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A RESIDENTIAL LOCATION MODEL BASED ON CHARACTERISTICS OF SPATIAL PROXIMITY

A case study in the North of Belgium

Kobe Boussauw Msc, Prof. dr. Frank Witlox
Geography Department, Ghent University, Belgium

ABSTRACT

Based on previous research, a number of characteristics of spatial proximity have been identified and qualified for the study area of Flanders and Brussels (Belgium). Moreover, recent travel behaviour data is now available for this area, particularly on daily distances travelled in connection with residential location. By combining these data in an econometric model we can gain understanding on the additional traffic volume that will be generated by developing a new housing unit, dependent on the location. Model results will be represented in a map that can be used in urban and regional planning practice.

KEYWORDS

Spatial proximity, travel behaviour, sustainable spatial development, Flanders

INTRODUCTION

Research into the relationship between spatial structure and travel behaviour has been done in many formats. In this over years soundly documented research field, we determine the presence of two constant issues: in general, intuitively expected relationships appear to be statistically significant (1) but explain only a small fraction of the observed variance (2). The first finding is actually trivial: it would be remarkable if the spatial distribution of various types of destinations, determining the mutual distances that need to be covered, would even not pass significance tests (Naess, 2003). The second finding, however, is a lot less comforting: the explained variance (in many analyses represented by the coefficient of determination (R^2) of a linear regression equation) is usually very low (Cervero, 1996, Maat and Timmermans, 2006, Cervero and Kockelman, 1997; Naess and Sandberg, 1996). This means that the influence of spatial characteristics on travel behaviour is actually very limited.

By combining many socio-demographic and economic variables (such as income, car ownership, family composition, lifestyle or job preference) with spatial characteristics a relatively satisfactory fit may be obtained (Maat and Timmermans, 2006). An advantage of this approach is the accurate estimation of the model coefficients since the influence of any potential correlation between spatial and socio-economic variables is filtered out. An example of such a correlation is the inverse relationship between income class and residential density. A major drawback of upgrading a spatial model to a socio-economic model to explain travel behaviour is that the influence of the spatial structure, which is present anyway, seems to fade into the background.

A model built on mere spatial features is nevertheless useful for spatial policy. Although spatial characteristics explain only a small part of the assessed travel patterns, the built environment is still determining the physical preconditions for sustainable mobility patterns. Moreover, we argue that the importance of the spatial component in the genesis of travel patterns is not constant throughout history, but is linked to the declining cost and the rising speed of mobility. Both developments have led to the weakening of the transportation-land use connection (Giuliano, 1995). In statistical analyses based on spatial characteristics this phenomenon is reflected in a low coefficient of determination.

Based on the peak oil theory we can say that the relative cost of oil will significantly increase over time, leading to a reduction in mobility and an increase in the interest of mutual spatial proximity of destinations (Dodson and Sipe, 2008). This means that the proportionately small share of the variance in travel patterns that is explained by spatial structure, should not be considered unimportant.

Previous research shows that in regional studies (which go beyond the urban scale), the daily distance travelled per person is a good approximation of sustainability of travel behaviour (Boussauw and Witlox, 2009). The aim of this research is the development of a model for the study area of Flanders (Belgium), based on mere spatial characteristics, indicating how much mobility (expressed in daily travel distance per person) the location of an additional housing unit in a certain area would generate. We do this using data from the third phase of the Travel Behaviour Survey Flanders (Janssens et al., 2009) and a number of additional data sets containing spatial variables. Based on a regression equation, eventually for each ward a map is put up indicating how much mobility is generated by dwellings in this location. Obviously, the model will explain only a limited share of the expected variance, an aspect which should be taken into account in the interpretation.

ANALYSIS AND MODEL STRUCTURE

The objective of the paper is to develop a model that forecasts regional variations in mobility production based on characteristics of spatial proximity at the residential location. We use regression analysis, with daily kilometrage per person as the dependent variable. Explanatory variables consist of a number of measures of spatial proximity that are observed at various aggregation levels around the individual residential locations. In addition, a number of socio-economic variables are used as control variables.

We start from a full model that includes all considered variables. Then, we trim the model and ultimately only retain those variables and scale levels that show statistically significant. If necessary, transformations are applied to address potential deviations from the normal distribution or prominent non-linear relationships.

After building and trimming the model, the obtained equation is used to estimate the mobility generating character of each neighbourhood (i.e. census ward) in Flanders. For each ward the relevant spatial variables are recalculated, from which the expected daily number of generated kilometres per person is regressed. These values are then displayed in the form of a map. When interpreting the map, it is important to realize that the extent to which spatial structure explains the mobility of a (new) resident of any area is indicated by the coefficient of determination (R^2) of the regression equation.

USED VARIABLES

The daily kilometrage per respondent is used as the dependent variable in the regression analysis. The used data source is the third phase of the Travel Behaviour Survey Flanders (OVG3) (Janssens et al, 2009).

