National Transport Model

Volume 3

Demographic and Economic Forecasting Report

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NRA
An tÚdarás um Bóithre Náisiúnta
National Roads Authority

AECOM

ESRI

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Demographic and Economic Forecasting Report

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1.0 Introduction

1.1 Overview

This report which is referred to as the Demographic and Economic Forecasting Report forms Volume 3 of the National Transport Model (NTpM) suite of supporting documentation. In order to provide all the relevant detail of the NTpM in a clear and concise manner the documentation for the NTpM is split into four volumes as follows:

- **NTpM Volume 1 – Model Development Report** – Provides the background to the NTpM and outlines the development, calibration and validation of the various modules of the NTpM;
- **NTpM Volume 2 – Data Collection Report** – Presents details of the data and data sources used to update and enhance the NTpM;
- **NTpM Volume 3 – Demographic and Economic Forecasting Report** – A detailed discussion on the background data and methodologies used to inform the estimates of future travel demand in the NTpM is presented in this report; and
- **NTpM Volume 4 – Variable Demand Model Report** – The final report provides the details on the background, development and function of the variable demand model.

1.2 Model Structure

The NTpM is made up of several sub-models, each having its own unique inputs and structure. The overall basic structure of the NTpM is illustrated in Figure 1.1.

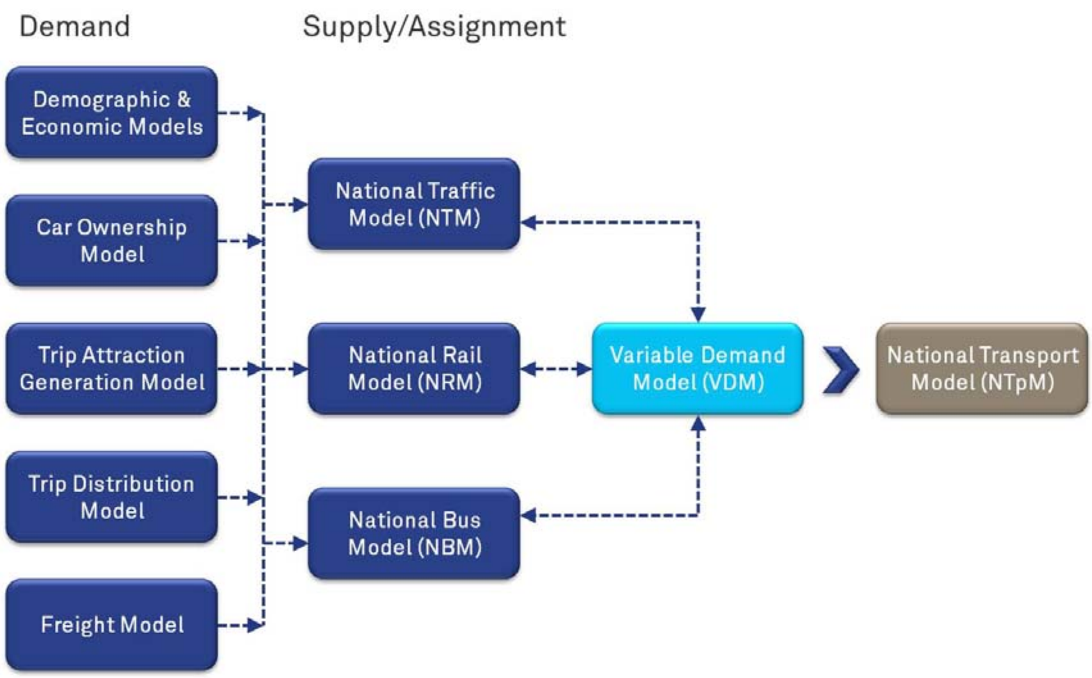


Figure 1.1 – NTpM Basic Structure

The role of the Trip Attraction Generation Model (TAGM) is to take the outputs of the Demographic and Economic Models (i.e. population and jobs) and the Car Ownership model and convert them to origin and destination zone trip ends total for each mode.

A Trip Distribution Model then distributes the origin and destination trip ends totals between the various zones in the model. The Freight Model is used to estimate the increase in freight at a national level.

The assignment models (Traffic, Rail & Bus) are used to assign the demand for travel represented by the demand matrices to the network, generating travel costs (e.g. time, distance, tolls, fares) for each mode.

The role of the Variable Demand Model (VDM) is to assess, if required, the impact of a change in the transport network or change in the cost of travel (e.g. fuel costs, fares) upon the demand for travel. This is calculated by comparing the zonal travel costs from the assignment models between a Do-Minimum (without change) scenario and a Do-Something scenario (with change).

1.3 Purpose of Report

The National Transport Model (NTpM) requires travel demand forecasts for two future years, 2030 and 2050 across both private and public transport modes. In order to estimate the level of demand across these transport modes various demographic and economic forecasts are required.

A bespoke Trip Attraction Generation Model (TAGM) is used to convert the demographic and economic forecasts into both private vehicle trips and public transport passenger trips. This report provides the background and approach to forecasting the various demographic and economic inputs required for the TAGM.

1.4 Overview of Approach

The demand for transport varies according to a range of different factors, including;

- The size of the population;
- The age distribution of the population;
- The rate of car ownership among the adult population; and
- Economic activity both in terms of the movement of goods and the location of jobs.

As such, it is necessary to develop a number of different forecasts that, when input to the TAGM, will ultimately give rise to forecasts of future traffic and passenger demand. Figure 1.1 below gives a simple illustration of how the various demographic and economic forecasts work together.

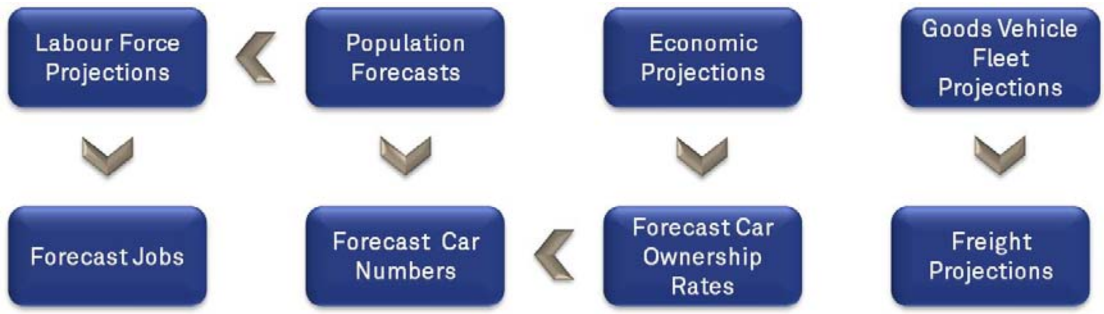


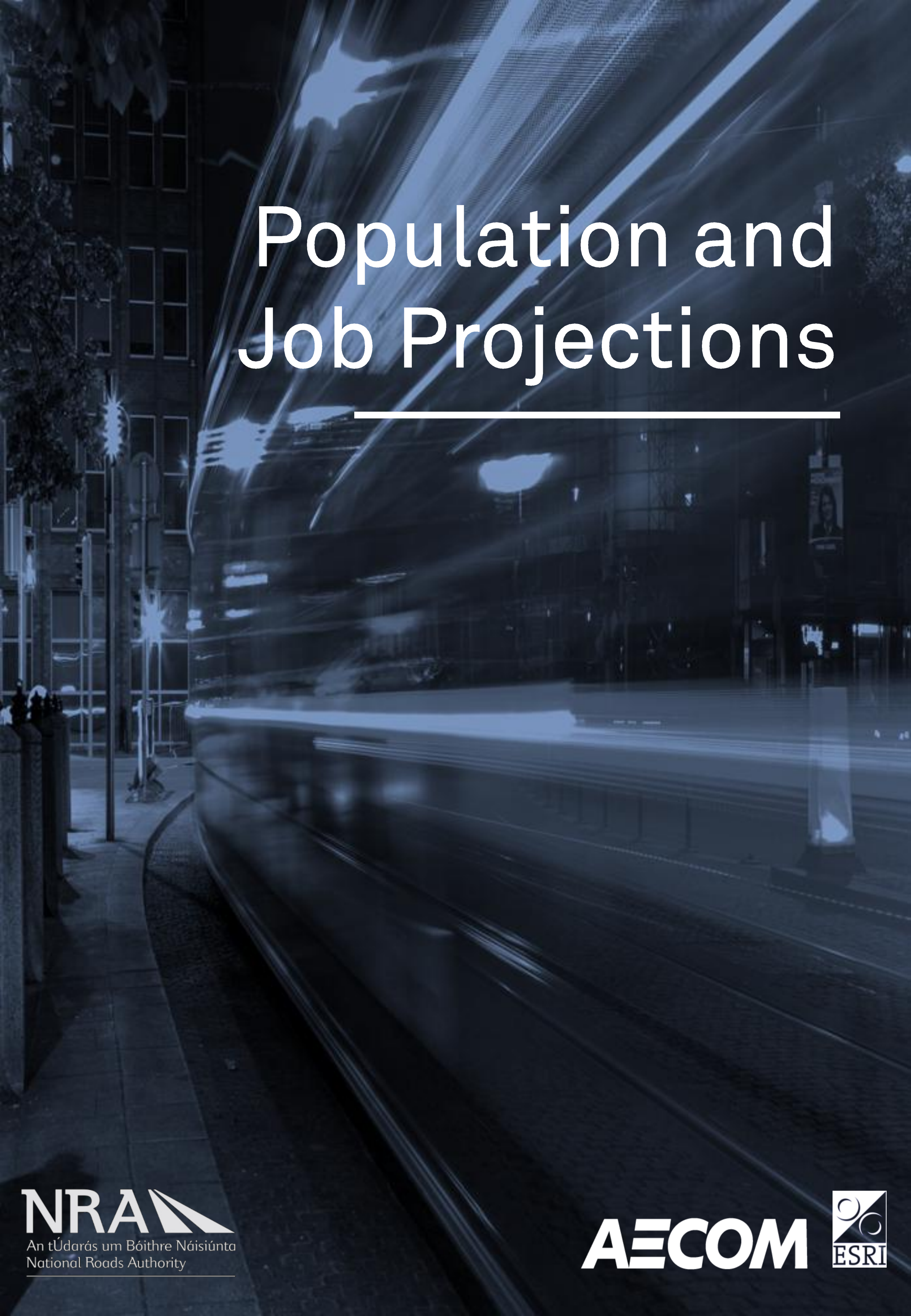
Figure 1.1 – Demographic and Economic Inputs

