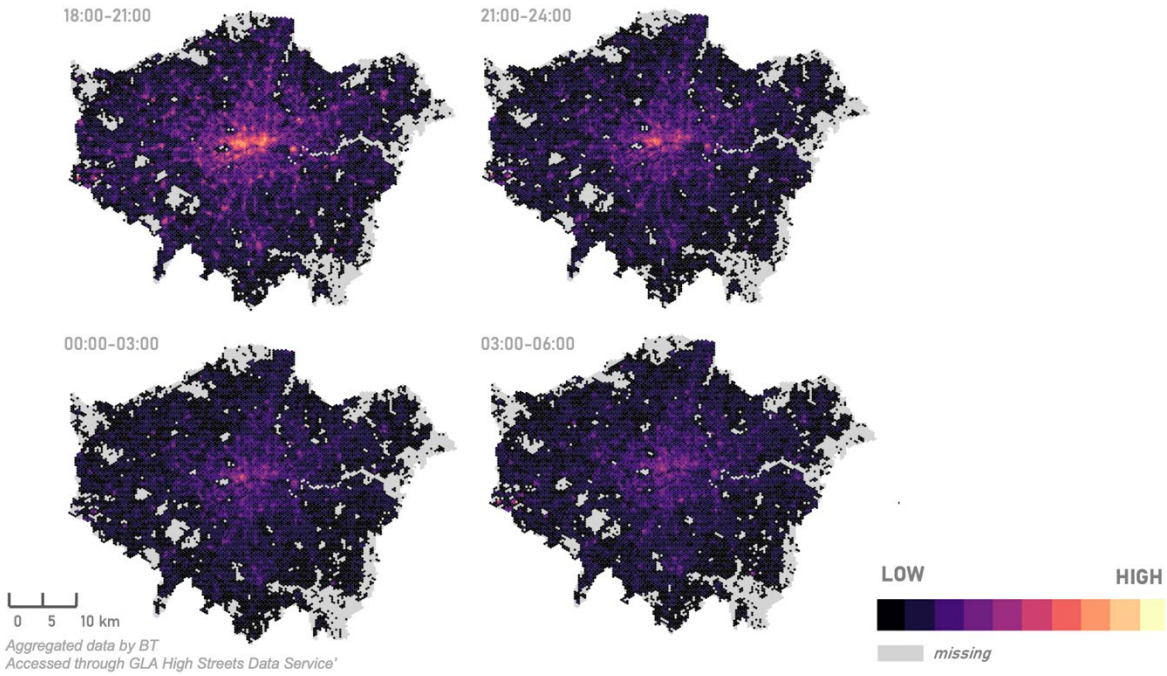


Figure 1: Average workers by 350 metre hexagonal grid by 3-hour block

To align the gridded mobile phone data with the census and administrative geography of the employment variables, we proportionally assign the hexagons to the LSOAs with which they intersect. Figure 2 illustrates this process. For instance, if a total footfall of 100-night workers is recorded within a hexagon that intersects with three LSOAs, these night workers are assigned proportionally to these three LSOAs based on the degree of overlap. So, if 35 percent of a hexagon falls within ‘LSOA 1’, 35-night workers will be assigned to that LSOA. The total number of people assigned to each LSOA is therefore the sum of all hexagons contributing to that LSOA.

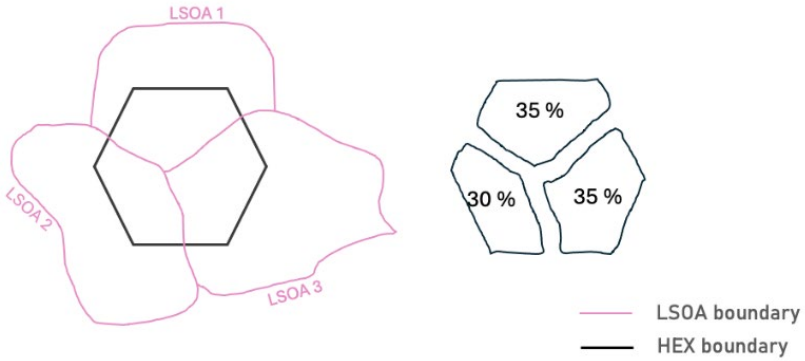


Figure 2: Proportional assignment of Hexagons to LSOAs. This step was necessary as access was not permitted to the more granular mobile phone data prior to its aggregation into hexagons.

3.3 Clustering methodology

The LNC builds on well-established geodemographic classifications such as the OAC and the LWZC (Vickers et al., 2007; Gale et al., 2016; Cockings et al., 2020; Wyszomierski et al., 2024). We considered two possible approaches to the development of the classification. The first only utilised the BT footfall data to undertake activity-based clustering, with the aim to identify patterns of night-time worker activity that arise solely from the variation of footfall levels through the days of the week and time windows. However, there was insufficient differentiation within the data to provide robust clusters. This is likely due to the similar activity patterns between time windows that made it difficult to form distinct and meaningful clusters even though each time window experienced different volumes of night-time workers. We therefore pursued a second option which introduced business location variables in addition to BT footfall to provide a more comprehensive representation of night-worker characteristics, linking the supply of night workers (BT footfall data) with the demand for night workers (businesses contributing to the night-time economy).

3.3.1 Data preparation

The first methodological step prepared the data for clustering by normalising and standardising the variables to ensure comparability. To account for the non-uniformity of the areal units, BT footfall and business counts were converted to counts per square kilometre (km²). This adjustment ensured that higher recorded values of BT workers or businesses reflected actual concentration rather than variations in LSOA size. Figure 3 presents the distribution of variables prior to transformation using boxplots, grouped by

domain. All variables exhibited positive skewness, but the BT footfall variables displayed a larger interquartile range (IQR), generally consisted of higher values across LSOAs and had a less pronounced skew than the business variables. The variables with the most extreme outliers were retail businesses per km², weekday workers between 6pm and 9pm, and weekend workers between 6pm and 9pm.

