Street network morphology and retail locations. Application to the city of Nice (France).

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Abstract

The urban street network of the city of Nice (France) is analysed taking into consideration both the logics of pedestrian and of car mobility, at different geographic scales. The goal is to understand which morphological parameters are fundamental in order to explain the observed distribution of small and medium retail activities. Retail densities are explained within a probabilistic causal framework by a mix of micro- and meso-, pedestrian-based and car-based configurational indicators, with a non-negligible role played by big-retail constrained configurational indicators.

Keywords

Urban morphology, Street networks, Retail distribution, Multiple centrality assessment, Nice.

Introduction

Retail distribution is undergoing profound re-organization in European cities (Wiel 1999; Boquet and Desse 2010). The

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starting hypothesis of the present research is that street network morphologies play an important role in the functional organization of the city. Retail is indeed an urban function which is particularly reactive to modifications of urban morphology and transportation networks. At the same time, transformations of retail structure and distribution reveal more general reorganisations of urban functioning. Recent trends in European cities include an upscale specialisation of city-centre retail, new logics of car accessibility for big retailers in suburbia and commercial blight in intermediate areas, whose street networks were generally laid out after the War. Going with our starting hypothesis, we want to assess what role urban morphology plays on retail distribution in the city. The impact of big retailers should also be investigated in its capacity to thwart the logics of free movement on the street network. With its diverse urban morphology, the city of Nice, represents a particularly interesting case study for our analysis.

Configurational methodology

Street network morphology is analysed through the configurational approach. The latter differs considerably from classical urban morphology analysis. The configurational approach derives from the complex network community, it integrates computational issues and considers the relationship that each form element (here street segments) has with all other elements at the same time. This gives to the configurational approach the possibility to perform multi-scale analysis without pre-established element selection. In more classical and qualitative urban morphology approach, on the contrary, urban fabric analysis considers all form elements at the neighbourhood scale, while city layout analysis at larger scales only focuses on main streets.

Configurational analysis can be seen as the adaptation to urban space of complex network approaches already developed in social network analysis (Freeman 1977, 1979). Porta *et al.* (2006, 2009) identify two schools of thought in configurational analysis: the dual approach of Space Syntax, where street segments are modelled as nodes and intersections as arcs (Hillier 1999, Cutini 2010), and the primal approach of Multiple Centrality Assessment, where intersections are nodes and street segments are arcs within the network graph. It was this second method that was implemented in our research through newly available GIS tools (Sevtsuk and Mekonnen, 2012). MCA provides a rich panel of configurational indicators: closeness (proximity centrality), reach (simplified proximity centrality), betweenness, straightness (proximity centrality taking into account deviations from Euclidean distance). By normalizing through reach, new indicators are produced: relative closeness, relative betweenness, network efficiency. We calculated these seven indicators at different scales: micro- (300 m), meso- (1200 m) and macroscale (5000 m) for pedestrian movement; meso- (5 min) and macroscale (20 min) for car movement. Numeric values were calculated for 88 700 street segments in the study area (24 municipalities around the central city of Nice).

Retail distribution, on the other hand, was used to calculate a network kernel retail density on every street segment, using Okabe's network density estimation discontinuous at nodes (Okabe et al. 2012) from the 22 300 small- and medium-sized retailers (<2000 Sq. m) within the study area.

The influence of big retailers on small and medium retailer distribution had to be explored going beyond the free movement theory of classical configurational analysis. Additional configuration indicators had to take into account the possible impact of specific functions (here 37 big retailers) on movement on the street network.

Exploring the form/function relationship

The impact of configurational parameters on retail densities has been investigated through Bayesian network models (Jensen, 2001; Korb and Nicholson, 2004). Bayesian networks are among the most powerful techniques for probabilistic data-mining. They can detect linear, non-linear and even non-functional relationships in a probabilistic context (dirty knowledge). In order to limit edge-effects on indicator values, only the inner core of the study area, encompassing 52300 street segments (but 80% of population and 90% of retailers) was analysed. More than 20 alternative models have been compared, corresponding to different data-mining parametrizations. Although powerful in knowledge discovery, Bayesian data-mining produces a relatively coarse model. Retail density was discretised in 5 classes:

Class of Commercial Density	KDE value
1. No retailers and no influence from nearby retailers	KDE=0
2. Influence from nearby retailers	0<KDE≤0.4
3. One retailer	0.4<KDE≤1.6
4. Several retailers	1.6<KDE≤6.4
5. Many retailers	KDE>6.4

In our case study, more than two thirds of retail activity distribution (66% to 70% according to the model) can be explained through a combination of pedestrian micro-scale accessibility (proximity reach or straightness centrality), car meso-scale network performance (5 min normalised straightness) and parameters of street betweenness (1200 m betweenness, 5 min betweenness or betweenness to big retailers). With a little loss in predictive power (1 to 2 percent points in correct predictions), model outcomes can be improved (by increasing small errors and reducing big errors), by taking probabilistic uncertainty into account.