1.5 Structure of Report

The report is divided into a number of key chapters which discuss the core elements of the demographic and economic forecasting process, as follows:

- Population and job projections;
- Car ownership forecasting;
- Travel demand forecasting; and
- Goods vehicles forecasting.

Population and Job Projections



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2.0 Population and Job Projections

2.1 Introduction

For transport planning some understanding of land use changes is important in order to identify where constraints are likely to arise and thus allocate investment to locations with the highest return. This return arises over an extended period of at least 30 or 40 years which implies that the land use changes over this time horizon need to be taken into account.

Importantly, land-use changes occur at a local level and thus national projections are of limited value in identifying investment needs. In order to assist in identifying investment needs the National Roads Authority (NRA) uses their National Transport Model (NTpM). The NTpM requires inputs for 927 zones in the Republic of Ireland, including population, jobs (where they are located) and employed persons (where they reside).

Such inputs tend to be available at the national or the regional level over a longer time horizon, for example the Central Statistics Office (CSO) published national population projections for the period up to 2046[1] based on six different growth scenarios as outlined in Table 2.1. Regional population projections for the period 2016 to 2031[2] are also provided by the CSO. However, they do not exist for smaller spatial units[3].

Table 2.1 – CSO National Population Projections

Year	M1F1	M1F2	M2F1	M2F2	M2F1	M2F2
2011	4.59m	4.59m	4.59m	4.59m	4.59m	4.59m
2031	5.64m	5.52m	5.29m	5.19m	4.99m	4.89m
2046	6.73m	6.42m	5.91m	5.64m	5.24m	4.99m

Therefore a new set of projections were constructed as part of the development of the NTpM. The aim of this section of the report is to document the methodology used in devising updated population, jobs and employment projections for the updated NTpM. These projections are based on the latest demographic baseline data from the CSO Census 2011 and reflect the changed demographic and economic conditions.

This is important as the initial projections incorporated very significant net-immigration of 50,000 persons for the first 5 years and continued strong net-immigration of 37,500 thereafter, which stands in stark contrast to the net-emigration of 30,000 over the period 2010 to 2013.

[1] Central Statistics Office, Population and Labour Force Projections 2016 – 2046, 2013
[2] Central Statistics Office, Regional Population Projections 2016 – 2031, 2013
[3] Small areas refer to spatial units that are smaller than counties.

Instead of generating separate projections for the population and employment/location of jobs the central scenario constructed in this report calculates a consistent linked set of population, jobs and employment numbers based on the Economic and Social Research Institute (ESRI) Medium-Term Review[4] (MTR) for the recovery scenario contained in that report.

Furthermore, instead of following a top-down approach, spreading national projections across zones using a fixed share, the new methodology utilises both a top-down approach and a bottom-up approach, with the former ensuring overall consistently while the latter is better able to reflect local differences. The projections are first produced for 3401 Electoral Districts (EDs) and the results are aggregated to the 927 NTpM zones.

This section of the Demographic and Economic report is organised as follows. Section 2.2 outlines the methodology chosen to generate the population projections. The methodology adopted for the jobs (where the jobs are located) projections is outlined in section 2.3, the employment (where employed persons reside) projections are outlined in section 2.4 and section 2.5 summarises the findings and offers some conclusions.

2.2 Small Area Population Projections

2.2.1 Overview

Small area population projections are usually produced either by some form of trend extrapolation at the small area level or through a top-down share attribution methodology where a national projection is spread across spatial units using population shares[5]. Here a hybrid approach is adopted which utilises county level projections constructed using a cohort-component model and applying a bottom up approach using estimated parameters from regression analysis to share out these projections for each county. Cohort component models use data such as births, deaths, migration etc to project future populations. This approach ensures consistency with county level and national projections, while also allowing for the impact of small area factors.

2.2.2 County Projections

The county level projections are generated using the ESRI Irish County Population Model (IC-POP). This is a cohort component model that takes the number of males and females by single year of age from the Census 2011 and applies mortality, fertility and migration assumptions to each cohort in order to project this into the future (see Morgenroth, 2008).

The cohort component model is based on the fundamental balancing equation of

[4] J Fitzgerald and Ide Kearney, Economic and Social Research Institute, Medium-Term Review, 2013
[5] Morgenroth, Edgar, Evaluating Methods for Short to Medium Term County Population Forecasting, 2002

population growth:

$$P_t = P_0 + (B_{0-t} - D_{0-t}) + (I_{0-t} - E_{0-t})$$

Where P denotes the population, 0 denotes the starting year and t denotes the year to which the population is to be projected. B denotes births and D denotes deaths between the starting period (0) and the projection year t, so that the second term generates the natural increase in the population. I denotes immigration and E denotes emigration, such that the third term equals net-migration.

Given a starting population P_0, in order to project the population one needs to project the number of births, deaths and net-migration between the starting and the projection year in order to calculate the population in the projection year. The natural increase is achieved by applying a mortality rate to the population in order to project deaths and by applying assumptions about the age specific fertility rate of women in order to project the number of births.

Here the CSO F2 assumption is followed for fertility, which assumes that the Total Fertility Rate (TFR) (i.e. the average number of children that would be born to a woman over her lifetime) will decline from 2.1 to 1.8 by 2026 and remain constant thereafter[6]. This is implemented at the county level by applying the implied trend in the fertility rate to the county specific fertility rates, which implies that the differences across counties stay constant. Mortality rates are assumed to be the same throughout the country and the rates used by the CSO are applied here.

While the different assumptions for both mortality and fertility do change the results, the impact of alternative migration assumptions tends to be significantly larger. Thus, as the key assumption relates to international migration, three alternative migration scenarios are considered. These are consistent with the CSO M2 and M3 scenarios (see CSO 2013a, 2013b) and ESRI MTR Recovery scenarios[7]. Within the NTpM these scenarios represent the following:

- CSO M2 = Low Growth Scenario
- ESRI MTR Recovery = Central Growth Scenario
- CSO M3 = High Growth Scenario

The CSO M2 assumption assumes a return to net-immigration from 2016, averaging 4,700 persons per year in the period 2016 to 2021, which rises to 10,000 per annum for the remainder of the projection period. The ESRI recovery scenario results in a return to net-immigration by 2021, which runs at 5,000 per annum thereafter. Finally the CSO M3 assumption does not envisage a return to immigration and instead assumes that emigration averages 25,100 for the period 2011 to 2016 which gradually reduces but continues at a rate of 5000 per annum from 2021.

The spatial distribution of migration, both internal and external, is also an important factor. Internal migration patterns are assumed to follow the CSO patterns (traditional) and the international migration patterns are also calibrated to the pattern used by the CSO for the production of their regional population projections[6].

[6] Internal migration flows have been subject to significant changes over the last two decades. The traditional

These imply flows towards the large cities and particularly Dublin.

The results for the three different international migration scenarios are shown in Figure 2.1 for the total national population. The graph shows that the CSO M2 assumption is the most optimistic one while the CSO M3 assumption results in only modest growth at the start of the projection period. The ESRI recovery scenario which incorporates a relatively benign economic scenario with a return to full employment yields a central projection. As such, while the underlying economic scenario that would give rise to the CSO M2 and M3 scenarios is not known[7], the CSO M2 scenario implies a significantly stronger recovery than that in the ESRI recovery scenario while the CSO M3 assumption implies no recovery and continued stagnation.

