An econometric study of the relationship between land use and vehicle trip generations

TRICS Research Report 09/1

Dr David C Broadstock

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Job No. J051007C

Report No.

Prepared by IDC

Verified AS

Approved by AS

Status Final

Issue No. 1

Date 19 August 2009

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Contents Amendments Record

This document has been issued and amended as follows:

Status/Revision	Revision description	Issue Number	Approved By	Date
Final			Annette Smith	19/08/2009

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1 About the author

David is currently an economist with Halcrow Group Ltd working on an array of economics projects in Europe, the Middle East and North America. He has provided a number of guest lectures for postgraduate courses including automotive technology management and environmental economics.

Prior to joining Halcrow David worked as a transport planner within JMP where he also was involved with term commission projects evaluating the transport aspects of minor and major scheme development applications on behalf of Transport Scotland.

David is an associate member of the Surrey Energy Economics Centre, at the University of Surrey, where he regularly contributes to research in various aspects of transport and energy econometrics.

The PhD which this report is based upon was also done in collaboration with the University of Portsmouth where David previously obtained his BA(Hons) and MSc in Business Economics. A full copy of the PhD report can be obtained from the TRICS® Development Team upon request.

2 Executive summary

2.1 This report has emerged from the sponsorship of a PhD course of study by the TRICS® Consortium in collaboration with Economic and Social Research Council (ESRC Project Number PTA-033-2004-00035). This collaboration also had inputs from JMP, the University of Portsmouth and the University of Surrey.

2.2 The principal purpose of the report is to summarise evidence from a series of economic studies into the relationships between land use, land zone and trip generations using the TRICS® database.

2.3 In particular the work sought to answer a number of questions and particularly, establish a scientifically grounded response to two key issues (i) can the data held in the TRICS® database be used for `sound' econometric modelling and (ii) using appropriate econometric methods, is whether or not is land zone placement (as defined in accordance with Planning Policy Guidance definitions) a genuinely important determinant of trip generation behaviour.

Site information for the following three site types was used;

- Office Developments;
- Food Superstores; and
- Residential Developments

2.4 For Offices and Food Superstores single equation trip attraction models are used based on the tenets of a standard derived demand modelling framework. While for Residential Developments a system is estimated to allow for interactions between the generation of trips in residential sites and the levels of car ownership at those sites.

2.5 The results support that land zone features, as a group of indicators, should be accounted for in trip generation models for office developments.

2.6 The full thesis, from which the information in this report is drawn is also available from the TRICS® Consortium and aside from touching on the policy issues highlighted in this report, makes a more considered review of the technical matters arising when analysing this data source.

Table 2.1 Summary of findings

Food Superstores	The results exemplify the complexity of trip generations at food superstores revealing that trip generations are jointly determined by land zone features, site specific characteristics, local demographics and also the competitive nature of the local food retail industry.
Office Developments	The results affirm the common wisdom in that size/parking provision is the biggest determinant of trip generations; however the results reveal that the model needs to incorporate land zone measures. If land zone is not considered when assessing the trip generations at office use developments, then the trip generations will be either under or over-estimated.
Residential Developments	Trip rates at residential developments are found to be determined by land zone placement. While the results for the trip generation model for residential sites implies the specific determinants of trips at residential sites might be too complex to accurately specify using TRICS® data. However the evidence supporting the role of accounting for land zone features is consistent and robust, and as such cannot be neglected.
General	The results demonstrate the importance of controlling for land zone features in assessing trip rates across a range of different land use types. Although different land use types are borne from different functional relationships between the specific influences of demand, land zone features are consistently important, as is an overall appreciation of the socio-economic characteristics.

3 Introduction

3.1 This report has evolved as a deliverable from a scientific research project looking into the TRICS® database, and so it should be borne in mind that what may appear to be restrictive assumptions at points throughout the analyses are in fact necessary assumptions to make the research viable.

3.2 This is the first formal application of econometrics to the TRICS® database, and although some previous regression type work has been conducted, the present report is built upon more theoretically grounded relationships.

3.3 The intention of the findings herewith was not to produce a definitive assessment of the TRICS® database but rather to make the initial footsteps into a more considered review of the true value of the database. In so doing it has made useful contributions to the transport professionals community, though it has also identified issues and questions which were beyond the scope of the project and hence not yet answered.

What are the core economic principles in relation to studies of transport?

3.4 Transport is a service good meaning that it is not demanded in its own right but rather is a necessary complementary good in order to access other goods or services.

3.5 Underlying principles of economics dictate that demand for any given good or service is driven by **prices**, **income** and **tastes**.

- **Prices:** As prices rise the consumer cannot afford as many goods as before and so demand falls and vice versa;
- **Income:** As incomes rise the consumer can afford to purchase more than before and so demand rises and vice versa;
- **Tastes:** Tastes are reflected in the combinations of goods that consumers buy. Individual preferences will for instance determine a consumer's ability to walk or travel by car.

