Temporal Transferability of Vehicle Ownership Models in the Developing World: A Case Study of Dhaka, Bangladesh

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1. BACKGROUND

Growing use and ownership of private vehicles in developing countries

Accurate prediction of vehicle growth important for policy aimed at control and management

Research on the temporal transferability of vehicle ownership models in the context of developing countries

Modelling of vehicle ownership costly. Previous models used without updating.

Transport conditions in developed and developing countries are significantly different.

2. OBJECTIVES

- To develop vehicle ownership models and test for temporal transferability
- To investigate the effect of model structure on temporal transferability
- To compare the performance of potential methods in improving temporal transferability

3. DATA AND SCOPE

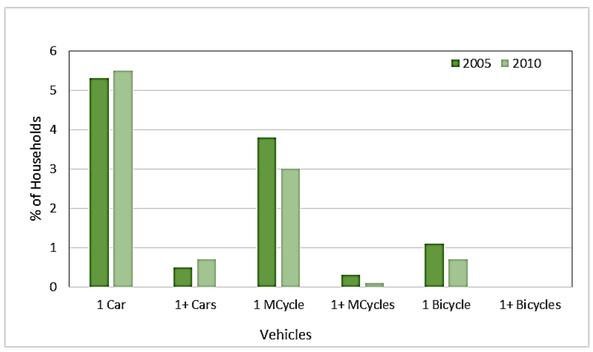

Fig 1: Vehicle ownership distribution

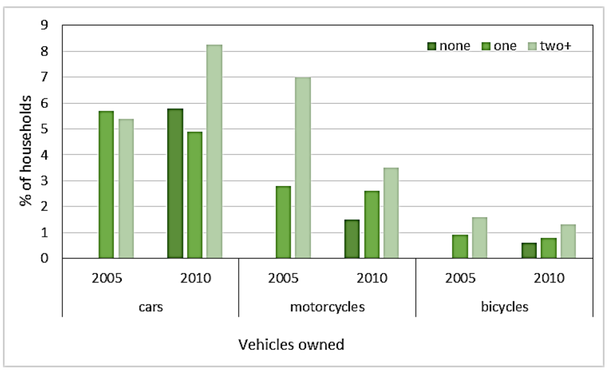

Fig 2:Vehicle ownership and no. of workers

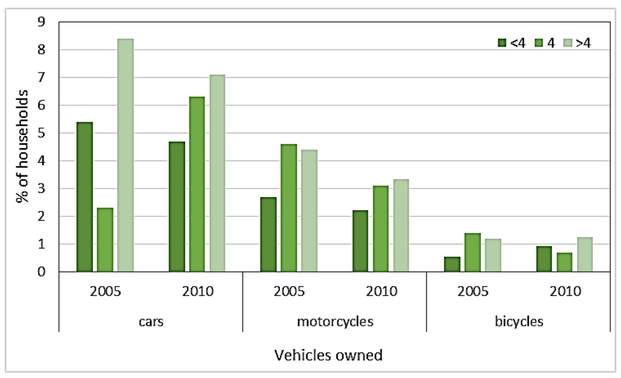

Fig 3: Vehicle ownership and household size

4. METHODOLOGY

Model Structure

i. Discrete Choice Models

- Multinomial logit (MNL)
- Nested logit (NL): No significant correlation between ownership of one car and that of two or more cars and/or between motorcycles and bicycles.

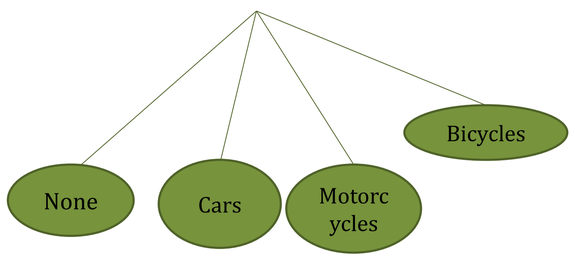

Fig 4: MNL model structure

ii. Count Regression Models

- Poisson
- Negative binomial
- Zero inflated negative binomial (ZINB)