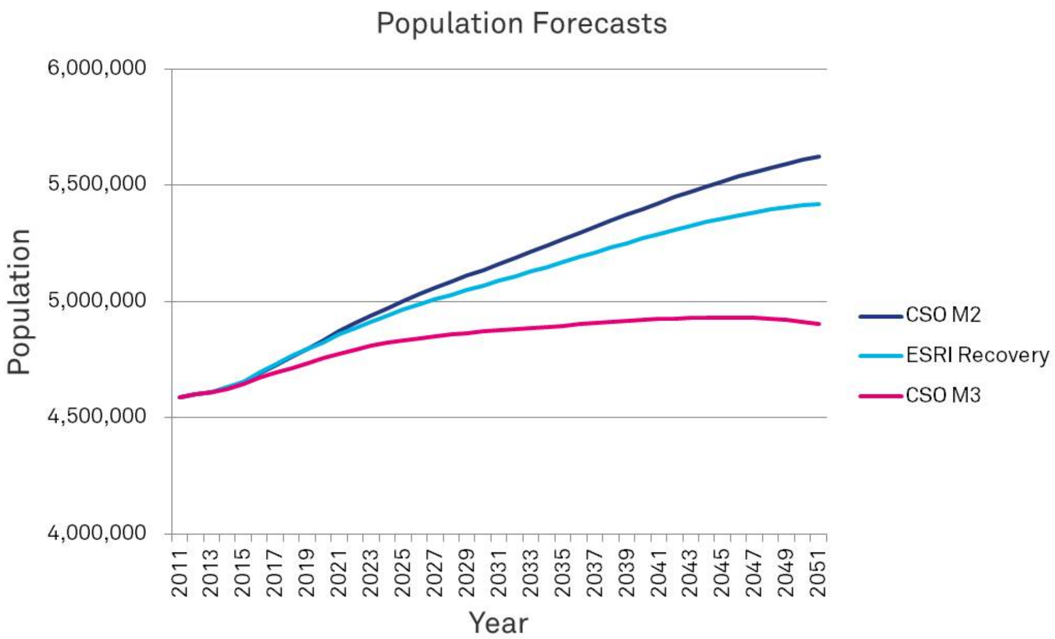


Figure 2.1 – Population Projections form IC-POP using Alternative Migration Scenarios

At the county level the ranks in terms of population share do not change significantly (correlation of 0.98), but in all scenarios the most peripheral counties, Leitrim, Roscommon, Mayo and Kerry are expected to either grow very little or indeed experience a decline in the population. This is a function of both the age structure in the counties, and especially the number of females in the child bearing age groups, and the assumed spatial migration patterns

2.2.3 Small Area Projections

One way to generate small area projections is to simply apportion the county

pattern corresponds to the stable pattern of internal migration that existed up to the late 1990s. This pattern encompassed migration towards the cities and surrounding areas from the late 1990s to the end of the Celtic Tiger boom, internal migration patterns inverted, with net-outflows from the cities and strong inflows into more peripheral counties.

[7] The CSO population projections are not constructed as part of a wider consistent set of economic projections.

population on the basis of existing small area share in the county population. While this is a simple exercise it would ignore key local factors. For example any analysis on population change at the small area level in Ireland will find a negative relationship between existing population density and population growth. This relationship both reflects residential preferences i.e. Irish people on average seem to prefer less dense areas to reside in, and the simple fact that areas that are already densely populated offer less opportunities for further housing development and thus offer less potential for population growth.#

Therefore the approach adopted here attempts to take account of such local factors by distributing the projected county level population across electoral districts (EDs) using the parameters from a regression analysis. Specifically the share (s) of each ED (i) in the county (c) population change for a particular period (t) is defined as:

$$s_{ic,t} = \frac{pop_{ic,t} - pop_{ic,t-1}}{\sum_{ic} pop_{ic,t} - pop_{ic,t-1}} \tag{1}$$

Where pop refers to the population, this is modelled as a function of ED specific variables that for convenience we denote Z, measured in the previous period:

$$s_{ic,t} = f\left(Z_{ic,t-1}\right) \tag{2}$$

Here Z includes size of the population, the population squared, the population density and the density squared, the initial population share, a measure of accessibility that is defined below and lags of the share of each ED in the population change at the county level. $s_{ic,t}$ is thus modelled in a regression analysis as a function of these variables.

Formally this can be written as:

$$s_{ic,2011} = \beta_1 \text{pop}_{2006} + \beta_2 \text{pop}^2{}_{2006} + \beta_3 \text{pop density}_{2006} + \beta_4 \text{pop density}^2{}_{2006} + \beta_5 \text{pop share}_{2006} + \beta_6 A_{2006} + \beta_7 s_{ic,2006} + \beta_8 s_{ic,2002} + \beta_9 s_{ic,1996} + \beta_{10} s_{ic,1991} + \epsilon_{2011} \tag{3}$$

Where the βs are parameters that are to be estimated, and ϵ denotes an error term. County specific effects are also allowed for. Accessibility (A) of ED i in 2006 is measured as the inverse drive time weighted population or jobs:

$$A_{i,2006} = \sum_{i \neq j}^{i} \frac{1}{t_{ij,2006}} P_{j,2006} \tag{4}$$

Where t denotes the drive time between NTpM zones[8]. Accessibility can thus change as the spatial pattern of the population changes but could also be allowed to change with changing roads infrastructure and transport patterns. However, in the regression analysis and the projections accessibility is assumed to stay fixed[9].

Using lagged values for the explanatory variables it is possible to predict the share which when multiplied by the county level change generates the population projection:

$$\widehat{\Delta \mathrm{Pop}}_{ic,t} = \widehat{s_{ic,t}} * (\widehat{\mathrm{Pop}}_{c,t} - \mathrm{Pop}_{c,t-1}) \quad (5)$$

Where hats indicate projections and Δ indicates the absolute change. Adding the latter to the starting population yields the new population. The projected population $\widehat{\mathrm{Pop}}_{c,t}$, is generated by the county level population projection model (IC-POP) and the past county population is known for 2011 from the Census of Population. Together they form the top-down part of the projection, while the bottom-up part is $\widehat{s_{ic,t}}$, which is determined by local factors.

It is important to ensure that the model is well behaved i.e. that it does not allow an individual ED to become infinitely large or more than empty out (no negative population). This property should hold in the limit i.e. when going towards an infinite time horizon, and certainly over all reasonable projection periods.

It should however be possible to have negative shares i.e. EDs that grow in the opposite way to the county overall. Extensive sensitivity analysis using alternative specifications was conducted to settle on a preferred regression model which includes four lags of the shares, squared population and population density, a lagged population share as well as county specific fixed effects. This model has very good explanatory power and results in well behaved parameters for the extrapolations (see Table 2.2).

Table 2.2 - Regression Results (dependant variable is ED share in the change in county population)

[8] Accessibility is assumed to be the same for each ED in an NTM zone. The drive time was calculated using Microsoft Map Point using the Mile Charter utility. MS Map Point uses the NAVTEQ roads data set for Europe.
[9] By assuming no change in accessibility the projects form a valid baseline which could be used to assess the impact of new infrastructure in a particular location. Thus, the population projection model can be used as a tool to assess land-use impacts of a particular transport project.

Variable	Parameter
Population	7.11E-07*
Population Squared	-3.24E-11**
Population Density	-5.40E-06***
Population Density Squared	2.90E-10***
Population Share	0.34315393***
Accessibility	1.59E-07***
Share (t-1)	-0.0054543***
Share (t-1)	0.53801943***
Share (t-1)	-0.0193134**
Share (t-1)	0.00270366***
Adjusted R^2	0.58

*Note: *, ** & *** denotes statistical significance at the 10%, 5% and 1% confidence level. Standard errors are corrected to account for heteroskedasticity*[10]

A higher population in the starting period is associated with a higher share in the county growth, but as the square of the initial population carries a negative coefficient, this effect reduces as the population increases. A higher density has the opposite effect, and again that reduces as the density increases. A higher initial population share is associated with a larger share in the county change and more accessible EDs have a higher share in the county change. The lags of the dependent variable alternate sign indicating that an ED that accounted for a higher share in the county population change in the previous period tended to experience a lower share in the following period.

The results of the projections at the NTM zonal level are shown in Figure 2.2 below where they are scaled by the area of the zones (i.e. as a density in persons per squared kilometre) in order to account for the heterogeneity in their size. The maps show that density is projected to increase in and around the major cities. For example the model predicts that the corridor between Cork and Limerick will see significant increases in the population density. The dense area around Galway is also expected to increase size. The remote counties like Donegal, Leitrim, Sligo, Mayo and Kerry are not expected to experience much change.

[10] In statistics, a collection of random variables is heteroscedastic if there are sub-populations that have different variability's from others. Here "variability" could be quantified by the variance or any other measure of statistical dispersion.

