Private or Public Transport? The Determinants of Travel Behaviour in Post-industrial City – the Case of Łódź

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1 ABSTRACT

Travel mode choices and the frequency of the usage of different modes of transport are subject to numerous studies nowadays. The importance of this research is especially visible when we consider the level of pollution, noise and congestion in big cities. These phenomena became more problematic as the agglomeration develops. Therefore careful analysis of the factors determining travel mode choices in daily travel activity of citizens should be conducted. Especially when the share of private car usage overwhelms other transport modes.

This situation is particularly visible in developing economies as the possession of car can be used as a proxy for the economic status. The case of Łódź - the post-industrial city located in the centre of Poland seem to be a very interesting case study in terms of the problems described above. According to the report of TomTom Traffic Index 2016, Łódź was the fifth most congested city in the world. On the other hand, the city of Łódź faces the problem of rapid ageing of its inhabitants and very low birth rate. This motives summed up give us a justification to use Łódź as a scientifically interesting subject of the analysis.

The data used in the empirical exercise are taken from the study Quality of life of the citizens of Łódź and its spatial diversification. Such choice of the dataset allows us to include a broader range of explanatory variables than in regular travel mode choice studies. As a tool of econometric analysis, we employed multinomial logistic regression model.

The results are in line with the findings of similar studies in the field of travel behaviour analysis. We observe the high impact of socio-demographic factors on the frequency of the usage of a particular mode of transport. Also, the state of city's infrastructure and effectiveness of functioning of the public transport turned out to be the meaningful factors determining travel behaviour of the citizens of Łódź in their daily travel activity. The set of determinants differs between the modes of transport. Especially interesting results were obtained for age groups, where we observed an intensive increase in private car usage for mid-aged people, and afterwards gradual decline in favour of public transport. The statistically significant impact of financial situation assessment and the student/employee status were also confirmed in this study.

Keywords: travel frequency, travel mode choice, multinomial logit, travel behaviour, microdata

2 INTRODUCTION

The purpose of this study is to investigate the factors which determine travel behaviour of the citizens of Łódź. According to Eurostat and Polish Local Data Bank, there were 502 registered cars per 1000 inhabitants in Łódź in 2016. This number should be considered as high, especially when we compare it to 396 cars per 1000 citizens registered in Berlin. It's worth mentioning that Poland has the oldest passenger car fleet in the EU (33% of cars older than 20 years in 2015). Considering a high number of private cars, which results in high level of pollution and noise in the city, we claim that careful study of the travel behaviour and its reasons can be helpful in shaping urban policy dedicated to public transport development and infrastructural investments. Also, knowing the determinants of the choices regarding transport mode in daily travel activity, we can formulate some recommendations for local policymakers in terms of addressing the transport needs of particular groups of inhabitants.

The goal of this study is achieved with the usage of microeconometric models, namely multinomial logistic regression model. This approach is widely used in the literature and will be discussed in following sections.

3 MOTIVATION

The city of Łódź is located in the nearly exact centre of Poland next to the intersection of the two main motorways namely: A1 (E75) and A2 (E30). As Łódź is the third largest city in Poland, this location provides a convenient way to travel for nearly 700 thousands of its inhabitants. Moreover, this high accessibility to motorways asserts suitable environment for the development of the transport companies and

logistics centres. Dynamic evolution of the transport sector carries on many positive effects, however, it also causes some problems which decrease the quality of life of the inhabitants. To this, we can add serious delays in the development of transport infrastructure in the city and in a whole agglomeration. This obstruction can be explained by the financial problems caused by the transition from planned economy to market economy in the early nineties. As the city of Łódź was primarily built on the textile manufacturing, the economic system change caused a strong downturn in the city, by opening the polish economy for cheap goods from abroad – in this case especially inexpensive textiles from China. Eventually, the unemployment rate in Łódź rose rapidly which caused many social problems. These issues were to be solved in the first place leaving infrastructural investments for the future.

Nowadays the city of Łódź starts to regain its position on the economic map of Poland. The development of highways and express roads followed by investments in tram lines and railroad infrastructure stimulates the economic growth of the whole agglomeration. On the one hand, these dynamic changes improve the state of the transport system in the city by enhancing the offer and shaping up the quality of services. On the other hand, the level of congestion and complementary side effects (noise, pollution, etc) started to rise which situated Łódź in the fifth place in the TomTom Traffic Index 2016 among the most congested cities in the world.

Therefore in our opinion, the case of Łódź can be the scientifically interesting subject of travel behaviour analysis. The results of this study can be helpful for local urban planners as a source of knowledge of the determinants of mode choices made by the citizens of Łódź. This information will be especially useful in case of the need to address social campaigns aimed at the particular groups of the society to persuade them to use public transport instead of private cars.

4 LITERATURE BACKGROUND

The literature concerning travel behaviour research is rather broad. To the seminal papers, we can include the work of McFadden (1974, 1977) who employed microeconometric methods (conditional logit model) in the modelling of the demand on San Francisco Bay Area Rapid Transit (BART). The models introduced by McFadden proved the relevance of microeconometric methods in travel behaviour research. These models are still widely used and developed.