A total of six different explanatory variables are selected, each of which can be considered as a measure for mutual spatial proximity between potential destinations. These variables are: accessibility (*ACC*), residential population density (*POPD*), spatial diversity (*DIV*), job density (*JOBD*), minimum commuting distance (*MCD*) and the proximity of facilities (*SPROX*). The applied control variables are: education level (*EDU*), income level (*INC*), age (*AGE*) and gender (*GND*).

To avoid biased results by the influence of geographical scale at which the data are aggregated, each variable was calculated at three different levels of aggregation. To this end, the residential location of each respondent is used as the centre of three circles with radii (*r*) equal to 1 km, 4 km and 8 km. Within these circles data are aggregated on the basis of proportional overlap with the original zones for which the variables were calculated (wards, traffic analysis zones or a one-square-kilometre grid).

Accessibility is defined as the total distance that should be travelled by a resident of the considered ward to visit every inhabitant of all other wards in Flanders and Brussels once and return back home. Residential density is based on population data for 2007, aggregated by ward. Spatial diversity is based on the official topographical maps with scale 1:10000. Job density is based on on commuting data as recorded in the traffic model for Flanders (version 2007). The minimum commuting distance is an approach to measure the spatial proximity between the housing market and the labour market and is obtained by a specific algorithm. Proximity of facilities is constructed based on the spatial distribution of non-work-related destinations such as schools, shops, cafes, clubs, banks, medical doctors, ...

CALCULATION AND PRELIMINARY CONCLUSIONS

The basic equation is composed of eighteen independent variables and four control variables, and is expressed formally:

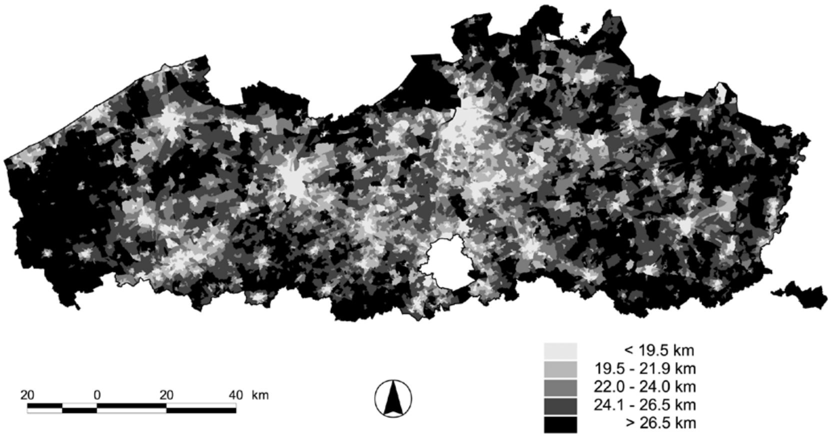
$$
\begin{aligned}
\log_e(PKM) = \alpha &+ \sum_{r=1,4,8} \beta_{1r} \cdot ACC_r + \sum_{r=1,4,8} \beta_{2r} \cdot POPD_r + \sum_{r=1,4,8} \beta_{3r} \cdot DIV_r \\
&+ \sum_{r=1,4,8} \beta_{4r} \cdot JOBD_r + \sum_{r=1,4,8} \beta_{5r} \cdot MCD_r + \sum_{r=1,4,8} \beta_{6r} \cdot SPROX_r \\
&+ \gamma_1 \cdot AGE_{0-19} + \gamma_2 \cdot AGE_{20-39} + \gamma_3 \cdot AGE_{40-59} + \gamma_4 \cdot AGE_{60-79} \\
&+ \gamma_5 \cdot GND + \gamma_6 \cdot EDU + \gamma_7 \cdot INC + \varepsilon
\end{aligned}
\tag{1}
$$

The purified regression equation is as follows:

$$
\begin{aligned}
\log_e(PKM) = \alpha &+ \beta_1 \cdot POPD_1 + \beta_2 \cdot DIV_1 + \beta_3 \cdot SPROX_1 \\
&+ \gamma_1 \cdot AGE_{0-19} + \gamma_2 \cdot AGE_{20-39} + \gamma_3 \cdot AGE_{40-59} + \gamma_4 \cdot AGE_{60-79} \\
&+ \gamma_5 \cdot GND + \gamma_6 \cdot EDU + \gamma_7 \cdot INC + \varepsilon
\end{aligned}
\tag{2}
$$

The results of the regression analysis are given in the table below. Based on the inverse of equation (2), the expected amount of generated kilometres per inhabitant for each census ward in Flanders is calculated and represented in the map below.

$R^2 = 0.143$	**coefficient**	**p-value**
(constant)	1.502	0.000
$POPD_1$	$-3.99 . 10^{-5}$	0.000
DIV_1	-0.278	0.001
$SPROX_1$	0.004	0.000
AGE_{0-19}	0.847	0.000
AGE_{20-39}	1.066	0.000
AGE_{40-59}	0.969	0.000
AGE_{60-79}	0.624	0.000
GND	-0.245	0.000
EDU	0.173	0.000
INC	0.111	0.000



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