Integrating New Measures of Retail Unit Attractiveness into Spatial Interaction Models

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Summary

This paper proposes the use of urban analytics to predict the attractiveness of a retail unit in dense urban environments. Traditional attractiveness measures (e.g. retail unit size and store frontage) are compared against urban integration measures (e.g. reach and betweenness) to explore their predictive power in estimating the magnitudes of consumer flows. The study concludes that using urban centrality metrics, such as betweenness, as attractiveness measure has a higher positive effect on predicting footfall compared to traditional measures.

KEYWORDS: footfall, retail, retail attractiveness, urban analytics

1. Introduction

Footfall[4] has been recognised as one of the key metrics in estimating retail success (Wrigley & Lambiri, 2015). Thus, applying this measure to the analysis of existing business locations is a common practice and there is a vast range of recent case studies available (Kirkup, 1999; Graham, 2017).

However, obtaining access to footfall data when determining a new location is often very restricted. Therefore, many retailers rely on traditional retail analytics, such as spatial interaction models. The predictive power of those models depends on the input variables, which are often abstract (e.g. retail unit attractiveness) or do not reflect location specific dynamics.

This paper investigates the effect of common input variables (e.g. retail unit size) and proposes new measures (e.g. betweenness) to define the attractiveness of the retail unit. Various attractiveness measures are applied using the Huff Model and the results of the analysis are compared against actual footfall data.

Footfall data are made available through the SmartStreetSensor Project, which is a collaboration between the Consumer Data Research Centre at University College London and the Local Data Company. The project currently collects footfall data in over 80 towns and cities across the UK (CDRC, 2016).

2. Literature Review

Retail location models aim to explain why some retail locations attract more consumers than the others. Given its significance, this topic has generated a prodigious amount of academic studies (Findlay & Sparks, 2002; Birkin et al., 2017). The most researched (Brown, 1993) and widely applied is the Gravity Model developed by Huff (1963).

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[4] Footfall is defined as "the number of people who go into a shop or business in a particular period of time". (Oxford Dictionary, 2018)

Huff's Model is based on the principle that the probability of a given consumer visiting and purchasing at a given site is a function of the distance to that site, its attractiveness, and the distance and attractiveness of competing sites (Esri, 2017).

While the distance variable is considered straight-forward, the attractiveness variable is subject to further debate. The attractiveness attribute of each retail location can describe any kind of feature that has a positive effect on consumer patronage (Sevtsuk & Kalvo, 2017). Often, the square footage factor is seen as a proxy for an assortment of merchandise (Stanley & Sewall, 1976) and therefore defined as attractiveness (Esri, 2017).

The model has been criticised for the lack of dynamic perspectives. It assumes that shopping trips are single-purpose and home-based rather than multi-purpose and ancillary to other activities (such as returning from work) (Brown, 1993). In contrast to this assumption, a recent study by Sevtsuk (2014) found that ease of access from any given residential address was less important than a location at places of intense footfall and passing traffic.

Potential pedestrian traffic can be predicted using urban network analysis techniques. An example of urban network analysis is Space Syntax (Hillier et al., 1983), which analyses the integration of the street network. The correlation between integration and the distribution of pedestrian movement has been extensively investigated and the findings suggest that such a relationship exists (Raford & Ragland, 2006). In simple terms, this means that better-integrated streets receive more footfall than others and therefore, retail units on integrated street segments are exposed to more potential customers.

Based on the literature review, this study takes an assumption that retail units located in well-integrated urban areas are more attractive to customers and therefore proposes the use of urban analytics to define the attractiveness of a retail unit. The predictive power of urban analytics measures, such as reach and betweenness, will be compared against more traditional attractiveness measures such as the size of the retail unit and store frontage size. The measures are tested using the Huff Model to predict the number of people attracted to a retail unit, and the results are compared against footfall counts.