3.6 The present study takes cognisance of the above three facets of demand behaviour in using the TRICS® database to model demand for transport. However in the knowledge that transport demand is derived, it does so by analysing three distinct land-use types.

What is econometrics?

3.7 This section provides a very cursory overview of the fundamentals of econometrics from a largely non-technical perspective.

3.8 The term econometrics stems from the combination of two words, economics and metrics. Metrics is an alternative word for measurement and a simple interpretation of the term econometrics would be 'the measurement of economic theory'. In other words, econometrics is a tool to establish whether underlying economic theories are relevant to real world situations.

3.9 The measurement aspect is heavily grounded in statistical theory, and there is no way of avoiding some simple statistics when generating econometric outputs. Fundamentally, econometrics is the fusion of economic theory with statistics.

3.10 Although the element of statistics increases the analytical burden, it does also however allow such studies a far greater degree of confidence and provides the necessary testing frameworks and control environments to enable economics to be accepted as a science and not simply an art.

3.11 The following hypothesis underpins the three subsequent case studies: **'Spatial placement has a statistically significant impact upon car use at office, retail and residential developments.'**

4 Land use and zone definitions

4.1 A critical feature of the research was to determine whether or not different land use types have fundamentally different trip attraction drivers, and importantly to what extant they differ. Within this report three different land-use types were considered namely;

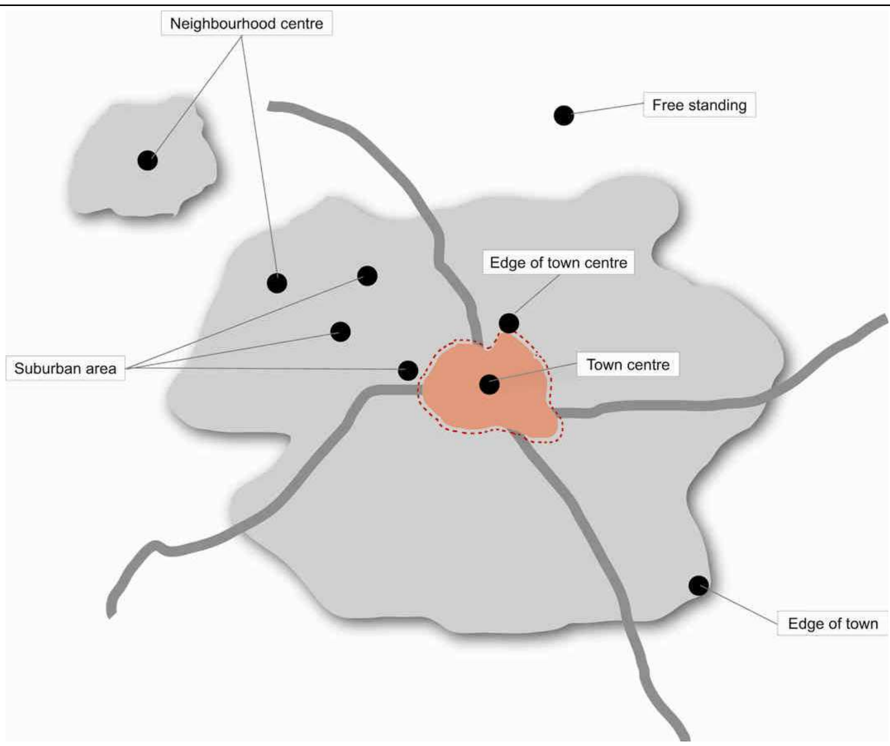
- Food Superstores;
- Office Developments; and
- Residential Developments

4.2 The first two are sub-sections from the retail and employment TRICS® categories respectively while the third category encapsulated the entire housing development category.

4.3 These categories were chosen on the basis that they represent three 'policy relevant' land use categories.

4.4 As a further extension to the study and in an effort to control for all relevant geographical characteristics, land-zone types were also controlled for in the econometric model using dummy variables.

Figure 4.1 The land-zone definitions



TRICS 2009(b)v6.4.1

5 Case Study 1: Food Superstores

Introduction

5.1 This section presents the findings from a trip attraction model for food superstores in the UK.

Discussion of econometric results

The model

5.2 The foundations of the econometric specification are given in the Appendix. The results of the present case study are based upon a general model specification which determines the trip rate (or Flow) as a linear function of economic, socioeconomic physical and geographical characteristics. The final specification being expressed as follows;

$$Trips = f\,(Economic, Socioeconomic, Physical, Geographic)$$

Variables description

5.3 The data, as is also the case with the office and residential case studies, comprises information from the UK Census of Population, the NOMIS (National Online Manpower Information System) archive and traffic and site-specific data from TRICS®.