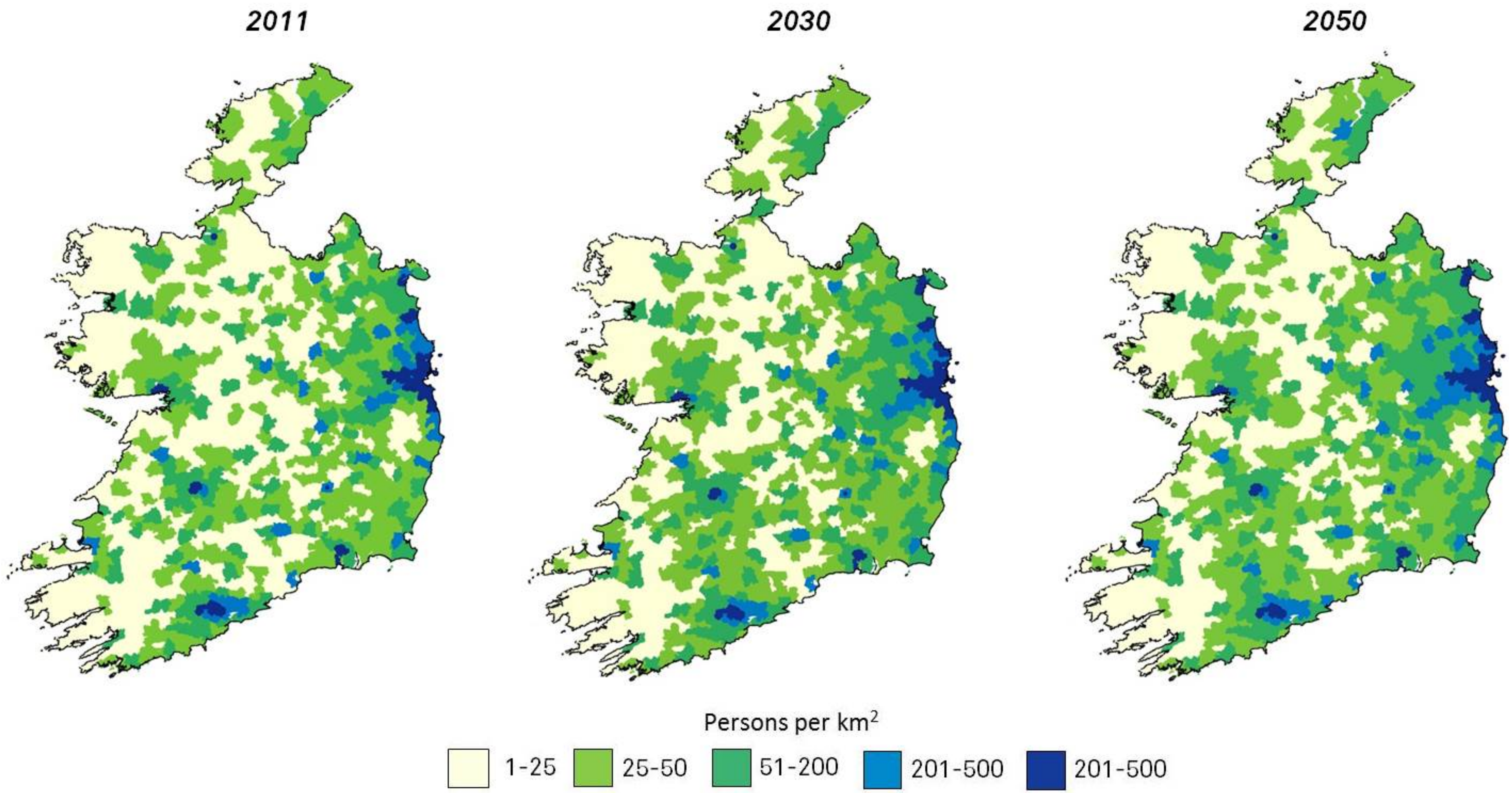


Figure 2.2 - Projected Population Density on the basis of the ESRI MTR Recovery Scenario 2011, 2030 and 2050

2.3 Small Area Jobs Projections for the National Transport Model

2.3.1 Overview

The general approach used for projecting the population, to combine a top-down and bottom-up approach, is also used for the jobs projections[11]. The approach incorporates aggregate projections and models the contribution of an ED to the aggregate change using a regression analysis, the parameters of which are utilised in the detailed projections.

Data availability is an important constraint in projecting the evolution of the number of jobs at the small area level. Firstly, regional or county level projections of the number of jobs are not available and instead the analysis needs to rely on the national projections from the ESRI Medium-Term Review[12] (MTR). As the projection horizon in the MTR only extends to 2030 and given that the projection horizon in the NTpM is 2050, the MTR projections need to be extended to cover the required time horizon.

The MTR has details for eleven sectors[13] and the projections from the recovery scenario are extended by assuming that Agriculture, Forestry and Fishing and the Construction sectors continue to grow at their long run rates, while all other sectors are assumed to continue growing at the same rate as projected by ESRI MTR for the period 2025 to 2030.

Data on the geography of jobs at the small area level is only available for two years, 2006 and 2011. This data comes from a special tabulation[14] from the CSO Place of Work Census Anonymised Records, 2006 (POWCAR) and CSO Place of Work, School and College Census Anonymised Records, 2011 (POWSCAR).

As with the population projections, the share of each EDs jobs change in the total national jobs change is modelled as a function of a set of local explanatory factors. The ED share in the change in national jobs is given as:

$$\frac{jobs_{i,t} - jobs_{i,t-1}}{\sum_i jobs_{i,t} - jobs_{i,t-1}} \quad (6)$$

This is modelled using regression analysis for each of the 11 sectors, given that the factors that may impact on the growth of individual sectors may vary. The explanatory variables considered include the lagged values of jobs, jobs squared, jobs density, jobs density squared, population, population density and accessibility.

[11] Here a job refers to the location of the job rather than the residential location of the worker (the latter is considered in section 2.4).

[12] J Fitzgerald and Ide Kearney, Economic and Social Research Institute, Medium-Term Review, 2013

[13] The sectors are Agriculture Forestry and Fisheries, Manufacturing of Food Products, Traditional Manufacturing, High-Tech Manufacturing, Utilities, Building and Construction, Wholesale and Retail (Distribution), Transport and Communications, Other Market Services, Health and Education and Public Administration and Defence.

[14] Morgenroth, Edgar, Exploring the Economic Geography of Ireland, Journal of the Statistical and Social Inquiry Society of Ireland, Vol 38, 2008/9.

In order to get well behaved projection equations a range of specifications were tested, with the final specification being chosen on the basis of fit and projection performance. Overall most of the models are relatively straightforward. In general the explanatory power of the estimated models is considerably lower than that found for the population model, which reflects the fact that lagged shares are not available due to the data limitations and because 2006 to 2011 is also the period during which the economic crash happened, which adds additional noise to the data that is difficult to model[15]. The results of the regression analysis are shown in Table 2.2.

[15] The change in the number of jobs is considerably more sensitive to the economic cycle than changes in the population.

Table 2.2 – Regression Results (dependant variable is the share of each ED in the change in national employment in each sector)

Sector	Jobs	Jobs Squared	Jobs Density	Jobs Density Squared	Population	Density of Population	Accessibility	Constant	Adjusted R^2
Agriculture Forestry Fishing	1.88E-05***	-3.50E-08	2.06E-05	-1.28E-07					0.22
Food	1.78E-07	8.61E-08***	4.14E-05***	-2.70E-08***				-4.1E-05	0.42
Traditional Manufacturing	1.58E-05***							-198E-05	0.35
High-Tech Manufacturing	1.29E-05***			-8.48E-09***					0.42
Utilities	6.28E-05***								0.09
Construction	5.46E-06***	-9.31E-10**	-2.00E-06	1.09E-09					0.95
Distribution	-5.75E-06***				8.03E-07***				0.07
Transport Communications	1.20E-05***								0.32
Other Services				3.66E-11	2.42E-0.7***		5.40E-09***		0.17

Sector	Jobs	Jobs Squared	Jobs Density	Jobs Density Squared	Population	Density of Population	Accessibility	Constant	Adjusted R^2
Health and Education	3.94E-07	2.85E-10	8.47E-0.7		1.11E-07***			8.24E-07**	0.30
Public Administration and Defence	6.99E-06	-5.27E-09		3.44E-10***	2.32E-07***				0.11

*Note: *, **, *** denotes statistical significance at the 10%, 5%, and 1% confidence level. Standard errors are corrected to account for heteroskedasticity.*

Given the available data, it is useful to do at least some sensitivity testing. This is achieved through the calculation of a simple projection which keeps the spatial distribution of jobs in each sector fixed at the 2011 values and simply lets the total number of jobs in each sector vary. Formally these 'naive projections' are constructed as follows:

$$\widehat{J_{i,t}} = \varphi_{i,2011}\widehat{J_t} \qquad (7)$$

Where ϕ denotes the share of the total jobs in 2011 accounted for by ED i in 2011, and $\hat{J}_t$ is the national projection from the ESRI MTR. Again these are calculated for each of the 11 sectors using the national projections from the ESRI MTR and the results are aggregated to the total number of jobs in each ED.

The results for the model based and naive jobs projections are shown in Figures 2.3 and 2.4 below. Careful analysis is needed to identify the differences in the maps indicating that the location pattern of jobs only changes slowly. However, some changes can be identified. For the model based projections (Figure 2.3) the projections indicate an increase in the jobs densities along the radial routes out of Dublin, such as the Dublin-Belfast corridor to the north, but also to the south along the coast, into Kildare and Meath (Navan). Furthermore, the dense areas around Cork, Limerick, Galway and Waterford are also expected to expand. In contrast, the naive projections suggest that no significant dispersal of employment is going to take place.