3. Methodology

The Huff Model calculates distance-based probabilities of people from at each origin patronising each retail destination in the dataset. Those probabilities are then used to calculate the potential number of people attracted to each retail location.

The input variables for the Huff Model are described in Figure 1. The calculation is based on the population at workplace zones. Workplace population was chosen over residential population as the study area covers Liverpool city centre, which is primarily a retail area and has a low residential population density. There are eight retail units in the study area which are equipped with a footfall sensor. The population at the workplace zones will be distributed between those eight locations, based on their distance to customers and attractiveness.

Attractiveness is first defined as retail unit size and store frontage size, both of which are considered traditional retail attractiveness measures, and then as (metric) reach and betweenness, which are urban analytic measures.

Urban analytic measures applied in this study are calculated using the Urban Network Analysis (UNA) toolbox for ArcGIS developed by The City Form Lab (Sevtsuk et al., 2016). UNA toolbox attributes the different urban metrics to the buildings along the street segment and allows the prediction of potential pedestrian flows based on geographic accessibility (travel time or distance). This approach allows for the calculation of various centrality measures. Reach and betweenness used in this study are introduced below:

a) (Metric) Reach

Metric reach describes the number of other locations in the network that are reachable from it at the shortest path distance within the given radius (Han et al., 2013).

b) Betweenness

Betweenness is based on the idea that a location is more central when it is traversed by a larger number of the shortest paths connecting all couples of points in the network (Sevtsuk et al., 2016).

The Huff Model is run separately using different attractiveness measure for every calculation. The workflow is described in the graph below (Figure 1).