5.4 The variables used in the analysis of food superstores are summarised in the following table.

Table 5.1 Variables used in the analysis of Food Superstores

Continuous variables					
	Number	**Mean**	**Std. Dev.**	**Min**	**Max**
Car ownership	201	-0.136	0.320	-1.386	0.262
Bus services	201	3.882	0.633	2.303	4.500
Gross Floor Area	201	8.565	0.400	7.097	9.218
Retail Floor Area	199	8.006	0.385	6.783	8.817
Resistance	201	1.120	0.866	-1.386	3.367
Average household size	201	0.861	0.527	0.759	0.977
Employment level for the area	201	0.190	0.205	-0.185	0.595
Parking provision at the site	201	6.107	0.504	4.489	6.908
Dummy variables					
	Number	**Mean**	**Std. Dev.**	**Median**	
Petrol filling station dummy	201	0.507	0.501	1	
Town centre	201	0.099	0.099	0	
Neighbourhood centre	201	0.358	0.481	0	
Suburban area	201	0.020	0.140	0	
Edge of town	201	0.054	0.228	0	
Free standing	201	0.035	0.184	0	
Commercial zone	201	0.129	0.336	0	
Industrial zone	201	0.194	0.396	0	
Economy brand indicator	201	0.094	0.293	0	
Saturday survey	201	0.313	0.465	0	
Sunday survey	201	0.144	0.352	0	
Monday-Thursday survey	201	0.104	0.306	0	

5.5 See Appendix B for a more detailed description of the content of these tables.

Figure 5.1 Mean trip generations for sample of Food Superstores

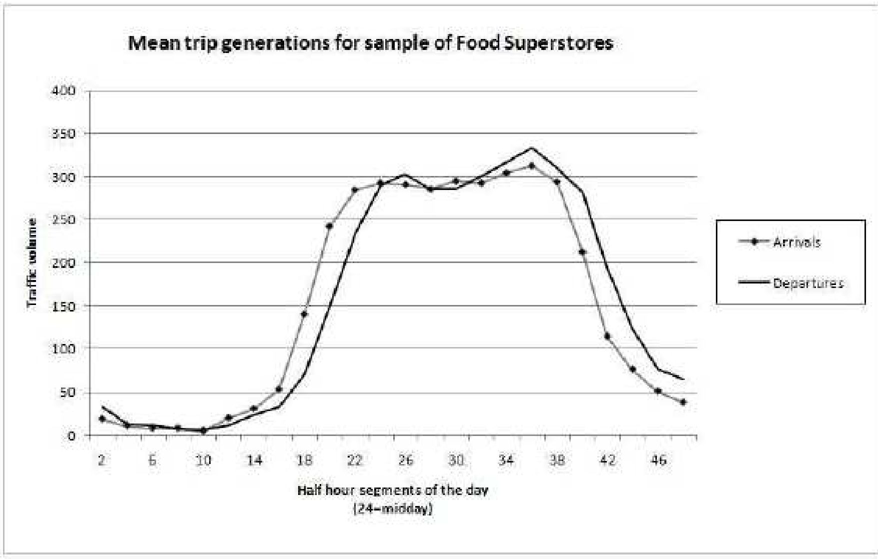


Table 5.2 Estimated results – Food Superstores

Table Header	GFA Model	RFA Model
Constant	1.539*	1.230
Car ownership	0.202***	0.214***
Bus services	0.141***	0.143***
Gross Floor Area	0.303**	
Retail Floor Area		0.339**
Distance to nearest competitor	0.084***	0.102***
Average household size	-1.724***	-1.557***
Employment level for the area	0.494***	0.432***
Parking provision at the site	0.338***	0.343***
Petrol filling station dummy	0.136***	0.150***
Town centre	0.334***	0.375***
Neighbourhood centre	0.102	0.096
Suburban area	-0.067	-0.019
Edge of town	0.280***	0.241**
Free standing	0.109	0.096
Commercial zone	0.153*	0.161*
Industrial zone	0.214***	0.172**
Economy brand indicator	-0.341***	-0.315***
Saturday survey	0.029	0.032
Sunday survey	-0.658***	-0.656***
Monday-Thursday survey	-0.258***	-0.251***
Number of observations	201	199
Adj R-squared	0.694	0.689

Achieved Significance Level: ***=1%, **=5%, *=10%

Specification i=Model estimates using GFA, Specification ii=Model estimates using RFA.

The coefficients in these tables represent elasticises e.g. the car ownership coefficient of 0.202 indicates that a 1% change in car ownership levels leads to a 2.02% change in vehicle trip generations.

Implications of results

5.6 The results indicate that traffic to a given food superstore, increases with household car ownership, store parking provision, site size (floor space), and distance to the nearest competitor. Furthermore, increases in public transport provision are shown to be associated with increasing car trips. This makes sense if it is considered that a larger number of car trips are likely to be reflective of a larger throughput of total trips and hence reflective of a larger consumer base for a bus service provider to tap into. This latter effect is discussed in the light of planning policy for development control purposes and a role linked to the reinforcement of 'food deserts'. The results also reveal activity-specific household economies of scope and scale. It is suggested how these may also further perpetuate unsustainable development and 'food desert' characteristics.

