



Delineating retail conurbations: A rules-based algorithmic approach



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ABSTRACT

Retail conurbations may be defined as market areas with high intra-market movement. A limited range of approaches has been used to delineate such retail conurbations. This paper evaluates a simplified version of an existing zone design method used to define labour market areas, the Travel-To-Work-Area algorithm (TTWA), for application in a retail context. Geocoded loyalty card spend data recorded by Boots UK Limited, a large health and beauty retailer, were used to develop retail conurbations (newly termed Travel-To-Store-Areas (TTSAs)) for several UK regions using this algorithm. The output TTSA boundaries displayed significantly greater intra-zone flows compared to existing retail conurbation delineation approaches. There is thus scope for researchers and analysts to broaden the zone design approaches used to develop retail conurbations.

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1. Introduction

1.1. Overview

The zone design problem refers to identification of the most appropriate method for subdividing a region into smaller areas for a given purpose. This paper is concerned with the particular challenge of defining zones for the spatial mapping and analysis of flow data i.e. interactions between zones. Approaches to the design of zones for flow data vary considerably, particularly between different sectors. Retail organisations face the problem when determining catchment areas and conurbations of stores based on customer shopping information. Retail conurbations differ from store catchments in that they often encompass many stores, representing regions in which customers travel internally. Thus, retail conurbations are shared, collective catchments for a group of stores drawing on a similar customer base. By delineating such conurbations, retailers can better understand customer movement to guide decisions such as store location, performance comparisons and investigation of competitor presence. In labour

market analysis, an approach to delineating zones, known as the Travel-to-Work-Area (hereafter TTWA) algorithm, is now widely used (Coombes et al., 2010). The TTWA algorithm has been successfully employed internationally to delineate Local-Labour-Market-Areas (hereafter LLMAAs) based on commuting flows (Coombes and Casado Díaz, 2007; Eurostat, 1992; Flórez-Revuelta et al., 2008). However, a similar rules-based approach has yet to be applied to retail conurbation delineation. The closest application of the TTWA algorithm in a retail context is to the design of bank catchments using synthetic data (Coombes, 2000). The aim of the research reported here is to demonstrate how the TTWA method (Coombes et al., 1986) can be adapted to create a new planning geography based on customer shopping patterns by defining non-overlapping areas of retail conurbations while maximising the intra-zonal flow of spend between places of residence and stores. The method is generic in that it can be applied in any country or to any retailer with a sufficient number and coverage of stores and a flow matrix, ideally based on loyalty or bank card transactions.

In the rest of this paper, in addition to the terms TTWAs and retail conurbations, we use a newly introduced term 'Travel-To-Store-Area' (TTSA). Given that the computed areas are not Travel-To-Work-Areas, new terminology needs to be developed which reflects the application of this algorithmic approach to the delineation of retail conurbations. TTSAs are defined as 'retail conurbations delineated via the application of the Travel-To-Work-Area algorithm'. A distinction is therefore made between the TTWA algorithm (Coombes et al., 1986) and our newly developed TTSA algorithm. The algorithm itself is still, however, referred to as the TTWA algorithm.

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The rest of this section reviews zone design methods, current approaches to retail conurbation delineation and the rationale for employing the TTWA algorithm in this context. Section 2 then describes the proposed generic TTSA methodology, followed by an empirical example of its implementation. The results of the empirical example are then presented and evaluated. Finally, the paper concludes with a discussion of the implications for the delineation of retail conurbations, highlighting conceptual and practical issues which need to be addressed.

1.2. Zone design methods

Zone design is the process by which boundaries can be systematically constructed to meet a particular purpose, such as delineating zones for marketing or assessing sales. Some zone design problems involve flow data between origins and destinations, which in the case of retail is typically the flow of consumers between home and retail outlets. Approaches to zone design for flow data aim to address the 'p-regions problem' which '...involves the aggregation of a finite set of n small areas into a set of p regions, where each region is geographically connected, while optimising a predefined objective function' (Duque et al. 2011, p. 1). In a retail context, one of the most common approaches to zone design is gravity modelling. Gravity modelling attempts to quantify the relationship between consumer movement and attractiveness of surrounding retail centres, while remaining confined by a distance-decay factor. The distance-decay factor describes how the probability of a consumer spending at a given outlet decreases with distance from that outlet. The approach is tailored towards "what-if?" scenarios such as the opening of a competing store (Hernandez and Bennison, 2000). Gravity models are a form of spatial interaction model, where by entities at different geographical points make contacts, location choices or supply/demand decisions (Roy and Thill, 2004). Simplistic gravity models allocate centres with largest flows to catchments or conurbations to give 'zones-of-dominance'. Many forms of clustering and gravity modelling require a predefined number of regions from the outset. Delineated regions through a gravity modelling methodology tend to create overlapping and non-tessellating regions. Thus, some areas may lie in more than one region, whilst others may be outside of any region.