For example, we can point to the research conducted by De Witte and Macharis (2010), where binary logistic regression was employed to research the propensity of the citizens of Brussels to use free of charge public transport. Their results suggested that sociodemographic characteristics of the respondents and their habits have a significant impact on the travel mode decisions. Cervero (2006) also used binary logistic regression in studying travel behaviour of white-collar workers in California.

In this paper, we used multinomial logistic regression (MNL) in order to find the determinants of the frequency of using the particular modes of transport (public or private). Multinomial logistic regression was used in similar context for example to study travel mode choices of the students in six Asian countries (Van et al., 2014). Schwanen and Mokhtarian (2005) also applied MNL model to research the relationship between travel behaviour and residential location of the citizens of San Francisco. The authors also tested the nested logit model, but multinomial logistic regression was better in terms of economic correctness. MNL model was also employed by Mahmud and Rabbani (2012) in order to study the travel behaviour of the white-collar workers in Dhaka. The authors compared MNL results with the outcomes of random parameters logit model. The outcomes turned out to be very similar, but for the multinomial model, a better goodness-of-fit was achieved.

For Poland, there were just a few papers regarding travel behaviour analysis. To the most important we can add Strawinski (2003), who used multinomial logistic regression in order to analyse the determinants of the travel behaviour of the citizens of Gdynia (northern Poland).

From the short review of the literature, we can infer that multinomial logistic regression is especially useful in the travel behaviour research. The validity of this method and its popularity in the literature let us justify the usage of MNL model in the empirical part of the study.

5   DATA AND METHOD

In the empirical part of this study, the multinomial logistic regression model was applied. This method is based on the concept of Additive Random Utility Modelling and can be considered as natural extension of standard binomial logistic regression model, where dependent variable has more than two categories, which are not ordered (see: Verbeek, 2000, p. 194-197; Cameron, Trivedi, 2009, p. 479). This model was primarily introduced by Luce (1959). In MNL model we assume that probability of the choice of j-th alternative by i-th respondent is defined as:

$$P(y_i = j | x_i) = \mathrm{p}_{ij},$$

where $x_i = (x_{i0}, x_{i1}, ..., x_{ik})'$ is the vector of explanatory variables. Each respondent chooses one of the J alternatives. Deterministic part of respondent's utility coming from the choice of j-th alternative, V_{ij}, can be written as the combination of explanatory variables and model parameters:

$$V_{ij} = x_i' \beta_j,$$

where β_j is the vector of parameters for j-th alternative. In this method, we assume that stochastic part of the utility has the Gumbel distribution, which allows us to define the probability of the choice of j-th alternative as:

$$p_{ij} = \frac{\exp(x_i' \beta_j)}{\sum_{r=1}^{J} \exp(x_i' \beta_r)}$$

It should be noted that MNL model requires the normalisation of one of the deterministic utility levels to zero in order to identify the parameters. The model is estimated by maximum likelihood, where the above probabilities enter the likelihood function. It's worth mentioning that MNL model must meet the assumption of the independence of irrelevant alternatives (IIA).

The data used in this research come from the study *Quality of life of the citizens of Łódź and its spatial diversification* (Rokicka, 2013; Rokicka and Petelewicz, 2014). The representative sample of the 1000 citizens of Łódź was surveyed in 2012. The questionnaire included 104 questions related to various aspects of social life and was supported by 16 demographic questions. Such choice of the dataset allowed us to employ more explanatory variables than in standard travel behaviour studies. The dependent variable was constructed on the basis of question: "How often during last 12 months were you using: a) private car as a driver or passenger, b) public transport modes (bus or tram)". The scale of answers was as follows: "Never, once a year or couple times a year", "At least once a week/once a month", "Every day or almost every day". Knowing the structure of the dependent variables we estimated two models. One for the frequency of the usage of private transport modes, and the second for public transport modes. The set of the explanatory variables was primarily based on the work of Curtis and Perkins (2006) who surveyed the literature on the determinants of travel behaviour. Additionally, some variables which were unique for this dataset were tested.

6   RESULTS

The empirical exercise was conducted with the usage of the multinomial logistic regression model (MNL) described above. In Table 1 we present the average marginal effects dedicated to the particular variables. The reason we do so is that parameters of MNL model do not have a straightforward interpretation. Due to the nonlinearity of the model, we can only assess the correctness of the sign of the parameters. Contrary, average marginal effects (AME) give us a possibility to interpret their values as the probabilities which are very convenient and much more informative from the scientific perspective.

The results presented in Table 1 are the best estimates obtained after the stepwise regression. It's worth noting that presented outcomes are related to the answer: "Every day or almost every day" while the base outcome was "Never, once a year or couple times a year". This was done to maintain the clarity of the presentation of the results. The goodness-of-fit of the models was scrutinised with the Pseudo-R2 measures. Model of private transport received a better explanation than the model of public transport, however, as for the microeconometric studies both levels of explanation can be assessed as satisfactory. The assumption of independence of irrelevant alternatives was tested with the Small-Hsiao test. The result of the test proved that assumption was met.