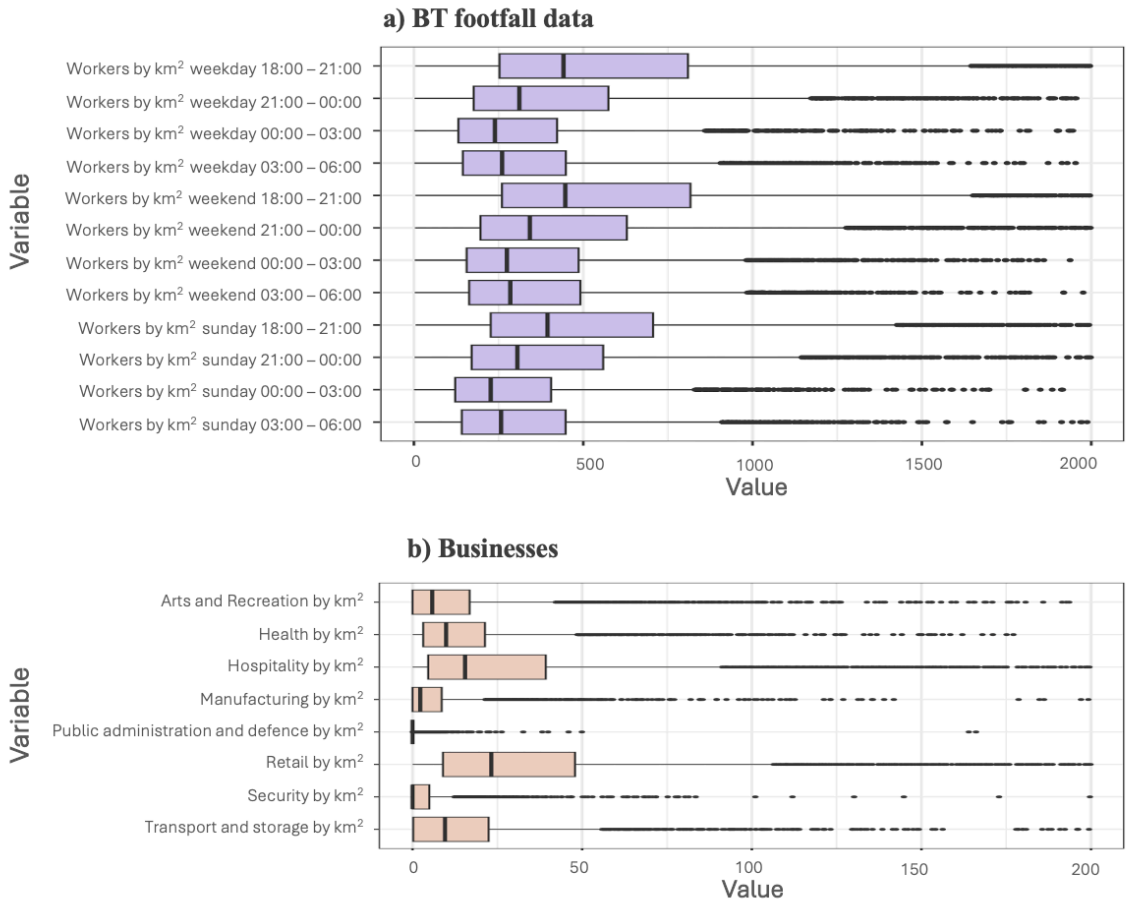


Figure 3: Variable distribution before transformation for a) BT footfall and b) Business variables. Extreme outliers have been removed.

Next, the Inverse Hyperbolic Sine (IHS) transformation method was applied to ensure the normality of the variables (see Wyszomierski et al., 2024; Gale et al., 2014; Vickers et al., 2007). Figure 4 illustrates the distribution of all variables following the transformation. All variables now appear normally distributed but some of the employment variables contain zero values, which were especially prevalent in the public administration and defence variable, but we decided to keep it in the final pool of variables since it appeared in the aforementioned survey as one of the night-worker business categories.