A formal way to summarise the spatial pattern of employment is to calculate a Herfindahl index which measures the spatial concentration of the variable under consideration[16]. For 2011 the Herfindahl index for jobs is 0.0024, and for the model based projections this declines to 0.002 by 2031 but rises again to 0.0021 by 2051.

This indicates an initial spreading of employment but a subsequent increase in concentrations. In contrast, the naive projections suggest a continuing trend of increased spatial concentration. The differences are accounted for by the alternative methods used. For the naive projections the changes in spatial patterns are purely driven by the changed sector sizes projected by the ESRI MTR, while the model based projections also account for some local factors. Of course being limited to the 2006 to 2011 period, long run trends in the location of jobs by sector could not be taken into account.

[16] Morgenroth, Edgar, Exploring the Economic Geography of Ireland, Journal of the Statistical and Social Inquiry Society of Ireland, Vol 38, 2008/9.

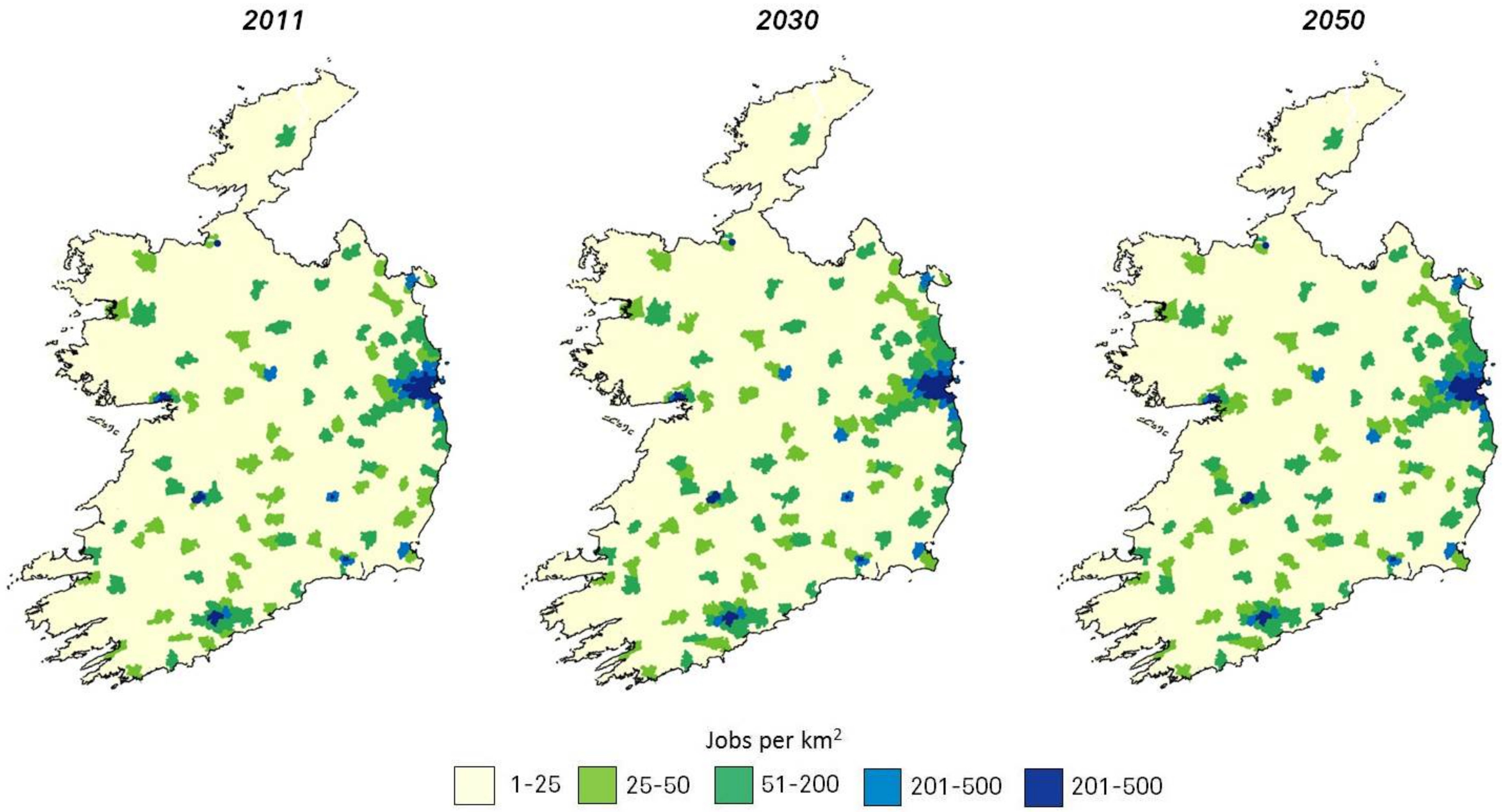


Figure 2.3 - Projected Jobs Density on the basis of the ESRI MTR Recovery Scenario 2011, 2030 and 2050

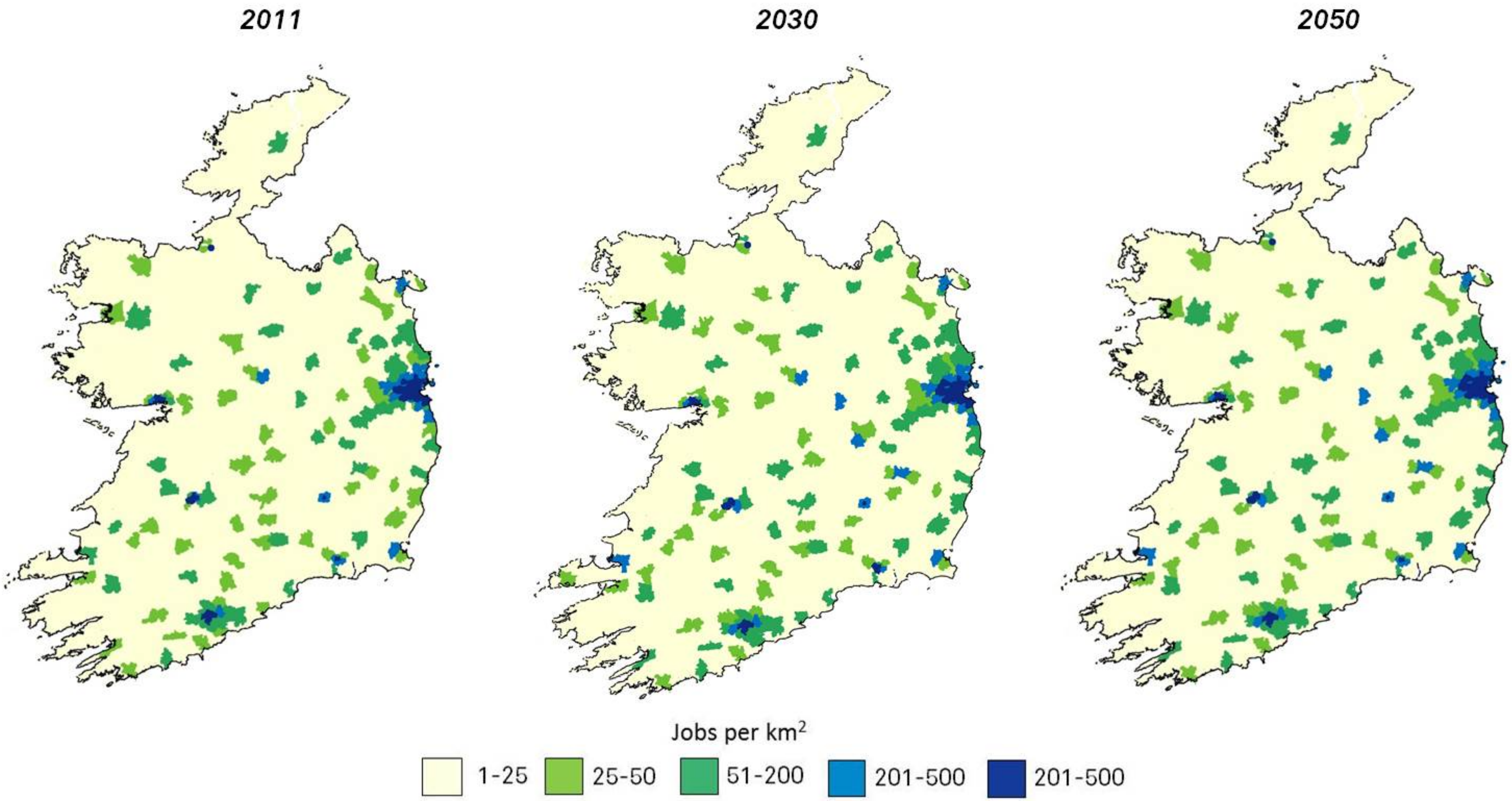


Figure 2.4 - Projected Jobs Density Applying Fixed Location Preference (Naive) on the basis of the ESRI MTR Recovery Scenario 2011, 2030 and 2050

2.4 Employed Persons by Residential Location

2.4.1 Overview

Having constructed the demographic projections and the jobs projection it is also necessary to construct a consistent set of employment projections, which identifies the number of persons employed identified by where they live.