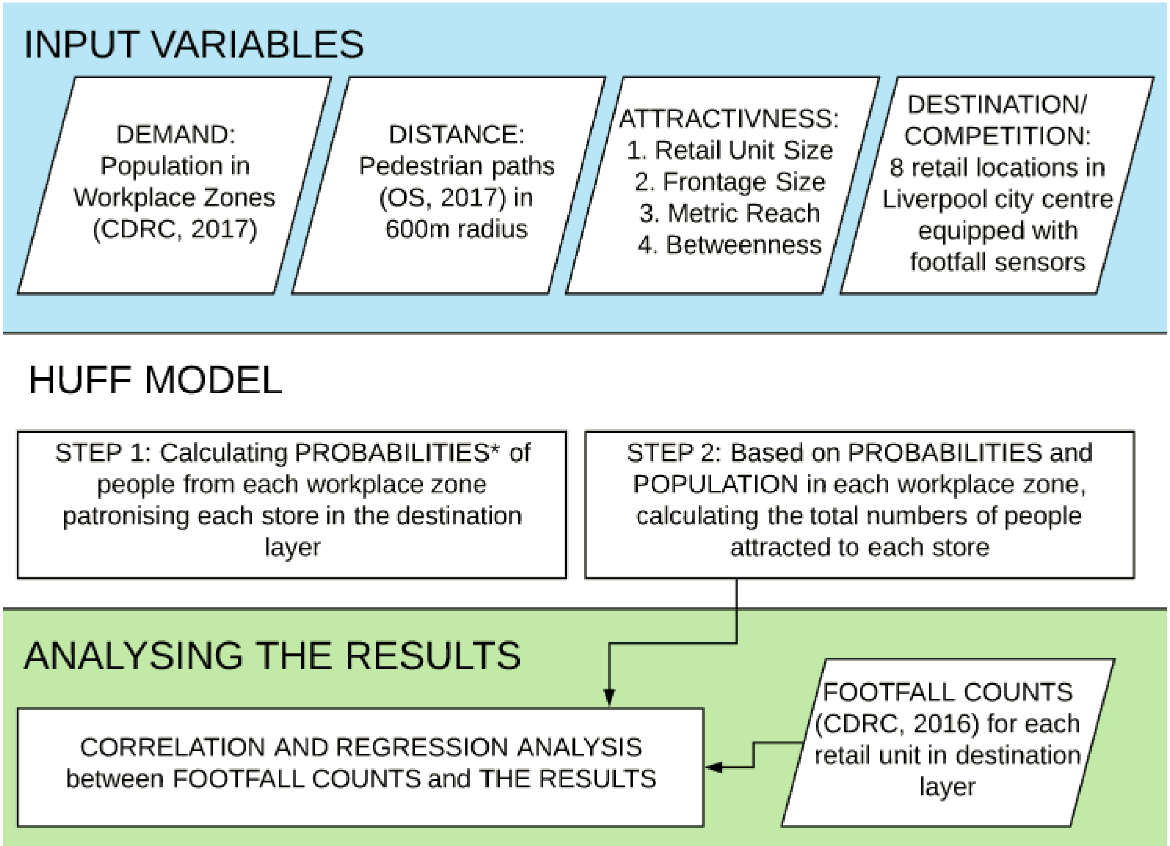

Figure 1. Input variables and Workflow
* The probabilities were calculated using ArcGIS Huff Model developed by Flater (2012)

The results of the model are compared against footfall. Footfall data used in this study represent average daily footfall counts from Monday to Friday between 07:30-19:30 in a one month period (August 2017).

4. Results

The results of the Huff Model did not show a significant correlation to actual footfall counts when retail unit size was used as attractiveness measure. Other attractiveness measures (Frontage r=0.8, Reach r= 0.7, Betweenness r=0.8) showed significant (sig. < 0.05) correlation, although the model significantly underpredicted the consumer flows at all eight locations.

This is an indication that workplace population does not cover the demand in this area and other, more dynamic, population groups, such as tourists and shoppers, should be included to the model to receive better results.

According to the linear regression between the output of analysis and footfall counts (Table 1), the results showed a positive effect on footfall, although the regression between retail unit size and footfall was not significant. Higher reach and frontage size have significant and positive effect on the footfall, but the effect of betweenness is the highest.

Linear regression between footfall and :	Coefficients	Std. Error	t value	Pr(>|t|)	R^2	p-value
Size	0.084	0.217	0.386	0.713	0.024	0.713
Frontage Size	0.729	0.293	2.491	0.047	0.508	0.047
Metric Reach	0.887	0.321	2.759	0.033	0.559	0.032
Betweenness	1.140	0.391	2.917	0.027	0.587	0.026

Table 1. Linear regression between footfall and results of the Huff Models, when applying different attractiveness measures.

Therefore, based on the data and methodology applied in this study, it can be stated that the customer flows in the dense urban environment are estimated most precisely when retail unit attractiveness is defined as betweenness measure.

5. Conclusion

The motivation for this paper was to find a measure which would help to predict footfall and by doing so, contribute to the knowledge of what drives retail success in dense urban areas.

The study found that defining retail location attractiveness using urban integration measures is justified. The estimated consumer magnitudes when applying betweenness measures in the Huff Model, showed the highest positive effect to predicting the footfall. Betweenness has also been mentioned in earlier research as a metric (Sevtsuk et al., 2012), which shows the highest predictive power to estimate pedestrian flows. Retail unit size, which is a commonly used attractiveness measure, did not have an effect on consumer flows in the chosen study area.

The study area covered Liverpool city centre, where half of the locations where located on a pedestrian street. Therefore, investigating additional urban characteristics (e.g. sidewalk width) and including the effect of anchor stores, store type and public transport stations to the model would be required before making any general conclusions. Moreover, the attractiveness measure could also be a function of many characteristics, such as urban measures (e.g. betweenness, etc.) and the composition of retail areas (e.g. anchor stores, etc.).

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7. Biography

Terje Trasberg is a Geography PhD student at University College London (UCL). Her research is primarily focused on retail geography and investigating the potential variables driving retail locations profitability and success. She previously studied Geography BSc at University of Salzburg, Austria and Geospatial Analysis MSc at UCL.

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