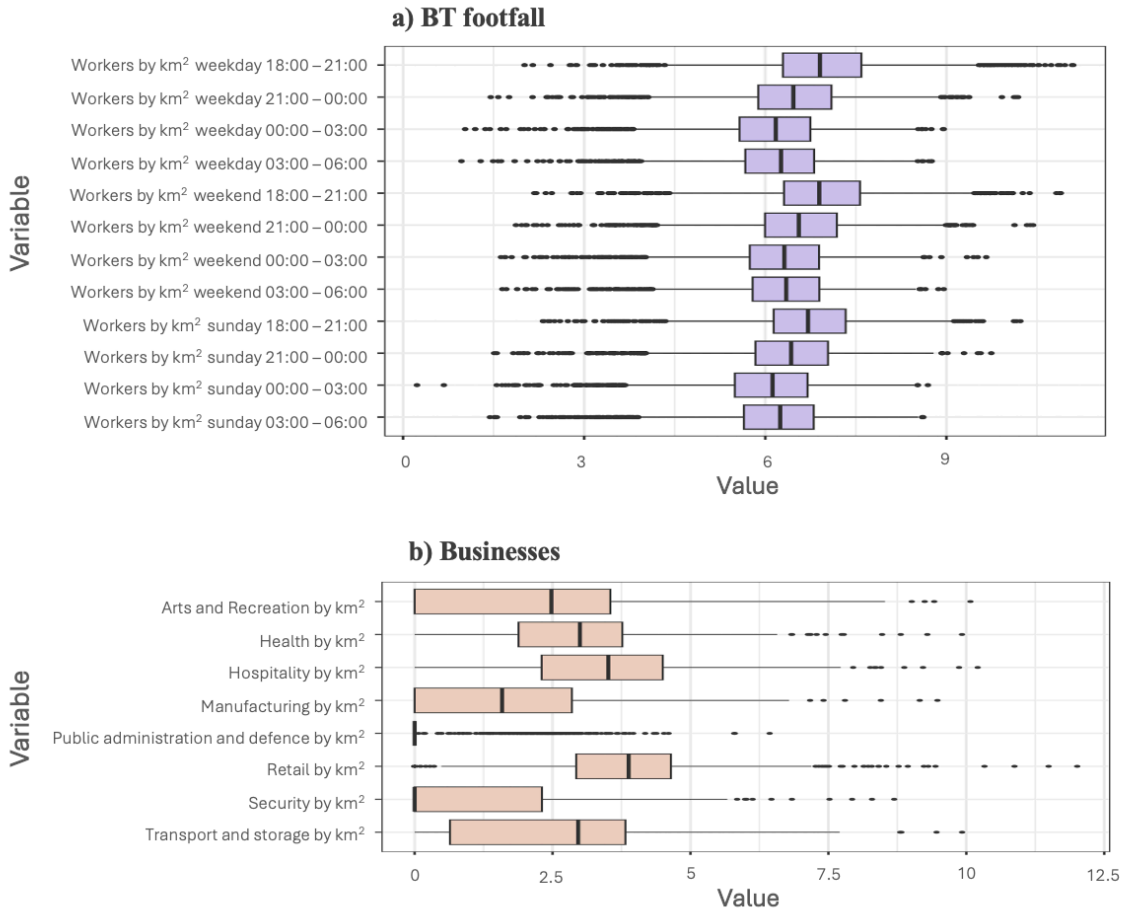


Figure 4: Variable distribution after transformation for a) BT footfall and b) Business variables

Range standardisation was then applied to ensure that all variables were placed on a common scale, ranging between 0 and 1. Finally, the variables were tested for multicollinearity. No issues were identified, as the correlation between any two variables did not exceed the cutoff threshold of 0.7 (Wyszomierski et al., 2024).

3.3.2 K-means clustering

Following data preparation, clustering analysis was conducted in Python version 3.9.7 using the scikit-learn library to group output areas with the greatest similarity based on the selected variables (Pedregosa et al., 2011). K-means clustering was employed, in line with past geodemographic classification research and in recognition of its ability to efficiently partition large datasets. To determine the optimal number of clusters (k), a clustergram

was used to visualise the redistribution of data as additional clusters are introduced (Singleton et al., 2022; Wyszomierski et al., 2024).

The clustergram shown in Figure 5 illustrates the variation between cluster solutions and the partitioning of data across different cluster counts, seeking to maximise between-cluster variation with each additional cluster. A solution with seven clusters was selected as the most appropriate based on its ability to balance compactness (the degree of similarity within clusters) and interpretability (how clearly the clusters can be understood and applied) while avoiding overfitting. This decision was guided by the trade-off between achieving sufficient data partitioning and maintaining well-separated clusters. More importantly, the final classification was guided by extensive consultations (set out below) with possible users of the classification, not least the GLA who were keen to ensure a robust classification that enabled actionable policy.

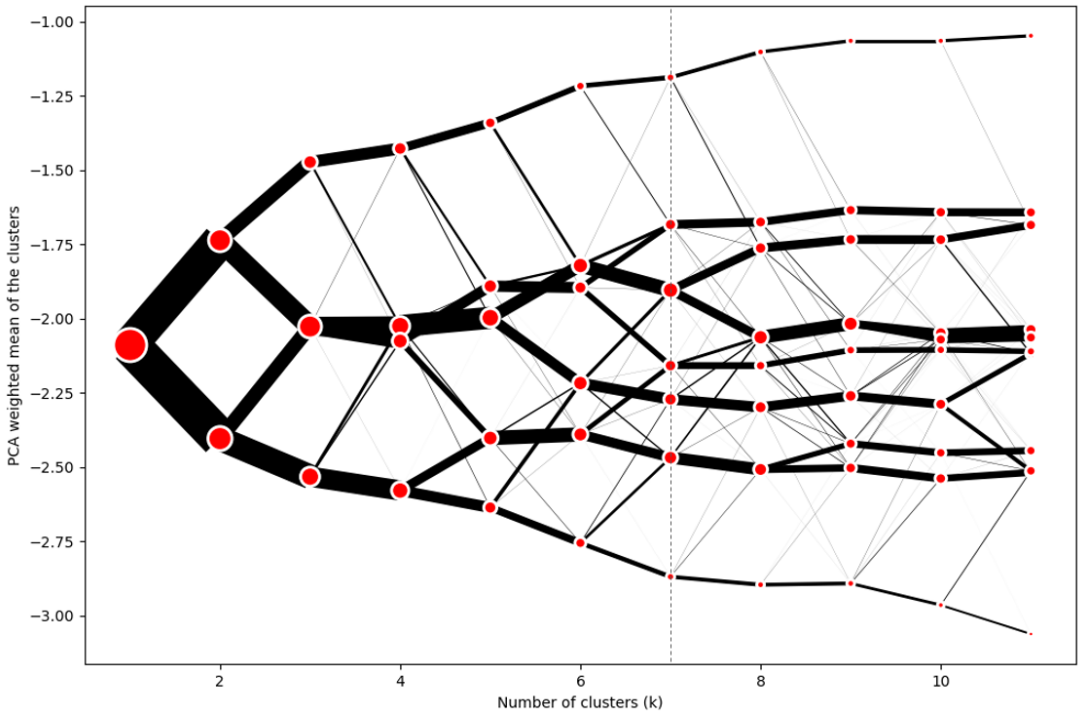


Figure 5: Clustergram of component distribution by number of clusters.