	Private transport		Public transport	
	AME	p-value	AME	p-value
Public_transport_too_rare	-.031	0.006	.034	0.000
Too_long_to_city_center	.037	0.000	-.032	0.019
Poor_offer_at_night	-.025	0.027	-	-
25-34 years	.079	0.803	-.03	0.869
35-44 years	.155	0.197	-.11	0.167
45-54 years	.053	0.670	-.03	0.954
55-64 years	.001	0.497	-.123	0.026
65-74 years	-.041	0.084	-.208	0.049
>74 years	-.226	0.004	-.28	0.000
Woman	-.18	0.000	.083	0.000
Worker	.069	0.002	.154	0.258
Student/pupil	-	-	.24	0.005
Own_car	.328	0.000	-.29	0.000
Moderate_finantial_sit	-.068	0.033	.112	0.000
Poor_finantial_sit	-.103	0.000	.096	0.010
Debts	-	-	.062	0.098
Pseudo-R^2		0.31		0.19
N		1000		955
LR chi^2		557.36		339.48
p-value (LR)		0.000		0.000

Table 1 – Average marginal effects calculated on the basis of the results of MNL estimates. Note that the base category for age groups is 18-24 years, and for the financial situation assessment the base outcome is "Good_financial_situation".

From the analysis of Table 1 we can draw following conclusions:[1]

- Opinions and attitudes toward the state of public transport and infrastructure in the city have statistically significant influence on the travel behaviour of the citizens of Łódź.
  - o Respondent's opinion that "Public transport operates too rare" negatively stimulates everyday choice of the private transport and positively the public one. This effect seems to be ambiguous. It can be partially explained by the low overall assessment of public transport offer in Łódź which, however, isn't connected with resigning from using the public transport modes.
  - o People declaring that "The journey to the city centre from the place they live in is too long" have a greater probability of choosing private transport in their daily activity than public modes.
  - o Negative assessment of the offer of the night public transport lines ("It's hard to reach my home destination using night public transport lines") is linked to the lower probability of the choice of the private transport. This phenomenon does not meet our expectations, but it can be explained by the fact, that many people use taxis to go back home at night. In the model of public transport, this variable was not statistically significant.
- The next group of variables is related to socio-demographic characteristics of the respondents.

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[1] The readers should remember that all the interpretations are related to the baseline category "Never, once a year or couple times a year". To preserve the clarity of the paper we do not repeat this statement for each interpreted marginal effect. Of course this also applies to the ceteris paribus rule.

- o The significance of the variables related to age groups was checked with the joint F-test, which confirmed the statistically significant influence of the whole set for both models. In the model for private transport, we observe that people of age 35-44 years have the highest probability of choosing private transport in their daily travelling activity, and it decreases gradually afterwards (negative values for age 65 and more). In the case of public transport, we observe the highest probability in the baseline group (18-24 years). Then the downward trend can be observed.

  - o Women are less likely to choose private transport in their daily activity (the probability nearly 20 percentage points lower than men). On the other hand, women have a slightly higher probability of choosing public transport than men.

  - o People who work are more likely to choose public transport modes than private cars than the people who are not employed. This effect is not statistically significant for public transport.

  - o The status of student/pupil is not statistically significant for private transport model (possibly by driving licence obstacles and car affordability). It's worth noting that this variable is the highest positive factor for choosing public transport (24 percentage points gain).

- • The last group of the variables is related to the financial status of the respondents.

  - o People who own at least one car in their household are very likely to use private transport in their daily journeys. This variable is also the strongest negative factor in the model of public transport choice.

  - o If the assessment of the financial situation of the household decreases the probability of using private transport modes is negatively influenced, whereas the probability of choosing public transport modes rises.

  - o If there are any debt/mortgages in the household its members are more likely to choose public transport (at the 10% level of significance).

7 CONCLUSIONS

The purpose of this study was to investigate the determinants of travel behaviour of the citizens of Łódź – the post industrial city located in central Poland. In order to achieve the scientific goal of this research, the multinomial logistic regression model was applied. The database used in this paper was taken from the quality of life studies which allowed us to enhance the set of explanatory variables in the manner rarely available in standard travel behaviour analyses.

The results of empirical exercise are in line with the findings of similar studies in the field. This means that for the city which suffered seriously from the economic decline caused by the industrial recession, we can find similar determinants of the travel behaviour as in well-developed cities from other countries around the world. We observe the strong impact of socio-demographic factors on the frequency of the usage of given modes of transport. Also, the state of city's infrastructure and effectiveness of functioning of the public transport turned out to be the meaningful factors determining travel behaviour of the citizens of Łódź in their daily travel activity. The set of determinants differs between the modes of transport. Especially interesting results were obtained for age groups, where we observed an intensive increase in private car usage for mid-aged people, and afterwards gradual decline in favour of public transport. The statistically significant impact of financial situation assessment and the student/employee status was also confirmed in this study.

Future research will concern identifying the spatial differences between the districts of Łódź. Also, the international comparisons with other post-industrial cities are considered. The realisation of this study depends on the availability of the data.

8 ACKNOWLEDGEMENTS

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