Conclusions

5.7 Shopping in a large food superstore is generally a time consuming experience, therefore the decision to engage in such an activity will be consciously influenced and weighed against the size of the shopping baskets that are being filled (i.e. the extent of the grocery needs). Furthermore, due to their larger shopping load requirements, the relative ease in which the trip can be conducted may actually be enhanced by the use of a car (due to increased comfort and security, door-to-door service etc).

5.8 Food superstores may seek to justify their extensive requirements for land in terms of customer parking provision. However, given city space limitations (and subsequently land price constraints too) it may be less feasible for superstores to locate at inner urban locations in a way that meets the objectives of their business model.

5.9 On the general assumption that these food retailers act largely as profit maximisers, they would rationally aim to facilitate greater customer access. As the results suggest, the level of parking provision significantly influences this ability. Thus, food superstore developers may rationally voice a preference towards outer urban areas, where it is easier to satisfy their parking ratio requirements.

5.10 Given the above food superstores are increasingly less likely to be placed in inner urban locations. Thus, of specific relevance to communities characterised by car-owning, growing families, there is a statistically significant burden of evidence to suggest that with further development of food superstores aiming to serve them, food desert concerns will inevitably be perpetuated and accentuated for some other sections of the community.

5.11 The evidence presented so far implies that the GFA variable can be used to determine trip rates which might appear counterintuitive to the recommendations of pre-2009 TRICS® Good Practice guides. Rather it is the contrary which is true insofar as the results presented here are based upon a *ceteris paribus* assumption or more simple that *all other things are held constant.* Therefore the finding that GFA has a positive relationship is only true when all other aspects are controlled for. As the 2009 TRICS® Good Practice Guide indicates, GFA by itself cannot accurately reflect the level of trip generations and this is reaffirmed by the findings here which demonstrate the complexity of the true underlying relationship.

6 Case Study 2: Office Developments

Introduction

6.1 The notion of sustainability is still in need of much debate by politicians, academics and the general public, as certain aspects still remain very `fuzzy' in terms of general (mis?)understanding. For instance the notion of sustainable communities treads carefully around the distinction between sustainable economic growth and sustainability from the viewpoint of energy/emissions.

6.2 From a transport perspective the two concepts generally walk hand in hand, as transport is quite often necessary to facilitate business transactions and thus economic activity. However, many of the key supporters of developing sustainable communities tend to put aside the sustaining of economic growth. This in itself seems a little surprising as the notion of sustainability is often coined as the reduction in carbon emissions and energy use with the provision of the same level of quality of life for future generations as our current generation enjoys. Gross Domestic Product (GDP) levels are an often used indicator of the quality of life.

6.3 The scope of this study is to define an econometric model for trip generations at office developments.

6.4 The trip to work (and accompanying return trip) serves to be an area of extended debate in which there are many accomplished works looking into multi-faceted aspects of travel behaviour, see for example Jara-Diaz (1998). There are multiple reasons why work based trips receive so much attention, not least of all is the existence/growth of work-based Travel Plans and the extensive debates arising from externalities associated with business activity. Of particular importance in this instance is the role of `non-point' pollution.

Discussion of econometric results

The model

6.5 As in the previous section, the model for office developments has the following general specification;

$$Trips = f\ (Economic, Socioeconomic, Physical, Geographic)$$

6.6 The sample size available for office developments is such that standard inference techniques were dropped in favour of semi-parametric methods to ensure accuracy of the conclusions.