Figure 6 illustrates the contributions of each variable to the cluster allocation, with those above the London average shown in blue, and those below the London average in red. These scores were derived by calculating the difference between the cluster mean and the global mean for each variable. Therefore, values below zero indicate that the variable's average within the cluster is lower than the global mean, while values above zero indicate a higher-than-average contribution. Figure 6 further shows that all variable

scores in Cluster 7 are substantially lower than the global mean, whereas the opposite is true for Cluster 1. Note that order of the clusters as determined by the algorithm differed to the way they are presented here but, to aid in interpretation, the clusters were re-numbered based on the number of night workers, ranked from highest to lowest in comparison to the global average. Radar plots for each cluster and their respective distributions of variable values are presented in **Appendix C**.

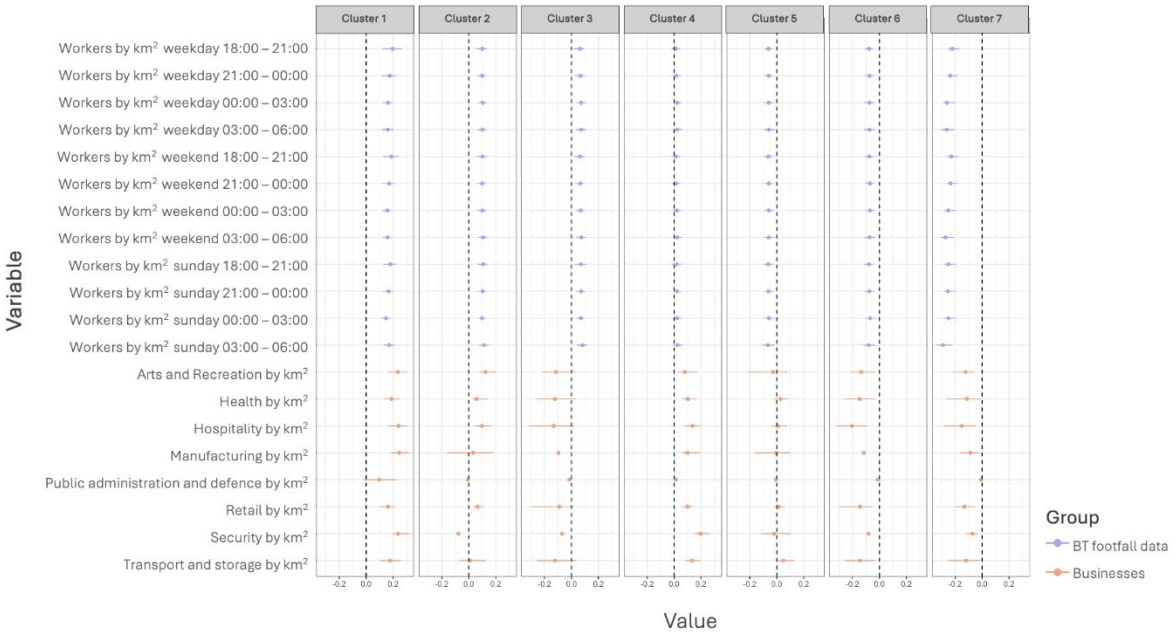
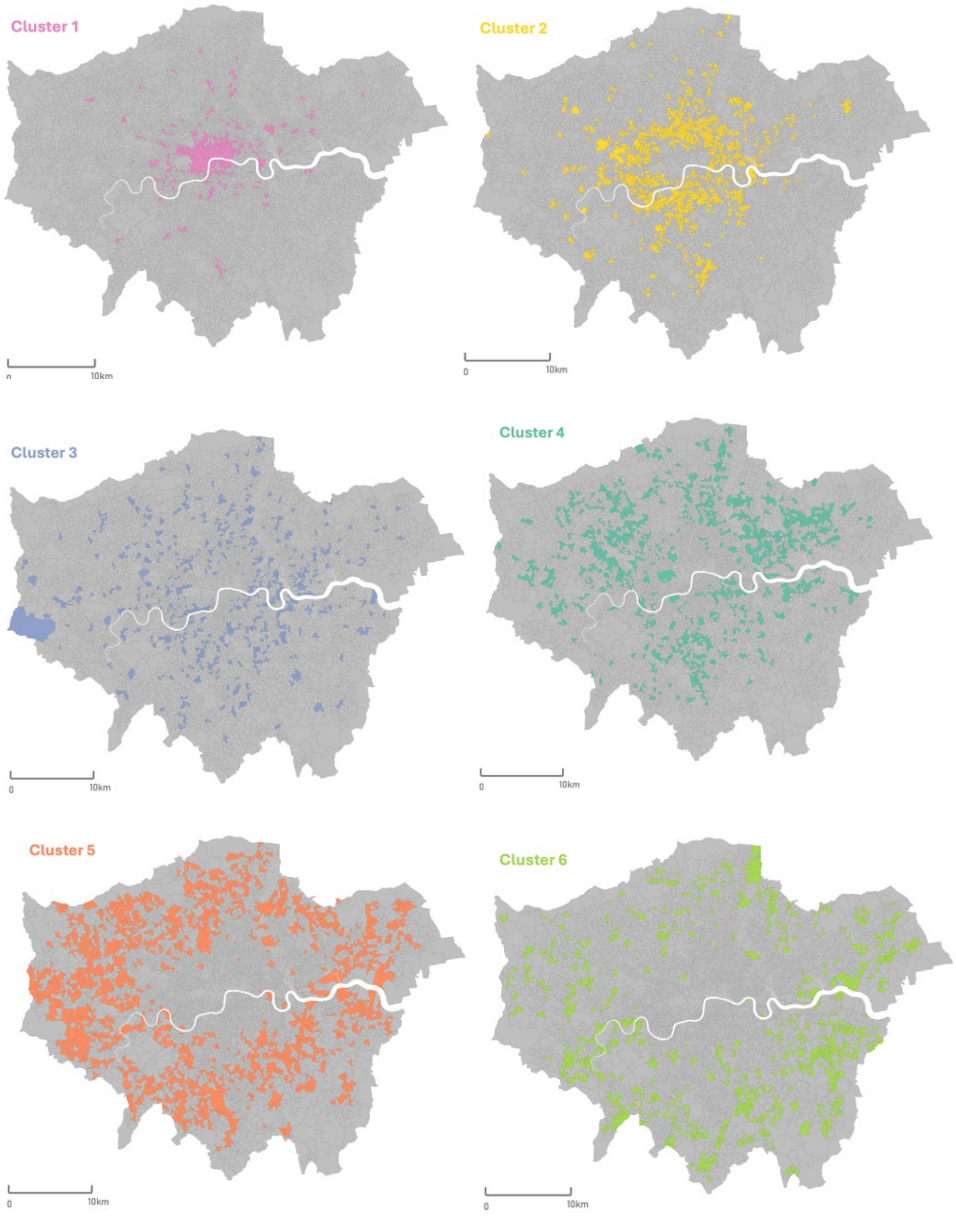


