Big Data for Urban Design

The impact of centrality measures on business success

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This paper investigates the role of spatial parameters in relation to the economic dynamic embedded in the urban fabric. The key element explored in this study is the role of the urban configuration and accessibility on the success of different business sectors in Switzerland. The underlying hypothesis is that economic markets are constant forces of change influencing the development of cities and functions on all scales. Markets are institutions that reduce people's choices based on a myriad of factors to a single number, the price. Accessibility is a resource for each business that yields multiple values of benefits and transactions in terms of economic properties. This project explores the interaction of multiple measures of accessibility, calculated by Space Syntax analysis, with the success of different markets represented by employment by business sector. 828548 business locations and 44 spatial measures were used to derive associations between them. The results show that the measure of 'Choice' correlates highly for smaller radii and 'Integration' for larger radii with the total number of jobs. The result also shows each sector has a specific set of accessibility measures that allows them to thrive.

Keywords: Big Data, Centrality, Economy, Accessibility, Urban Design

INTRODUCTION

This project explores the relation between the built form and the urban economy. The spatial configuration and movement patterns in the urban fabric are the result of human activity in the real world. Underpinning the urban fabric is a market structure that organises and influences behaviour and urban life. The constant shaping of the built form is the result of the same force that seeks to optimise the urban fabric towards the needs of the people within the existing constraints. This paper tries to reveal these forces in different configurations of space and the success of individual business sectors. The focus is on the configuration of the street network since it is the longest lasting elements in the urban fabric. The street network is also a resource that implicates costs of transportation and accessibility to costumers for every business location. Therefor, the relation between the spatial configuration and economic success is explored to find the relationship between them. For details on economic models and spatial accessibility see Narvaez et al. (2012).
In 'The social logic of space' Hillier and Hanson (1989) argue that space itself carries patterns of behaviour. In the consequent investigation of how urban systems behave Penn et al. (1993) showed that spatial configurations govern the distribution of movement. The configuration of the street network influences the movement patterns and the movement patterns evoke land use patterns and vice versa. This has been shown in cases where an increase of street connectivity has attracted a higher volume of people which attracted different land uses (retail) which depend on a high volume of customers, and amplified the density of pedestrians (Hillier 1996). Therefore, if the street network is guiding different movement patterns and starting a multiplier effect, then it is argued that spatial configuration can determine the success of businesses, which can be detected, in the number of employees.

**METHOD**

This paper explores employment by different business sectors using space syntax analysis. A total of 828548 business locations with their business sector, number of full-time and part-time employees was available.

The spatial variables used were measures of Integration, Choice and Total Depth at different metric radii: 800m, 1600m, 2500m, 5000m, 10000m, 50000m. The basis for the graph is the street network of Switzerland generated by TOMTOM, a company that provides mobile guiding services. By varying the distance radius upon which the integration is calculated, the measure can be representative for different modes of transport. The cleaned network consists of 1'356'105 links. Dangling links below 5m, parallel lines below 2m have been removed and nodes and link end of 5m have been merged in order for the algorithm to be able to calculate the measures in a meaningful way. For details on the individual calculation methods and implications of Choice, Integration and Total Depth see Aschwanden 2014.

**Switzerland**

Profile. Switzerland has grown historically in a decentralised way due to its historical federalism in organising land use and a high independence of towns to plan and implement their land use and street designs. Many town centres date back to medieval or Roman times and hold still memories of a fine meshed street layout for pedestrians. In contrast to other Eu-
European cities this has not been destroyed in WWII nor has it been altered by large-scale infrastructure projects tracing highways through their centre. Nevertheless, the dominating structures on the national scale are the highways and the majority of the new buildings within the last 50 years are constructed outside of traditional centres.

**Street Network Analysis.** This section shows a selection of variables tested using angular segment analysis. Figure 1 shows Switzerland with Total Depth 800m indicating small to large agglomeration centres, showing the location of more than 2700 municipalities. At a global level the Total Depth 10km highlights the large agglomeration centres like Zurich, Basel.

**Business Dataset**
The business datasets consists of 828542 individual data points including business sector, number of full-time and part-time employees. This information is collected 1995, 2001, 2005, 2008 resulting in a longitudinal dataset over a period of 13 years. The choice of business sectors was based on their homogenous distribution across Switzerland and minimum of having 100 locations leading to the following sectors: wholesale trade, except of motor vehicles and motorcycles, Retail trade, except of motor vehicles and motorcycles, Postal and courier activities, Hospitality Accommodations, Food and beverage service activities, Legal and accounting activities, Other professional, scientific and technical activities, Rental and leasing activities, Employment activities, Travel agency, tour operator reservation service and related activities, Public administration and defence; compulsory social security, Education, Human health activities, Residential care activities, social work activities without accommodation, creative, arts and entertainment activities, libraries, archives, museums, botanical and zoological gardens, gambling and betting activities, Sports activities and amusement and recreation activities, Activities of membership organisations, repair of computers and personal and household goods, other personal service activities.

**Feature Selection**
With the combination of both business and spatial accessibility measures linear models can be created to find associations between them. To investigate the relative importance of individual features hierarchical partitioning is applied. This method iteratively reduces the features and calculates the resulting increase of error in the predictive model. This allows to remove features, spatial accessibility measures in this case, that have a limited effect on the outcome. It also removes features that can be substituted by others and generates a model for prediction.

To test the model a bootstrapping algorithm is applied that uses a random distribution of values for prediction and returns the confidence intervals of the prediction. The higher the confidence interval is the better is the prediction capability of the model. This is done with each model created by all feature combinations. These models are then ranked according to their confidence interval to identify the model with the most accurate predictions. The features used in these models are therefore the most relevant for the individual business sector.

**RESULTS**
The location of jobs in Switzerland can be explained best with the measures of 'Choice' radii 800m, 1600m, 2500m and 10000m as well as Total Depth n and Integration 2500m and 5000m see Figure 3.

For individual business sectors the results are more heterogeneous. Employment agencies are located mainly in areas with high Integration radius 800 indicating that they need to be centrally located. Hospitality (NOGA 55) on the other hand requires a high value of choice with large radii and total depth indicating their requirement for a good accessibility by individual transportation and centrality in regard to the whole network. Retail (NOGA 47) thrives when there is a combination of small radii integration and large radii choice associated with pedestrians and ease of access to highways simplifying logistics. Some business locations are associated with high values of integration and do not relate to choice or to-
Figure 2
Swiss road network indicating the quintiles of Total Depth with 10km radius.

Figure 3
Confidence interval for models predicting the number of employment based on different spatial features.
Figure 4
Confidence interval of models for employment prediction for individual business sector based on NOGA codes classifications (national classification of economic activities).
ical and zoological gardens (NOGA 91) on the other hand are more located where total depth is high. The same is true for Human health centres (Hospitals etc.) whereas the residential care centres (NOGA 87) need an element of integration.

**DISCUSSION**

The study shows that different spatial configurations are congruous for different business sectors and that locations with similar characteristics can be identified. The heterogeneity of models explaining the labour market of a specific sector shows the complex interaction between the built form and the labour market. That the system is not producing a single model that is magnitudes better than the next is to be expected since the individual indicators are self-similar and represents minute differences in the urban fabric.

The question of thresholds for the individual indicators is not clear yet. Since only linear models are evaluated this is not taken into account but might be of interest when taking a decision.

The author is aware that this preliminary study neglects several aspects like global market trends, changes to the street network and longitudinal trends that exist in the data. Additional geographic factors like population density should also be included since accessibility is useful if it is towards a labour market or costumes. These aspects will be addressed in a later stage of the project.

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