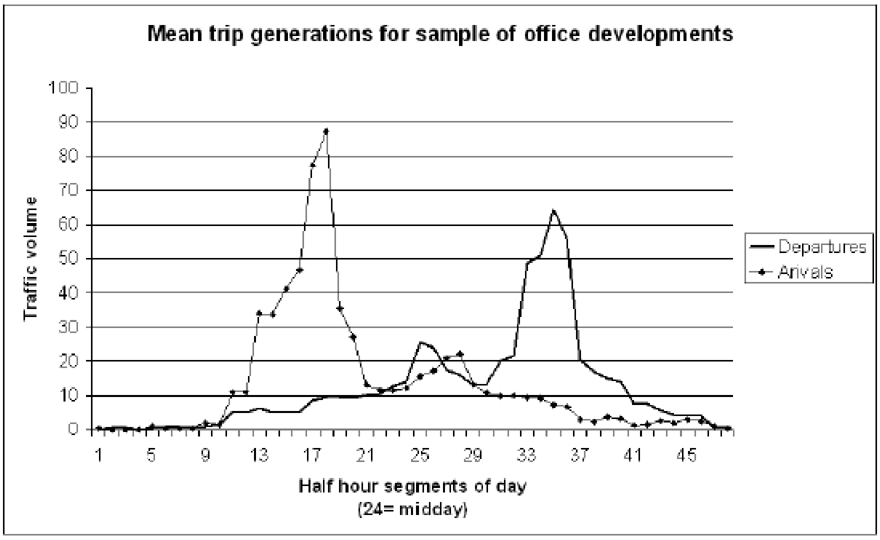
Variables description

6.7 The variables used in the analysis of office developments are summarised in the following table.

Table 6.1 Variables used in the analysis of Office Developments

Continuous variables					
	Number	**Mean**	**Std. Dev.**	**Min**	**Max**
Gross Floor Area	50	8.64	1.09	6.01	11.05
Site employment	50	5.75	1.05	3.61	7.94
Parking provision at the site	50	5.14	1.22	2.30	7.60
Car ownership	50	-0.18	0.37	-1.40	0.26
Bus services	50	3.74	1.21	0	4.25
Average household size	50	0.90	0.06	0.79	0.99
Employment level for the area	50	11.11	0.60	9.98	12.28
Wider area population	50	11.93	0.58	11.00	12.99
Household employment levels	50	0.09	0.13	-0.15	0.43
Year of survey	50	1993.70	4.62	1987	2002
Dummy variables					
	Number	**Mean**	**Std. Dev.**	**Median**	
Town centre	50	0.18	0.388	0	
Neighbourhood centre	50	0.04	0.198	0	
Suburban area	50	0.12	0.328	0	
Edge of town	50	0.26	0.443	0	
Free standing	50	0.10	0.303	0	
Commercial zone	50	0.08	0.274	0	
Industrial zone	50	0.06	0.240	0	
Development zone	50	0.06	0.240	0	
Edge of town centre	50	0.10	0.303	0	

Figure 6.1 Mean trip generations for sample of Office Developments



Estimated results

6.8 The results in the following table suggest upon initial inspection that many of the variables should be dropped, due to insignificance. However formal testing excluding groups of regressors (e.g. the land zone dummies) reveals that dropping these variables weakens the statistical properties of the model and hence that land zone has a significant effect on trip generations. Thus, a trip generation model including only parking provision as a determinant is likely to be incorrectly specified.

Table 6.2 Estimated Results - Office Developments

	Coefficient values
Gross Floor Area	-0.346
Employees at the site	0.381
Parking provision at the site	0.898*
Car ownership	-0.057
Bus services	0.188
Average household size	2.760
Employment level for the area	-0.134
Average household employment	-0.541
Town centre	-0.299
Neighbourhood centre	0.633
Suburban area	0.177
Edge of town	-0.094
Free standing	-0.119
Commercial zone	0.056
Industrial zone	0.125
Development zone	0.510
Edge of town centre	0.456
Number of observations	35
Adj R-squared	0.92

Achieved Significance Level: ***=1%, **=5%, *=10%

Specification i=Model estimates using GFA, Specification ii=Model estimates using RFA.

Implications of results

6.9 The burden of evidence indicates firstly that provision of public services ceteris paribus, is not consistent with mode switching behaviour and hence is not a feasible instrument to constrain demand for car use.

6.10 It is the provision of parking spaces at the site in question along with the scale of the business activity at that site that determines travel behaviour - or at least this is what the present data capture within TRICS® would conclude. Therefore in the absence of trying to constrain business behaviour by directly controlling site activity, the implication is that parking policies and land zone type are presently the most direct routes to controlling demand for car use at office employment sites.

Conclusions

6.11 With respect to implications for policy setters, it is seen that the most effective policy interventions would involve the reduction of either (a) employment levels or (b) parking provision.

6.12 These must inherently be supported with a great many caveats. Any site specific policy, e.g. a work based travel plan, must offer incentives `sweet enough' to avoid employee's considering changing their jobs due to the personal impacts of enforced changes in travel behaviour.

6.13 There is no 'one size fits all' solution and policy in transport must be tailored to suit the needs of the individual site and its employees.

7 Case Study 3: Residential Developments

Introduction

7.1 This section presents evidence from a case study on residential sites as taken from the TRICS® database.

7.2 There has been ongoing exploration into the interactions between car use and car ownership. Many previous works have considered the empirical relationship between car ownership and car use. Various studies focus purely on car ownership while others point to enduring differences of opinion as to whether car-ownership and car-use should be modelled individually or together.

7.3 Transportation practitioners often rely upon knowledge of car ownership levels and their interaction with travel demand in order to help define future transport behaviour.