To this end it is assumed that the total number of jobs has to be exactly equal to the number of employed persons i.e. that there is no cross border commuting[17]. Furthermore, the population of working age has to be larger than the number of persons in employment, given that some are unemployed at any point in time and some of that age group are not in the labour force. These constraints ensure the consistency of the demographic and economic (jobs) projections.

The first step in generating employment at the ED level is to calculate the population of working age at the county level using the output of the IC-POP demographic model. By applying labour force participation rates the labour force is estimated. Here it is assumed that the deviations in the labour force participation rate of each county from the national rate will be equal to the average deviation over the period 2002 to 2011[18].

These participation rates are spread down to the ED on the same basis (i.e. by assuming that at the ED level the differences within the county are constant). Using a similar approach the unemployment rate is generated for each ED using the projected unemployment rate from the ESRI MTR. Given the labour force and the unemployment rate the employment rate is then generated.

The results are shown for 2030 in Figure 2.5 where the distribution of jobs and population is also shown. Jobs are the most spatially concentrated, the population is most disbursed, and the density of employment is roughly an average of the jobs and population distributions. The difference between the employment and population distributions is a function of the age structure, differences in labour force participation and differences in (long-run average) unemployment rates. Thus, areas which have a higher population density than employment density either have a higher level of age related dependency, a lower labour force participation rate or a high average unemployment rate.

Areas with a higher jobs density than an employment density are areas that have a net inflow of commuters while those areas where the employment density exceeds the jobs density are areas with net out-commuting. The latter areas are largely located in and around the major cities, while the former are typically city centre locations.

[17] The Census of Population, 2011, identified 6419 individuals resident in Ireland that work outside of Ireland. These account for just 0.4% of the workforce and there will also be some commuting from Northern Ireland into the Republic of Ireland which is likely to result in a very small net external flow.
[18] Labour force participation rates differ significantly across counties and regions (see Morgenroth, 2013).

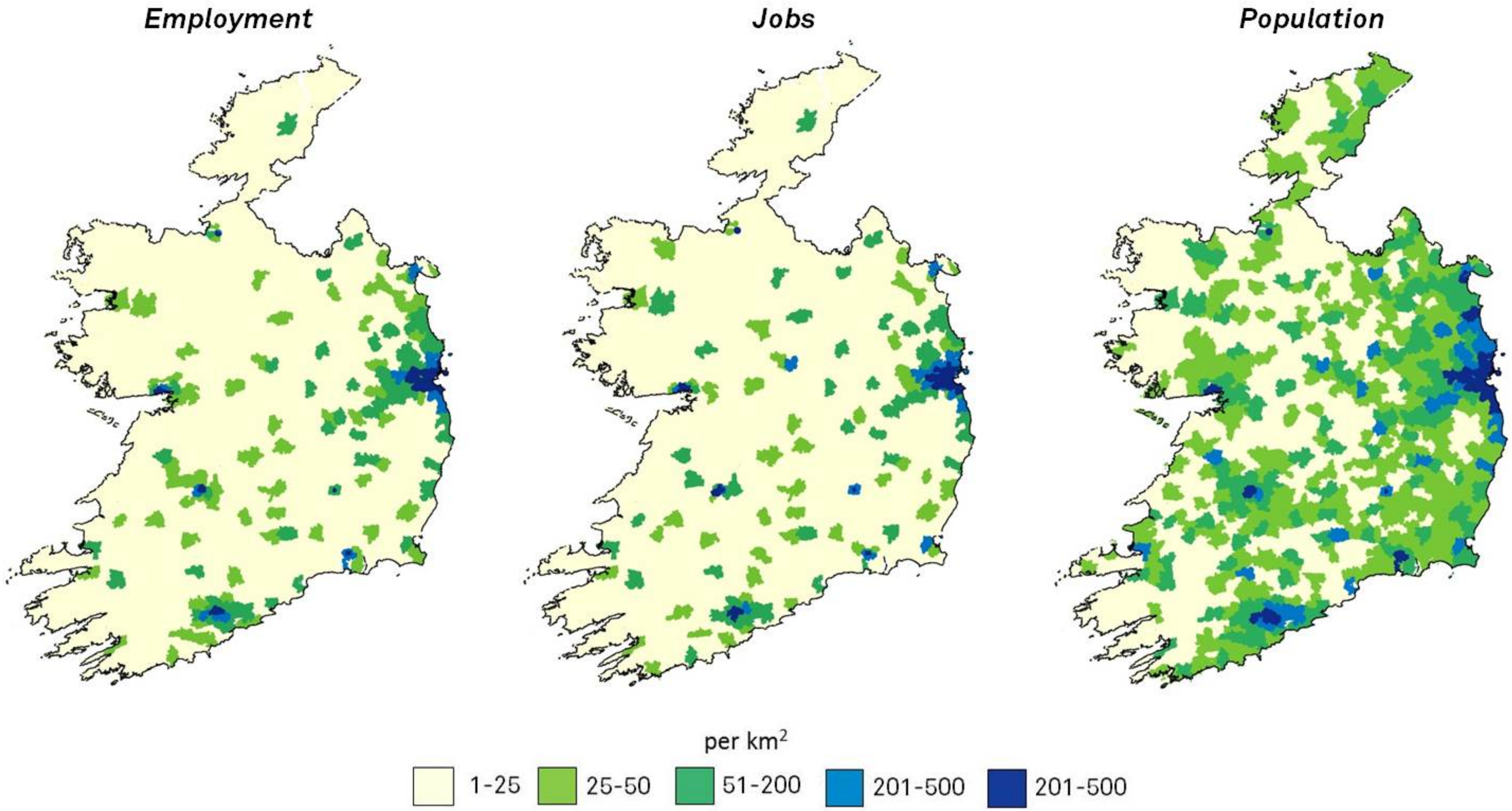


Figure 2.5 – 2030 Employment and Job Densities on the basis of the ESRI MTR Recovery Scenario 2013

2.5 Summary and Conclusions

This paper has outlined the method used to generate updated population, jobs and employment numbers as inputs into the NTpM. A mixture of a top-down and a bottom-up approach was used which is likely to be more accurate than a simple spreading of national projections on the basis of historical shares, which would leave the spatial patterns unchanged over time.

The projections for any one NTpM zone should only be taken as indicative. However on average, the overall spatial pattern is likely to be captured well by the model given the validity of the assumptions used[19].

For the population projections three scenarios were considered, corresponding to the CSO M2 and M3 migration scenarios and the ESRI MTR recovery scenario which is the central scenario. The CSO provided forecasts at 5 year intervals between 2016 and 2046, therefore slight adjustments of population were required to provide outputs for the NTpM forecast years of 2030 and 2050. Table 2.3 provides a summary of the population forecast used in the NTpM.

Table 2.3 – National Population Projections

Year	CSO M2	ESRI MTR	CSO M3
	NTpM Low Growth	NTpM Central Growth	NTpM High Growth
2011	4.59m	4.59m	4.59m
2030	4.87m	5.07m	5.14m
2050	4.94m	5.42m	5.62m

Jobs and employment are only projected for the MTR recovery scenario as a consistent economic scenario for either of the CSO demographic projections is not available. Therefore low and high jobs projections were calculated based on the estimated labour force and low and high population forecasts. Table 2.4 presents the estimated job projections for each scenario.

Table 2.4– National Jobs Projections

Year	CSO M2	ESRI MTR	CSO M3
	NTpM Low Growth	NTpM Central Growth	NTpM High Growth
2011	1.83m	1.83m	1.83m
2030	2.06m	2.18m	2.20m
2050	1.94m	2.17m	2.30m

[19] The spatial trends projected here will occur provided that migration patterns are broadly towards the cities and employment concentrates in urban areas.