Figure 6: Variable distribution by cluster compared to the global mean (lower quartile, mean, upper quartile)

4. Results

4.1 The London Night Workers Classification

The individual clusters across London are mapped in Figure 7 (for a unified map of the clusters see **Appendix D**), enabling a visual inspection of their spatial distribution. The final step in developing the classification involves assigning descriptive names and pen-portraits to each cluster. This is achieved through understanding the variables that contribute to each cluster, as previously demonstrated in Figure 4.



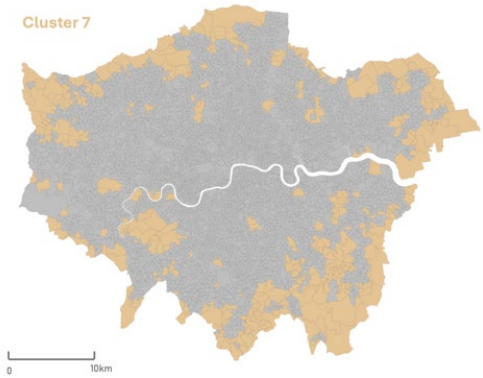


Figure 7: Cluster distribution across Greater London ordered by number of night workers. Cluster 1 has the most night workers and Cluster 7 the least.

4.2 Pen portraits

Clusters generated for geodemographic classifications are typically assigned descriptive names, referred to as ‘pen-portraits’, along with brief descriptions characterising the composition of each cluster. A common method for interpreting clusters involves examining whether the average value of each variable is above or below the global average. Based on the data, we can summarise each cluster as follows:

Cluster 1: Thriving night-worker central hubs
These areas have a much higher than the London average presence of night workers across all time windows and days of the week, particularly from 6pm to 9pm on weekdays, indicating how these areas attract workers who finish their day shifts (9am to 5pm) later in the evening, as well as workers on various types of night shifts, reflected in the higher-than-average night-worker activity across all night-time windows. All business categories associated with the night-time economy are much higher than the London average in this cluster, with arts and recreation, hospitality and retail businesses being dominant.

Cluster 2: Night-worker inner suburbs with high business concentration
These areas exhibit a higher than the London average presence of night workers across all time windows. While similar to Cluster 3 in terms of worker footfall, Cluster 2 differs by having above-average levels of all business categories associated with the night-time economy, except for security and public administration and defence businesses.

Cluster 3: Night-worker inner suburbs with low night business concentration
Cluster 3 exhibits a higher than the London average presence of night

workers at all time windows, but presence of all business categories associated with the night-time economy are underrepresented in this cluster. This suggests that the workers in this cluster may be employed in facilities outside the identified business categories. For instance, Heathrow Airport is in this cluster, which employs a significant number of night workers, such as airport staff. These workers are active during night-time hours, but an airport is not classified under one of the businesses categories that were found to be associated with the night-time economy. Additionally, another group of night workers includes cleaning crews employed in office buildings or public spaces, who typically work during the night to clean and maintain facilities, further contributing to night-time workforce activity outside of the identified night-time economy categories.

Cluster 4: Suburban night-time business locations with average night-worker activity
This cluster is characterised by an average presence of night workers across all time windows and days of the week. All business categories associated with the night-time economy are present at above-global-average levels, with the highest contributions from security, hospitality, and transport and storage businesses.

Cluster 5: Suburban transport, storage and health business locations with low night-worker activity Cluster 5 consists of lower than the London average presence of night workers across all time windows and days of the week. All business categories associated with the night-time economy are generally average, with health, transport and storage being slightly above average, and arts and recreation being the lowest relative to the London average.

Cluster 6: Low night-worker activity suburban zones
This cluster has lower than the London average presence of night workers across all time windows. In terms of night-worker footfall, this cluster resembles Cluster 5. However, it differs in that all business categories associated with the night-time economy are below the London average.

Cluster 7: Night-worker periphery
Located on the outskirts of Greater London, this cluster has an extremely low presence of night workers across all time windows, especially between 3am and 6am on weekdays. All business categories associated with the night-time economy are below the London average in this cluster. It represents the opposite end of the spectrum compared to ‘Thriving Night-Worker Central Hubs’ (Cluster 1) in terms of night-time economy activity.