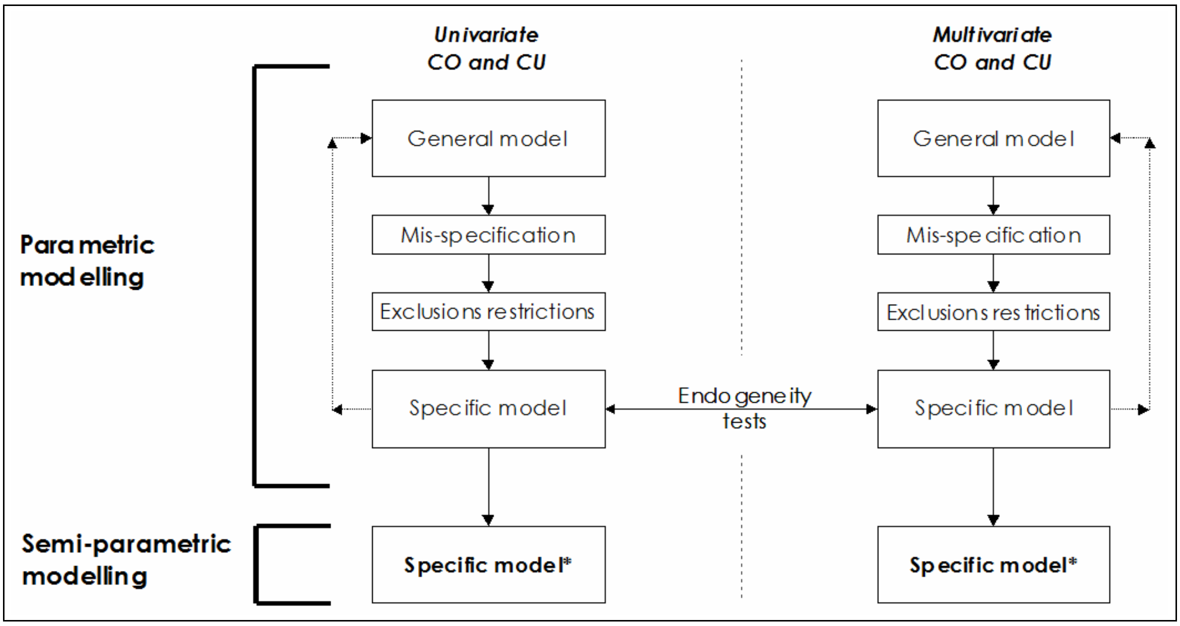
7.4 Joint models of car ownership and car use can help extend the information provided by pure trip generation models. Although, when using TRICS®, it is not feasible to consider models of car ownership and use as a function of activity purpose or trip length, it is possible to consider the total number of trips produced, and differentiate by different household structures. This can provide some light on different lifestyles within various household types and areas.

7.5 This case study seeks to identify whether land zone and residential dwelling type can be statistically related to car ownership levels and also car use, in so doing it employs a sequential, general to specific modelling strategy.

Discussion of econometric results

The model

Figure 7.1 Conceptual modelling framework



7.6 This econometric model considers estimates with two alternative model structures, namely a single equation specification (i.e. estimating trip generations by themselves) and a multiple equation approach (making trip generations dependent on car ownership). The general model specifications are as follows;

$$Trips = f\ (Economic, Socioeconomic, Physical, Geographic, Car\_Ownership)$$

$$Car\_Ownership = f\ (Economic, Socioeconomic, Physical, Geographic)$$

Variables description

Table 7.1 Variables description - Residential Developments

Continuous variables						
	Mean	**Median**	**S.D.**	**Min**	**Max**	**N**
Trip generations	2.823	2.798	1.467	-1.043	6.945	146
Metropolitan size area	11.876	11.791	0.478	10.857	13.801	146
Average household size	0.906	0.908	0.050	0.786	1.027	146
Household employment	0.086	0.074	0.098	-0.118	0.413	146
Bus services	3.931	4.248	0.953	0	4.500	146
Car ownership	4.892	4.682	1.333	2.416	8.957	146
Year	1994	1992	4.617	1987	2002	146
Dummy variables						
Town centre	0.014	0	0.117	0	1	146
Neighbourhood centre	0.096	0	0.293	0	1	146
Suburban area	0.295	0	0.457	0	1	146
Edge of town	0.425	0	0.496	0	1	146
Free standing	0.089	0	0.286	0	1	146
Edge of town centre	0.082	0	0.276	0	1	146
Household Classification Variables						
A – Houses Pri. Owned	0.281	0	0.451	0	1	146
B – Houses for Rent	0.021	0	0.142	0	1	146
C – Flats Pri. Owned	0.034	0	0.182	0	1	146
D – Flats for Rent	0.075	0	0.265	0	1	146
E – Institutional Hostel	0.027	0	0.164	0	1	146
F – Sheltered Accom.	0.075	0	0.265	0	1	146
G – Student Accom.	0.021	0	0.142	0	1	146
H – Nurses Home	0.007	0	0.083	0	1	146
I – Caravan Pk(non-hol)	0.007	0	0.083	0	1	146
J – Holiday Accom.	0.082	0	0.276	0	1	146
K – Mixed Pri. Housing	0.240	0	0.428	0	1	146
L – Mixed Non-Pri. Hou.	0.075	0	0.182	0	1	146
M – Mix. Pri./Non-Pri. H.	0.075	0	0.265	0	1	146
N – Retirement Flats	0.021	0	0.142	0	1	146