Transferability

i. Transferability Index (TI)

$$TI = \frac{\left[LL_{appl}\left(\hat{\beta}_{trans}\right) - LL_{appl}\left(\hat{\beta}_{const}\right)\right]}{\left[LL_{appl}\left(\hat{\beta}_{appl}\right) - LL_{appl}\left(\hat{\beta}_{const}\right)\right]}$$

ii. Transferability Test Statistics (TTS)

$$TTS_{appl}(\hat{\beta}_{trans}) = -2 \times \left(LL_{appl}(\hat{\beta}_{trans}) - LL_{appl}(\hat{\beta}_{appl})\right)$$

Where

$LL_{appl}\left(\hat{\beta}_{trans}\right)$ is the log-likelihood of the model in the application context with parameters from the estimation context;

$LL_{appl}\left(\hat{\beta}_{appl}\right)$ is the log-likelihood of the model with parameters from the application context;

$LL_{appl}\left(\hat{\beta}_{const}\right)$ is the log-likelihood of the model with constant parameters only

Model updating

i. Bayesian Updating

$$\beta_{updated} = \frac{\left[\frac{\hat{\beta}_{trans}}{\sigma^2_{trans}} + \frac{\hat{\beta}_{appl}}{\sigma^2_{appl}}\right]}{\left[\frac{1}{\sigma^2_{trans}} + \frac{1}{\sigma^2_{appl}}\right]}$$

ii. Combined transfer estimation method

$$\beta_{updated} = \frac{\left[\frac{\hat{\beta}_{trans}}{\sigma^2_{trans} + \alpha\alpha'} + \frac{\hat{\beta}_{appl}}{\sigma^2_{appl}}\right]}{\left[\frac{1}{\sigma^2_{trans} + \alpha\alpha'} + \frac{1}{\sigma^2_{appl}}\right]}$$

Where

$$\alpha = \hat{\beta}_{trans} - \hat{\beta}_{appl}$$

5. RESULTS

Estimation

- MNL model: an increase in household income, number of workers and licensed drivers positively influenced vehicle ownership, both in 2005 and 2010. Increase in household size however has negative impact. Model had good fit to data
- NL model examinations of this study do not offer logical results from which conclusive deductions can be drawn.
- Poisson: positive correlation between car ownership and household income and licenced drivers. Number of workers favoured motorcycle ownership. Model was inappropriate for 2010 data
- Negative binomial: household size and income increase favor motorcycle and bicycle ownership. Model inappropriate for 2010 car ownership
- ZINB model better suited to modelling 2005 and 2010 car ownership than the negative binomial. The probability of a household owning no vehicle at all increases significantly if they are a low income household and reduces even more for high income households

Transferability

- All models not transferable before updating. However, most model parameters were temporally transferable
- Transferability improves with model updating and even more with combined transfer method

6. CONCLUSION

- Household income is an important determinant of vehicle ownership
- Number of driving licence holders and workers is positively correlated with vehicle ownership.
- Smaller households encourage car ownership while the larger with workers tend towards motorcycle and bicycle ownership
- The basic MNL proved to be most suitable for the estimation of vehicle ownership across time.
- Updating estimated models for temporal transferability is indeed a practical way for developing countries to perform traffic and travel demand forecasts without the encumbrance of initial model estimation.

7. RECOMMENDATIONS

- Further investigation into the effect of other updating methods on temporal transferability and performance of more advanced model structures such as the mixed logit.
- Examine the use of the more flexible predictive tests such as; model elasticity to check the sensitivity of the model to variations in input variables and the relative error measure to compare parameter values between the estimation and transfer context (Fox, 2015)

Table 1: Model Comparison.

Parameters	MNL		Poisson				Negative Binomial				ZINB			
			Cars		M&B		Cars		M&B		Cars		M&B	
	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010
Appropriate Model Structure	Y	Y	Y	N	Y	N	N	N	N	Y	Y	Y	N	Y
Base Transferability														
TTS	N		N		N		N		N		N		N	
TI	N		N		N		N		N		N		N	
Transferability After Updating														
Bayesian TTS	N		N		N		N		N		N		N	
Bayesian TI	Y		N		Y		N		Y		N		N	
CTE TTS	Y		N		N		N		N		N		N	
CTE TI	Y		Y		Y		Y		Y		Y		Y	

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