5. Discussion

The final cluster allocations detailed above – and their interpretation – were shared for comment and validation with key stakeholders in three ways. The first was the circulation of a draft of the results via email to 12 representatives from the GLA and Transport for London (TfL) with interests in night workers and the London night-time economy more broadly. The request to this group was to confirm that the input variables were appropriately selected, and given their knowledge of the sector, that the methodology was robust (if they felt able to do so since a number were data analysts) and finally if the results matched their understandings of the geography of night-working in London. Getting a sense of the latter was important given the local expertise of the stakeholders who would be familiar with their contexts (a major employer for example) that could have been overlooked with this citywide analysis. Feedback was positive with only suggested tweaks to cluster explanations and not core data or methods.

The second point of validation was a stakeholder workshop attended by 15 representatives from the GLA, local councils and businesses and held in December 2024. The classification was presented at this event with an opportunity for feedback and discussion. As with the stakeholder email, feedback was positive with no indication that the data selections and cluster allocations were problematic. The push from the group was to ensure the policy relevance and applications of the work are well articulated and that the data were easily accessible to ensure its widespread and rapid use.

Lastly, we sought to validate this approach against analysis conducted by Transport for London (TfL). TfL operate most of the public transport in London, not least the network of night buses and the “Night Tube” which comprises London Underground and Overground services throughout Friday and Saturday nights. As a local government body with its board appointed by the Mayor of London, TfL is a major stakeholder in the night-time economy.

We therefore requested that an analyst at TfL check the above results against their own findings and understanding of the geography of night workers in London. The TfL data, unlike what has been used here, is tied specifically to where there is transportation infrastructure and so areas where this is lacking will be missing from their analysis. So given these differences in data granularity and sampling we did not see it as appropriate for doing a detailed quantitative comparison between TfL data and our own. Instead, we focused on the geographical patterns and likely interpretation of the results: principally whether they were in line with TfL’s expectations based on travel demand data. After receiving confirmation that this is the case, we are therefore

confident that the LNC offers a comprehensive and robust picture of the geography of night workers in London.

This is the first picture of its kind to be created for the city and marks an important development in the way that new forms of data, when combined with established methods and long established open datasets, can help to create data-driven policy. That said, we are not naïve to the critiques of geodemographic classifications that are well established (see Goss, 1995) and highlight the risks of oversimplification of complex lived experiences and heterogenous areas that may, in its worst form, lead to stereotyping. These concerns are mixed with legitimate anxieties about the ethical use of mobile phone data which can be so disclosive of an individual's movements and transforms them into a commodity to be bought and sold by commercial organisations (see Dalton and Thatcher, 2015 and Sieg et al., 2023). The use of such data, especially for policy, is also contingent on public trust who can see the benefits of its proper analysis and interpretation for the public good and not simply commercial ends.

5.2 Policy implications

As mentioned in the introduction, the creation of the LNC is one of three strands of activity that were jointly funded by the Mayor of London and UCL, the former in its capacity as a decision maker for the city, concerned with informed policy interventions for those within its jurisdiction, the latter in its capacity as a major stakeholder and employer in London, with interests in generating innovative research that has policy impacts for the city.

The LNC has the potential to offer policy insights across the full range of scales from the national to the local. Nationally, the datasets chosen to inform the classification are not unique to London and therefore we see this citywide analysis as a test case for a methodology that can easily be scaled to other areas. Subject to licensing agreements, the BT footfall data is available across the country and the choice of nationally available business data supplied by the ONS offers no barriers in this respect. The caveat here is that the choice of industrial classification variables was informed by the London-based survey and therefore creates a composition most relevant to the city. For a national analysis this will need to be revisited to offer a much broader range of variables. Experience from other geodemographic classifications – particularly the OAC – suggests the continued need for a bespoke London classification as there is likely to be significant heterogeneity in the city that gets lost in the national picture. In the case of OAC this resulted in the creation of the London Output Area Classification that sees more widespread use by the GLA.

The LNC offers insights across London, particularly away from the central area, which, although it has long been known as a hub for the night-time economy and provides a large amount of employment in that sector, is not the only place where night workers are found. So, the final way we hope to inform policy in is at the more local level. London's separate boroughs have a degree of independence in the policies they implement, and this means that they have areas of interest, such as their high streets, the provisions that they offer for certain workers, or in the lobbying for different transport and services and so on.

The granularity of this classification enables them to see which areas are distinct from others within the borough, and to explore further work around the more unique characteristics of the night workers that are employed there.

5.3 Limitations and further work

There are several avenues of further development for the LNC. The first would be the move towards a more frequently updated picture of night-working that falls into an established rhythm of updates that reflect policy imperatives. Those classifications that depend on census data for the variables associated with population distribution are necessarily decennial in their nature, but the use of mobile phone derived footfall indicators enables more timely updates. A further advantageous aspect of mobile phone data is its ability to capture the commutes of workers as they travel from home to their place of employment (if it is fixed). This information is particularly relevant to transportation planning for the likes of TfL, but it is also relevant to employers themselves and policymakers who may be interested in the extent of the catchment area of their workforce and the length of journeys they are undertaking.

Our broader work from interviewing night workers indicates that the journeys themselves can be quite long and arduous, particularly in contrast to those who work during daylight hours. TfL’s more sparse origin destination matrix as well as concerns around privacy may in fact be alleviated by aggregating to clusters rather than small spatial units. So we might, for example, calculate the average distance travelled to work by workers in Cluster 1 and compare it to those of Clusters 2 and 3. The data in this case would only need to be disclosed at the aggregate cluster level rather than LSOA to LSOA flows, but will provide vital intelligence in understanding what night workers are experiencing in terms of journey times.