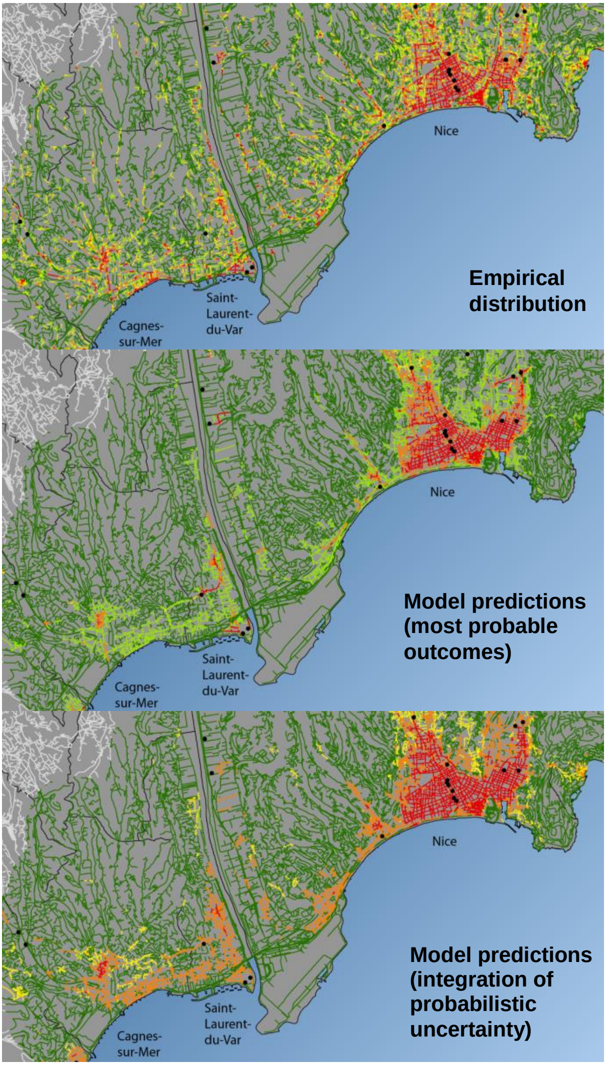

Figure 1 – Retail density distribution in the study area and model predictions.

Whenever the probability value of the most probable inferred density class is less than 0.4, the expected value of retail density has been used as prediction. By so doing, the model is also able to better predict class 3 commercial densities, even if this is done at the expenses of class 2 commercial densities. In general, the model is not able to correctly predict very small commercial presence in the peripheral and hilly neighbourhoods of the city (Figure 1).

Conclusion

In conclusion, retail densities in Nice can be explained by a mix of micro- and meso-, pedestrian-based and car-based configurational indicators, with a non-negligible role played by big-retail constrained configurational indicators. Our results go further than previous research on the cities of Bologna and Barcelona (Porta et al. 2009, 2012). They are derived from a full network approach to urban space, they explore the interaction between pedestrian and automobile free movement and they propose a probabilistic causal framework to understand these interactions.
In a more general way, we can also conclude by stressing that urban street and road networks have a geometry and not only a topology: they are embedded in topographic space and have a speed for motorised movement. MCA integrates this dimension, Space Syntax not. Of course, possible topologies in street and road networks are limited when compared to the theoretical models of social network analysis. Nevertheless, existing configurations differ considerably (in connectivity, network meshing, and hierarchy). Our models show that better connected street networks are a better business environment for small and medium sized retailers and that local pedestrian accessibility is still a central factor for retail localisation. The presence of

big retailers can, indeed, alter localisation strategies for a few retailers, but our conclusions on the role of urban morphology agree with Jacob's empirical observation of retail activity in big American cities (Jacob, 1960). In Nice, as in many other European cities, street networks are presently evolving towards more tree-like and less connected morphologies, with very selective distribution of betweenness centrality. Re-orienting these trends in order to increase network connectivity and meshing is a huge planning challenge.

Acknowledgements

This research was accomplished within the DAMA project (2011-2015, Ministry grant within PREDIT 4 program).

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