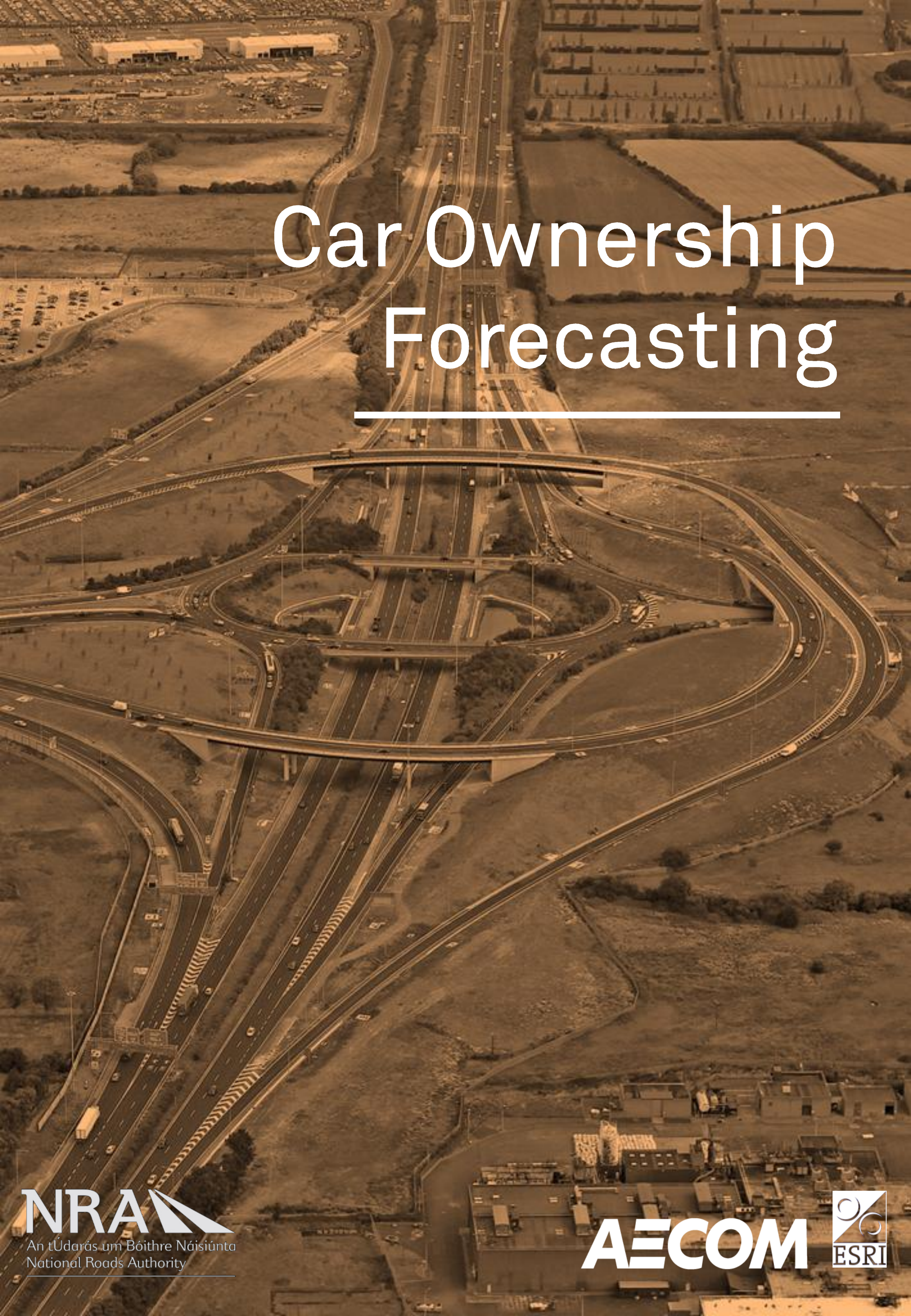
The population projections suggest that the population will increase particularly in and around the large cities, while peripheral counties may even see a decline in the population. The implication is that the population will be more spatially concentrated. However, jobs (where jobs are located) are considerably more spatially concentrated, although the alternative scenarios suggest that the level of concentration may either decrease or increase.

Despite this contradiction, both scenarios suggest that employment will continue to be concentrated in and around the cities. Employment (where employed people reside) while being more concentrated than the total population is less concentrated than jobs which results in commuting. The projections suggest that employment will be more spatially concentrated in the future, which might help reduce commuting distances.

2.5.1 Key Results

The key results of the population and jobs forecasts are provided below.

- The central forecast estimates that the population of Ireland will grow by 10% by 2030 and 18% by 2050.
- Population is forecast to increase in and around the large urban areas.
- Jobs are forecast to increase by 18% in the central forecast by 2030 and remain at this level up to 2050.
- The location of jobs will also be concentrated in and around large urban areas.



Car Ownership Forecasting

NRA
An tÚdarás um Bóithre Náisiúnta
National Roads Authority

AECOM

ESRI

3.0 Car Ownership Forecasting

3.1 Overview

The aim of this section of the report is to describe the methodology used to develop a set of forecasts of car ownership at national, county, Electoral District (ED) and National Transport Model (NTpM) zone levels. The forecasts cover the period 2011 to 2050. Its immediate use is for traffic forecasting in the context of the development of the National Transport Model.

Although data is available on car numbers up to 2012, the base year adopted for the car ownership model is 2011, as this is the most recent year for which definitive population data are available from the 2011 Central Statistics Office (CSO) Census.

The process of projecting car ownership begins with county car ownership projections and these then form the basis for the national and ED level estimates. County level projections are aggregated to create national projections and spread across the EDs to create ED level projections. Zonal projections are aggregates of the ED level projections. Population projections generated by the ESRI are then combined with projected car ownership levels to predict the number of cars at each geographic level.

3.2 Factors Influencing Car Ownership

3.2.1 Overview

This Section of the report introduces the concept of car ownership rates and the driving factors that ultimately influence the number of cars on Irish roads. It also puts car ownership in Ireland in a comparative context taking account of car ownership rates across Europe.

3.2.2 Historical Trends and Influencing Factors in Car Ownership

Rates of car ownership are calculated by dividing the number of private cars for a given year by the adult population for the same year. For the purposes of this report, car ownership refers to the number of private cars per 1,000 adults. It should also be noted that the adult population is defined herein as members of the population aged 17 years or over, as this is the minimum legal age at which one can apply for a driving licence in Ireland.

As illustrated in Figure 3.1 below, the number of private cars registered in Ireland more than trebled between 1976 and 2011, increasing from 551,117 cars to 1,887,810 cars over the period. This increase represents an average annual growth rate of 3.6 per cent.

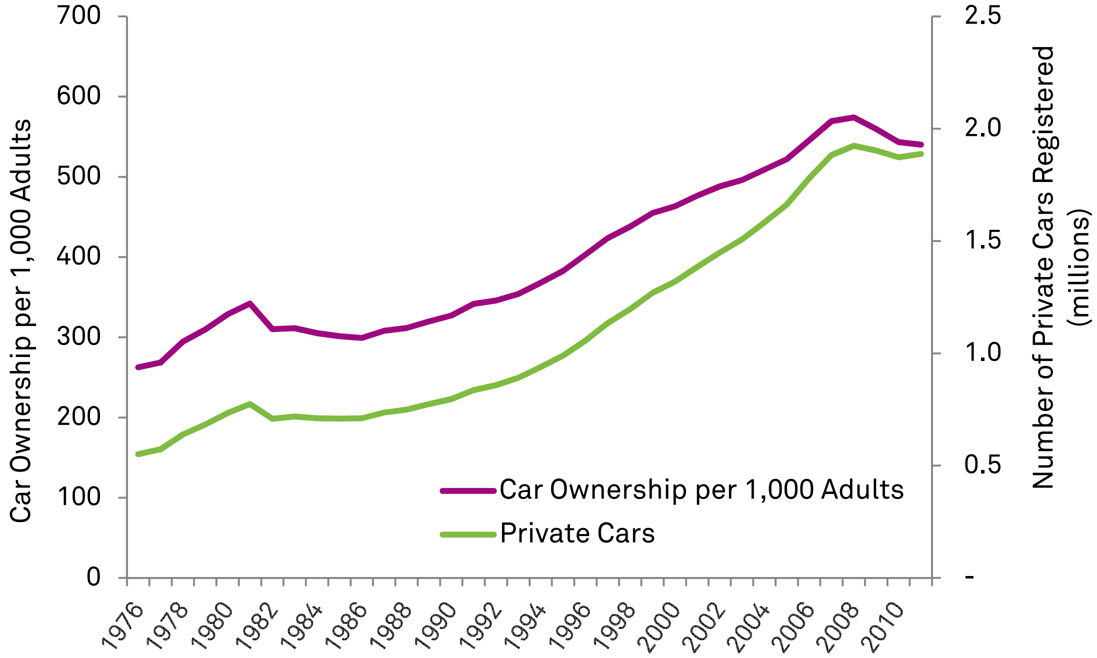


Figure 3.1 – Ireland: Number of Cars versus Car Ownership

Car ownership increased by an average of 2.1 per cent per annum over the same period, from 262.6 cars per 1,000 adults in 1976 to 540.1 cars per 1,000 adults in 2011. This data is also represented in the chart below.

Table 3.1 below sets out the number of private cars registered in Ireland and the car ownership rate for each year from 1976 to 2011. The population data included in the table is based on CSO Census results which were interpolated to give population figures for the inter-censual years.

The higher level of growth in actual car numbers compared to the growth in the car ownership is an indication of the effect that population growth has on car numbers. Over the same period, the population living in Ireland increased by an average of 0.9% per annum.