6. Conclusion

In conclusion the LNC offers a first attempt at creating a geodemographic classification tailored to those who work between the hours of 6pm and 6am. This workforce is often overlooked by conventional daytime data and therefore the LNC is founded on an innovative mix of official statistics and commercially gathered mobile phone activity grids. The methods, input data and results were appraised by key stakeholders of this classification, and we hope it will therefore provide an important addition to the policy evidence base for London. The approach taken was also deliberately applicable to the rest of the UK should it prove successful and could therefore provide a national classification of this important but often hard to measure aspect of economic activity.

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Appendix A: Night-time industries

2007 Standard Industrial Classification codes of the night-time industries as defined by the GLA and the ONS (GLA Economics, 2018)

General Category	SIC 2007 Name (sub-categories)	SIC 2007 code
Cultural and leisure activities	Hotels and similar accommodation	551
	Restaurants and mobile food service activities	561
	Event catering and other food service activities	562
	Beverage serving activities	563
	Private security activities	801
	Creative; arts and entertainment activities	900
	Gambling and betting activities	920
	Sports activities	931
	Amusement and recreation activities	932
Activities which support night-time cultural and leisure activities	Retail sale in non-specialised stores	471
	Retail sale of food; beverages and tobacco in specialised stores	472
	Retail sale of automotive fuel in specialised stores	473
	Retail trade not in stores; stalls or markets	479

	Passenger rail transport; interurban	491
	Other passenger land transport	493
	Holiday and other short-stay accommodation	552
	Security systems service activities	802
24-hour health and personal social services	Provision of services to the community as a whole	842
	Hospital activities	861
	Other human health activities	869
	Residential nursing care activities	871
	Residential care activities for mental retardation; mental health and substance abuse	872
	Residential care activities for the elderly and disabled	873
	Other residential care activities	879
	Social work activities without accommodation for the elderly and disabled	881
Activities which support wider social and economic activities	Animal production	014
	Mixed farming	015
	Support activities to agriculture and post-harvest crop activities	016
	Processing and preserving of meat and	101

	production of meat products	
	Processing and preserving of fruit and vegetables	103
	Manufacture of dairy products	105
	Manufacture of bakery and farinaceous products	107
	Manufacture of other food products	108
	Manufacture of pulp; paper and paperboard	171
	Manufacture of articles of paper and paperboard	172
	Printing and service activities related to printing	181
	Manufacture of basic chemicals; fertilisers and nitrogen compounds; plastics and synthetic rubber in primary forms	201
	Manufacture of rubber products	221
	Manufacture of plastics products	222
	Manufacture of domestic appliances	275
	Manufacture of motor vehicles	291
	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	292
	Manufacture of air and spacecraft and related machinery	303

	Manufacture of medical and dental instruments and supplies	325
	Manufacture of gas; distribution of gaseous fuels through mains	352
	Wholesale of food; beverages and tobacco	463
	Freight transport by road and removal services	494
	Sea and coastal freight water transport	502
	Passenger air transport	511
	Warehousing and storage	521
	Support activities for transportation	522
	Other postal and courier activities	532
	Motion picture; video and television programme activities	591
	Television programming and broadcasting activities	602
	Photographic activities	742
	Veterinary activities	750
	Temporary employment agency activities	782
	Activities of call centres	822
	Other education	855

	Activities of other membership organisations	949
	Other personal service activities	960

Appendix B: SIC categories informed by the Night Worker Survey

The businesses that contribute to the night-time economy, based on the survey, are presented below.

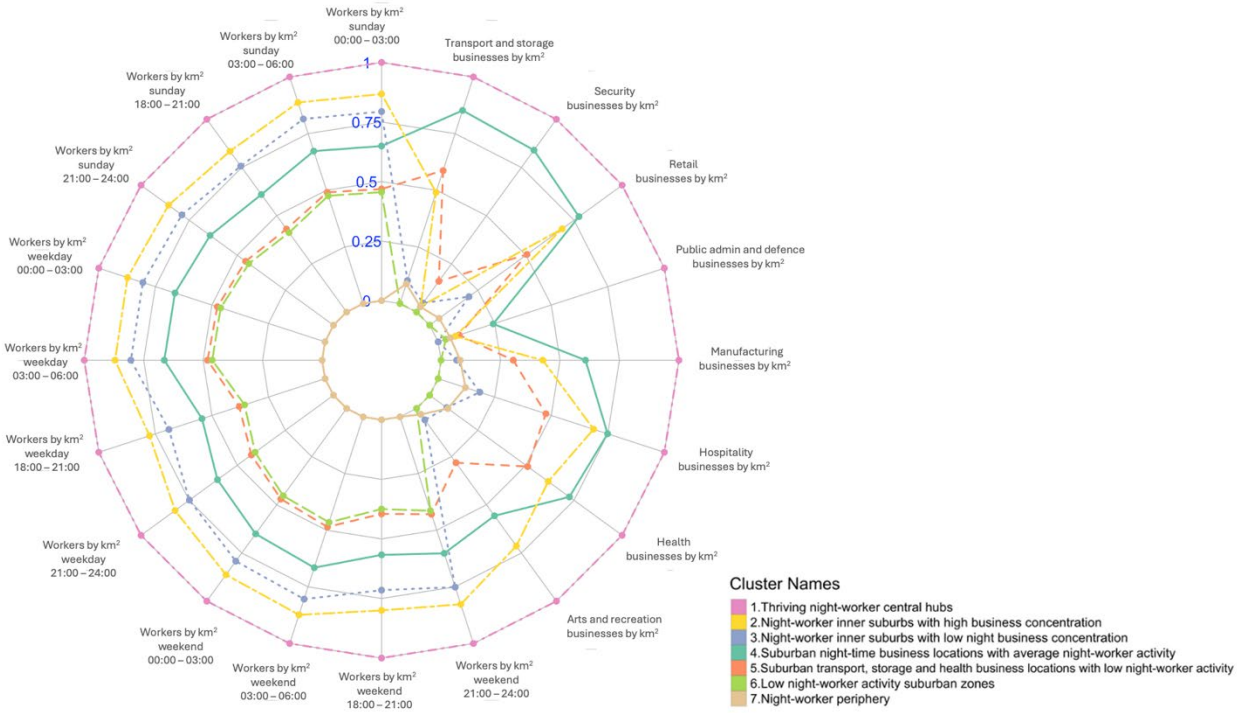
Survey Category	SIC 2007 Name	SIC 2007 code
Arts and recreation	Creative; arts and entertainment activities	900
	Amusement and recreation activities	932
Health	Hospital activities	861
	Other human health activities	869
Hospitality	Hotels and similar accommodation	551
	Restaurants and mobile food service activities	561
	Event catering and other food service activities	562
	Beverage serving activities	563
Manufacturing	Manufacture of dairy products	105
	Manufacture of bakery and farinaceous products	107
	Manufacture of other food products	108
	Manufacture of pulp; paper and paperboard	171
	Manufacture of articles of paper and paperboard	172
	Printing and service activities related to printing	181