Figure 7.2 Mean trip generations for sample of Residential Developments

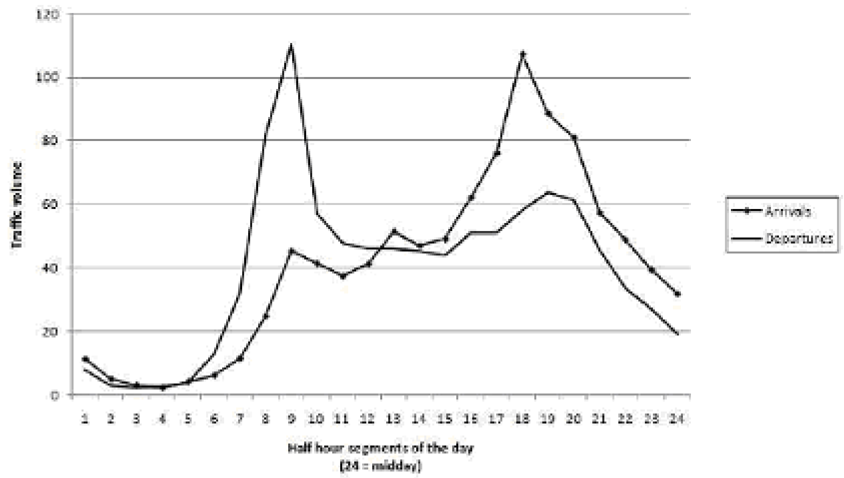


Table 7.2 Estimated results - Residential Developments

	Car ownership	Trip generation
Constant	-11.058	24.498
Metropolitan size area	-0.180	
Average household size	-0.618	
Average household employment	-0.879	
Bus services	-0.078	
Year	0.010	
Neighbourhood centre	0.043	
Suburban area	-0.076	
Edge of town	-0.055	
Free standing	-0.011	
Edge of town centre	0.079	
Trip generations	0.914***	
Car ownership		1.055***
Obs	146	146
Adjusted R_2	0.86	0.87

Implications of results

7.7 The results imply a very simple relationship whereby car ownership is determined by how much cars are used at a site, and how much cars are used is determined by car ownership levels.

7.8 Public transport has not really contributed to lowering the traffic impact of residential developments within the UK.

Conclusions

7.9 From a modelling perspective, the results reveal some interesting issues relating to the general approach to analysing trip generations from residential developments and also to parametric modelling in general.

7.10 The modelling of trip generations from residential developments is found to share some bi-directional causality with car ownership. As such, car use cannot be rationally treated as independent of the decision to own a car.

7.11 Unlike in previous empirical studies, the socio-economic indicators are not observed to have any significant effect on travel behaviour in either of the modelling approaches. In itself this may be a result of the aggregation of trip activities as well as households. Given the evidence available from the extant literature, it would be unwise to assert that socio-economic characteristics do not help determine travel behaviour and indeed they are a statistically valid feature of this model. However, the coarse nature at which they are defined is likely to be one of the reasons precluding their individual statistical significance.

8 Summary and conclusions

8.1 This section brings together and summarises the general conclusions of the three case studies, attempting to provide guidance on three underlying issues

- What is the best way to model vehicle trips?
- What determines vehicle trips?
- What are the differences across the land-use types?

8.2 This study arose from a desire to attempt to model the TRICS® data in a more rigorous manner than previously done and has engaged a scientific approach to demonstrate that traffic behaviour is, in part, determined by land use type.

What is the best way to model vehicle trips?

8.3 The majority of recent work points towards the application of large scale gravity type models, due to the way they can be incorporated into much larger models of economic behaviour - therefore at a coarse level of aggregation they seem to offer obvious benefits.

8.4 The form of the TRICS® data precludes the application of many types of mainstream transport modelling methods such as full network origin-destination analysis, as only one end of the journey is available. Similarly discrete choice based analysis of individual behaviour is not feasible due to the level of aggregation of the data.

8.5 Given the depth of the data and spread of observations over time, the possibility of applying time series and/or panel methods cannot be considered appropriate at present - more data, as will be collected over coming years, will however make these estimation technologies feasible in the future.

What determines vehicle trips?

8.6 Given the approach taken, the analysis strongly implies that geographical features such as land zone placement and site specific characteristics are crucial in determining vehicle trip rates at the three site types considered.

8.7 For offices there is clear evidence that the parking characteristics of sites play the largest determining factor in travel demand. However land zone placement is also important and MUST be controlled for when assessing trip generation levels as they are a significant feature of the model, as are other socioeconomic characteristics, although they are not individually significant.