1.2.1. Hierarchical zone design

One set of approaches to zone design are hierarchical procedures. The automatic zoning procedure (AZP) of Openshaw (1977) and Openshaw and Rao (1995) has been described as a hierarchical procedure (Spence and Taylor, 1970) since a criterion for amalgamating areas is lowered so that the process iteratively groups input areas into larger zones until these output zones satisfy the criterion (e.g. a specified number of zones or zones of a uniform size). These methods emerged in the 1970s due to the increased availability of computing power and commuting flow matrices. Alvanides et al. (2000) illustrate how the Automated Zoning Procedure (AZP) can be employed to design zoning systems for census-based flow data. Hierarchical approaches typically form groups at early stages leading to restrictions at later stages on zones being broken-up and reallocated. Some hierarchical zone design methods include a contiguity constraint, which ensures that output zones are formed only from neighbouring input zones. Such contiguity constraints ensure that the zones created are not split into two or more geographically separate 'islands'.

1.2.2. Rules-based zone design

A further set of approaches are rules-based methods. These employ a set of rules in a multi-step procedure to determine zone design. Often these are contained within a theoretical model,

guiding decisions as to how and when rules are applied (Flórez-Revelta et al., 2008). The most widely used rules-based method is that for the delineation of TTWAs, used in the UK since the 1980s (Coombes et al., 1986). The TTWA algorithm is designed to identify LLMA nationally, thereby aiding governmental bodies to understand commuting work flows and unemployment rates (Catton, 2002). The algorithm aims to maximise self-containment of flows within zones for a minimum flow size/population (Casado-Díaz and Coombes, 2005). Self-containment refers to the proportion of flows that do not cross output zone boundaries. By minimising self-containment, the TTWA algorithm therefore tries to ensure that commuters' home addresses and their workplaces lie within the same boundary. Goodman (1970) refers to this as 'external perfection'. Goodman (1970) first devised these concepts noting the inherent 'trade-off' between self-containment and flow size. It was Smart (1974) however who first defined the criteria and algorithm for analysing commuter flows for approximately 2000 building blocks. Building blocks can be defined as small elemental units which represent the phenomena of interest and can be aggregated into larger output zones. Smart's (1974) algorithm was later computerised by Coombes and Openshaw (1982). Around this time, numerous approaches were being developed with a similar objective to internalise larger commuting flows; a form of spatial analysis known as 'functional regionalisation' (Coombes, 2000). The first application of the TTWA algorithm was to the 1981 Census (Coombes et al., 1986) but in recent years, the algorithm has undergone several changes (Coombes and Bond, 2008). In 2001, advances in computational power allowed building block mergers to be broken-up and reallocated in a self-optimising fashion, while by 2007 the increased commuting in the UK (both length and frequency) necessitated a redefinition of the criteria for TTWAs. Zones became larger to internalise longer commuting flows: for example, 334 and 308 TTWAs for 1981 and 1991 respectively were delineated under identical criteria. As a result, the self-containment threshold is now lower and zones can cross international borders (Coombes et al., 2010).

A recent application of a rules-based algorithm within a different sector is provided by Martínez et al. (2009), who employ a rules-based algorithm to define Transportation Analysis Zones (TAZs). Although not directly referencing Coombes' research or the TTWA algorithm, there are similarities in that regions are delineated via self-containment and flow size thresholds. A significant issue however is the prevalence of data gaps due to the relatively small survey-derived dataset. Full scene coverage is still achieved (so there are no areas lying outside of any output zones), but only by sub-optimally merging unallocated building blocks based on their geographical proximity to the defined TAZs.

A more comprehensive review of zone design methods can be found in the Duque et al. (2011) paper on the p-regions problem.

1.3. Current approaches to defining retail conurbations

Approaches to zone design vary depending on the problem, input data and the purpose(s) for which the zones will be employed. The aim of this paper is to evaluate the TTWA method's suitability for defining retail conurbations. While retail conurbations are more appropriate for extensive store networks, many large retailers still currently favour single store catchments. In some instances, techniques used to delineate even single store catchments remain rudimentary. While 86% of UK retailers feel their methods for catchment area identification are sophisticated, only 65% were using techniques such as gravity modelling and as few as 29% were using expert systems (Reynolds and Wood, 2010). Single store catchments remain popular because of the added complexity involved in building retail conurbations and the relative ease of evaluating stores independently. In some cases, however, this potentially hinders planning because large store

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