	Manufacture of basic chemicals; fertilisers and nitrogen compounds; plastics and synthetic rubber in primary forms	201
	Manufacture of rubber products	221
	Manufacture of plastics products	222
	Manufacture of domestic appliances	275
	Manufacture of motor vehicles	291
	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	292
	Manufacture of air and spacecraft and related machinery	303
	Manufacture of medical and dental instruments and supplies	325
	Manufacture of gas; distribution of gaseous fuels through mains	352
Public admin. and defence	Provision of services to the community as a whole	842
Retail	Retail sale in non-specialised stores	471
	Retail sale of food; beverages and tobacco in specialised stores	472
	Retail sale of automotive fuel in specialised stores	473
	Retail trade not in stores; stalls or markets	479
Security	Private security activities	801
	Security systems service activities	802
Transport and	Passenger rail transport; interurban	491

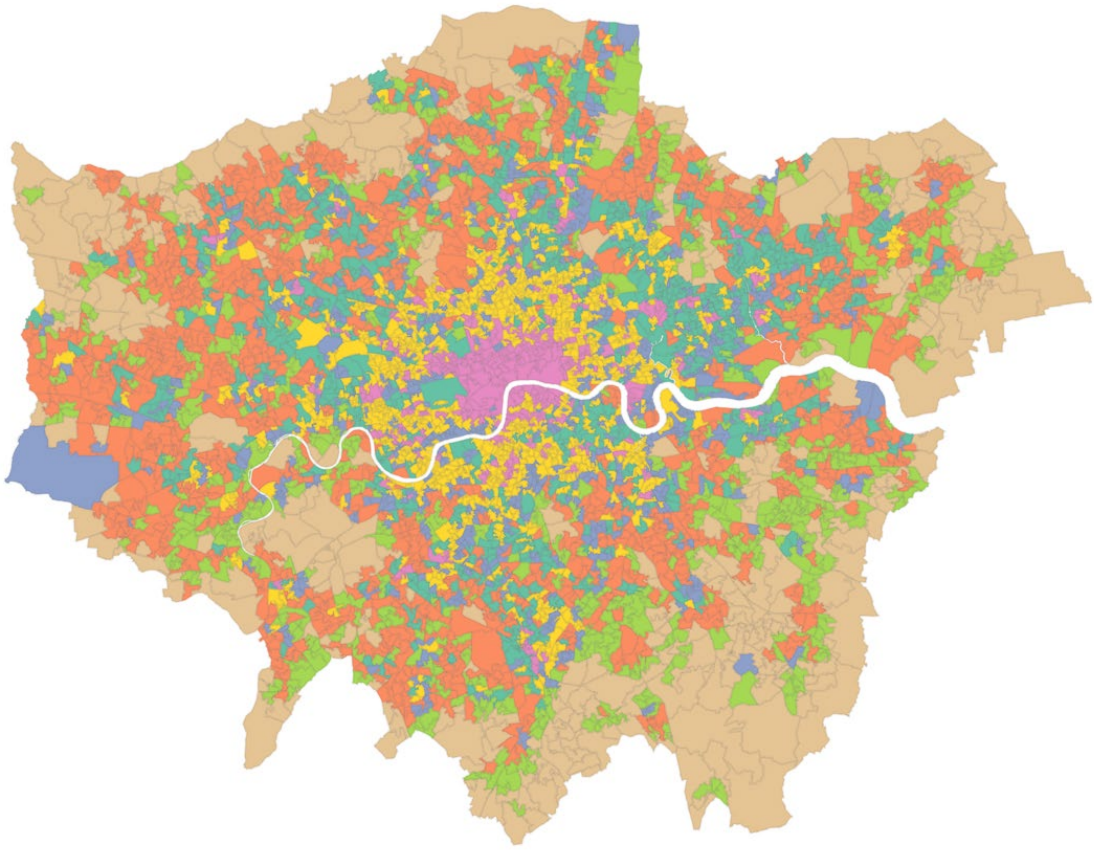
storage	Other passenger land transport	493
	Freight transport by road and removal services	494
	Passenger air transport	511
	Warehousing and storage	521
	Support activities for transportation	522
	Other postal and courier activities	532

Appendix C: Radar Plots

Radar Plot of the variable differences from the global mean for each cluster solution. Values are standardised to range between 0 and 1.



Appendix D: Map of the London Night Worker Classification



Cluster Names

1.Thriving night-worker central hubs
2.Night-worker inner suburbs with high business concentration
3.Night-worker inner suburbs with low night business concentration
4.Suburban night-time business locations with average night-worker activity
5.Suburban transport, storage and health business locations with low night-worker activity
6.Low night-worker activity suburban zones
7.Night-worker periphery

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