8.8 For food superstores, the evidence is a little clearer, with the results indicating a clear and significant relationship between land zone placement and travel behaviour with different land zone types being associated with higher vehicle trip levels when compared to others.

8.9 Furthermore, the other indicators featured into the model all feature significantly, indicating that for the purpose of food shopping, the decision to travel by car is determined by a rather complex interaction with many factors.

8.10 For residential developments there are no individually significant land zone variables, yet they are a statistically relevant feature of the final preferred model. This would again imply only weak evidence of a relationship between land zone placement and travel behaviour as found with offices.

8.11 Land zone indicators are important and their omission could lead to bias in the coefficients and hence inappropriate policy conclusions. The same is also true of socio-economic indicators and site specific characteristics, which are equally validly accepted to be a necessary feature of trip generation models, in all three land use types.

What are the differences across the land-use types?

8.12 There are both similarities and differences across the three land uses analysed e.g. Food Superstore, Offices and residential sites.

8.13 By way of similarity, in all three case studies it was found that land-use placement is an important feature within these forms of model. This is perhaps arguably an unsurprising finding but is a positive re-enforcement that the current directions in government policy are valid.

8.14 Land zone features are consistently found to improve the trip generation models reinforcing that they play an important role in assessing travel behaviour at the land use types considered.

8.15 This study has shown that the TRICS® database contains plentiful information to create well specified models of trip generation for certain land use types. Moreover, the results of these models raise some potentially interesting issues for local level planners and policy makers, such as the existence of scale and scope economies for food superstore trips, and the seemingly inadequate manner in which public transport services have been historically implemented.

General conclusions from the study

8.16 The ability to use the TRICS® data for sound econometric modelling has been demonstrated by the generation of three separate models, largely adhering to *a-priori* expectations, and satisfying the necessary statistical pre-requisites, albeit with the assumption of normality needing to be dropped in many cases.

8.17 A further feature arising from the model results is that provision of bus services is not consistent with a reduced traffic impact. The suggestion is that traffic levels are likely to remain unchanged.

8.18 There is no ‘one size fits all’ solution and policy in transport must be tailored to suit the needs of the individual site. The results presented in this report present one set of indications based on one general approach for one particular country. The dynamics of society are such that there could never be a single solution to transport problems as needs and norms are constantly evolving too.

8.19 What is clear however is that there are a raft of issues that the TRICS® database can provide a perspective upon by building on theoretically grounded statistical analyses.

APPENDIX A

Econometric model

Econometric model

An Activity-Based Trip Model is therefore specified under the same auspices as a standard demand relationship for consumer behaviour, derived from standard micro-economics so that the demand for a good or service is determined by the desire and ability to purchase the good (e.g. characteristics of the good, and individual capacity to consume), as well as interactions with substitute markets/goods and/or effects. This can be summarised as follows:

$$Trips_{m,o.d} = f\left(Economic_o, Socioeconomic_o, Physical_d, Geographic_d\right)$$

$$m \in M, o \in O, d \in D$$

Where '*M*' is the set of travel modes, '*O'* is the set of origins and '*D*' is the set of destinations. The dependent variable '*T*' is the one way hourly average traffic flow.

Equation (1) implies that the desire to travel to a site (by any chosen mode of travel, for instance cycling, walking or taking public transport), is determined by factors that influence the ability and/or wish to partake in (or consume) the activity (or service) which that site offers. In particular, the *Economic* characteristics of the local population, thus capturing the ability of individuals within that area to consume. *Physical* or site specific attributes, which may be considered as features of that site which may serve to attract more trips. The wider *Geographic* information may have some bearing on trip levels including site accessibility, and potential resistance offered by the existing geography. Finally *Socioeconomic* characteristics, which reflect (in part) lifestyles, and consequently, consumption choices within a given area.

For empirical tractability a number of simplifying assumptions are required to ensure that activity specific elasticises are revealed, as follows;

'M' is constrained to passenger vehicle traffic only.

'O' is not known with certainty, and is therefore assumed to be a function of the surrounding areas characteristics.

'D' is constrained to one type of destination, in this instance food superstores. i.e. the model estimates the levels of trips for only one individual type of activity.

Appendix B

Descriptive statistics

Descriptive Statistics

This appendix provides a brief description of the statistics provided in the tables in each of the analytical chapters.

Mean

The mean is simply the average of the sample of data. It is calculated as the sum of the observations of the variable in question, divided by the number of observations.

Median

The median represents the central tendency of the sample of data. The data is ordered from highest to lowest and if for instance there are 11 observations the median is the 6th observation from the ranked data.

Standard deviation (s.d.)

Is calculated as follows:

1. Calculate the deviations as the individual observation minus the mean of the variable;

2. Take the mean (average) of the deviations.

Minimum (min)

The smallest observation in the available data.

Maximum (max)

The largest value in the available data.

Number of observations (N)

The number of observations in the data used.