Table 3.1 - Car Numbers and Rates of Car Ownership in Ireland, 1976-2011[20]

Year	Population aged 17 years and over	No. Private Cars Registered	Car Ownership per 1,000 Adults
1976	2,098,456	551,117	262.6
1977	2,133,194	572,692	268.5
1978	2,168,601	638,740	294.5
1979	2,204,694	682,958	309.8
1980	2,234,061	734,371	328.7

[20] *Source: AECOM Economics/Irish Bulletin of Vehicle and Driver Statistics for the years 1976-2011.*

Year	Population aged 17 years and over	No. Private Cars Registered	Car Ownership per 1,000 Adults
1981	2,263,914	774,594	342.1
1982	2,285,971	709,000	310.2
1983	2,308,300	718,555	311.3
1984	2,330,904	711,098	305.1
1985	2,353,788	709,546	301.4
1986	2,376,955	711,087	299.2
1987	2,391,059	736,595	308.1
1988	2,405,307	749,459	311.6
1989	2,419,699	773,396	319.6
1990	2,434,237	796,408	327.2
1991	2,448,923	836,583	341.6
1992	2,482,720	858,498	345.8
1993	2,517,022	891,027	354.0
1994	2,551,838	939,022	368.0
1995	2,587,177	990,384	382.8
1996	2,623,047	1,057,383	403.1
1997	2,677,207	1,134,429	423.7
1998	2,732,603	1,196,901	438.0
1999	2,789,268	1,269,245	455.0
2000	2,847,235	1,319,250	463.3
2001	2,906,537	1,384,704	476.4
2002	2,967,211	1,447,908	488.0
2003	3,037,674	1,507,106	496.1
2004	3,110,010	1,582,833	508.9
2005	3,184,275	1,662,157	522.0
2006	3,260,530	1,778,861	545.6
2007	3,306,212	1,882,901	569.5
2008	3,352,534	1,924,281	574.0
2009	3,399,505	1,902,429	559.6
2010	3,447,134	1,872,715	543.3
2011	3,495,430	1,887,810	540.1

3.2.3 Trends in Car Numbers and Car Ownership and the Effect of Other Variables

Actual car numbers are affected by changes in the rate of car ownership and by changes in the population. Car ownership is affected by many variables, but perhaps the most significant of these is economic growth, as this drives personal income, which is an essential determinant of the demand for consumer goods[21].

Table 3.2 sets out 5-year growth rates in the adult population, car numbers, car ownership, and the economy between 1976 and 2011.

Table 3.2 - Periodical Growth Rates in Population, Car Numbers, Car Ownership, and the Economy (1976-2011)

Period	Change In			
	Adult Population	Car Numbers	Car Ownership	Gross National Product (GNP) per Person
1976-1981	7.9%	40.5%	30.3%	20.8%
1981-1986	5.0%	-8.2%	-12.6%	-1.7%
1986-1991	3.0%	17.6%	14.2%	20.0%
1991-1996	7.1%	26.4%	18.0%	30.8%
1996-2001	10.8%	31.0%	18.2%	46.3%
2001-2006	12.2%	28.5%	14.5%	25.8%
2006-2011	7.2%	6.1%	-1.0%	-15.3%

Car numbers grew significantly between 1976 and 1981. Some of this growth would be more apparent than real owing to the fact that car tax was substantively abolished in 1978. This affected the degree of tax evasion with the result that more private cars were registered.

Car numbers then fell between 1981 and 1986, but again some of this decline might be attributed to the reintroduction in 1982 of car tax and the effect that this might have had on the degree of tax evasion. The economic downturn of the early 1980s brought about high levels of emigration, affecting population growth. This, combined with the apparent fall in car numbers, resulted in a fall in car ownership levels of 12.6 per cent over the five-year period, but again it should be emphasised that this reduction is more apparent than real.

As the economy picked up, particularly during the 'Celtic Tiger' years, so too did car

[21] For the purposes of this report, economic growth refers to growth in GNP as opposed to GDP. GDP is usually higher than GNP due to profit repatriation by large multinational corporations. Using GNP over GDP assumes that money earned in Ireland but repatriated elsewhere will not influence consumption patterns in Ireland.

ownership. However, as Table 3.2 indicates, growth in car ownership in the years to 2006 had started to slow despite strong economic growth, suggesting that the market for cars in Ireland was starting to mature and that some saturation effects were beginning to be felt. It is inevitable that the car market, like most markets for durable goods, will eventually become saturated when all consumers who are going to acquire a car have done so. As car ownership approaches this saturation level, growth in car ownership levels will start to slow before beginning to level out.

The period that followed, 2006 to 2011, saw the first drop in car ownership since the 1980s. Although it is reasonable to suggest that car ownership had begun to experience some saturation effects in the period from 2001 to 2006; the unfavourable economic background is likely to have been the primary driver of the change in car ownership. The decline has nevertheless been less severe than the economic downturn. This is in line with international experience: decreases in car ownership resulting from falling incomes are not symmetrical with increases in ownership driven by increasing incomes[22].

3.2.4 Car Ownership in Ireland in a European Context

For comparative purposes, the most recent data available on car ownership in other EU member states relate to 2009. The car ownership data presented in Table 3.3 below relate to the number of cars per 1,000 inhabitants, owing to the lack of per adult data.

Table 3.3 - Car Ownership per 1,000 inhabitants per former 15 EU Member State

EU Member State	1995	2005	2007	2009	2009 Rank
Luxembourg	711	688	696	700	1
Italy	529	593	599	603	2
Germany	417	531	541	551	3
Austria	423	507	517	528	4
France	421	479	484	490	5
Finland	372	461	473	484	6
Sweden	412	458	471	481	7
Spain	361	471	472	474	8
Belgium	422	465	469	471	9
United Kingdom	354	448	456	463	10
Netherlands	367	439	445	449	11
Ireland	275	410	417	430	12

[22] Dargay, J., D. Gately and M. Sommer (2007). "Vehicle Ownership and Income Growth, Worldwide: 1960-2030." Energy Journal 28(4): 163-190.

EU Member State	1995	2005	2007	2009	2009 Rank
Greece	235	409	414	419	13
Denmark	332	372	380	386	14
Portugal	252	350	352	355	15
Average	**392**	**472**	**479**	**486**	

Of the 30 EU member states, Luxembourg has had the highest rate of car ownership since 1995. The 2009 rate of car ownership for Luxembourg is 700 per 1,000 inhabitants followed by Italy at 603. Turkey had the lowest rate of car ownership at 83.

Car ownership per 1000 inhabitants in Ireland (430) was 38.6 per cent lower than that in Luxembourg and 28.7 per cent lower than that in Italy. Ireland ranks 19th of all 30 member states, over the period 1995 to 2009 its ranking has been stable and this is consistent with other European countries.

As depicted in Table 3.4, only three countries have moved more than four places in the rankings since 1995. Lithuania has moved up 10 places to rank 13th, Slovenia, too, has increased significantly relative to the peer countries while Belgium and Norway have fallen in the rankings. If the former 15 EU member states[23] are ranked in order, Ireland ranks 12th, outranking only Portugal (355), Greece (386) and Denmark (419).

Table 3.4 - Ranking of Car Ownership per 1,000 inhabitants by EU Member State[24]

EU Member State	Rank				2009 Car Ownership	Rank Change '95 to '09
	1995	2005	2007	2009		
Luxembourg	1	1	1	1	700	0
Italy	2	2	2	2	603	0
Malta	3	5	4	3	561	0
Germany	8	4	5	4	551	4
Cyprus	10	3	3	5	548	5
Austria	5	7	7	6	528	-1
Switzerland	4	6	6	7	516	-3
France	7	8	8	8	490	-1
Slovenia	16	10	9	9	485	7
Finland	12	12	10	10	484	2

[23] The former fifteen EU member states comprise Austria, Belgium, Denmark, Finland, France, Germany.
[24] Source: Vehicle stock, 1995-2009 from TREMOVE v3.3.1. Population data between1995-2009 from Eurostat.

Sweden	9	13	12	11	481	-2
Spain	14	9	11	12	474	2
Lithuania	23	17	15	13	473	10
Belgium	6	11	13	14	471	-8
United Kingdom	15	14	14	15	463	0
Norway	11	16	16	16	454	-5
Netherlands	13	15	17	17	449	-4
Estonia	18	20	20	18	436	0
Ireland	**20**	**18**	**18**	**19**	**430**	1
Greece	22	19	19	20	419	2
Denmark	17	22	22	21	386	-4
Bulgaria	25	26	24	22	386	3
Czech Republic	19	21	21	23	386	-4
Latvia	28	24	25	24	357	4
Portugal	21	23	23	25	355	-4
Poland	24	25	26	26	342	-2
Hungary	27	27	27	27	294	0
Slovakia	26	28	28	28	244	-2
Romania	29	29	29	29	180	0
Turkey	30	30	30	30	83	0
EEA30 Total	**n/a**	**n/a**	**n/a**	**n/a**	**419**	
EEA30 Average	**n/a**	**n/a**	**n/a**	**n/a**	**434**	

Average car ownership for the 30 EU member states as a whole stood at 434 in 2009, indicating that Ireland was one per cent below the EU average. The average for the former fifteen member states was 486, with Ireland lagging by 13 per cent. As car ownership levels in Ireland approach the EU average, growth in car ownership is expected to slow. In interpreting these figures, it should be borne in mind that the pattern would most likely be altered if per adult data were available, as the population age distribution varies across countries.

3.2.5 Car Ownership by County for Ireland

Car ownership in Ireland varies considerably by county. Table 3.5 shows the change in car ownership levels by county over time. The county with the highest car ownership in Ireland in 2011 was Tipperary North, at 634 cars per 1,000 adults, a position it has held since 1981. The current lowest level of ownership is in Dublin, at 492 cars.

Table 3.5 - Progression of Car Ownership Levels of Counties

County	Car Ownership Levels 1976 - 2011							
	1976	1981	1986	1991	1996	2001	2006	2011
Tipp. North	350	382	341	380	448	536	627	634
Carlow	296	386	336	361	440	527	617	622
Wicklow	270	350	303	350	421	487	592	594
Wexford	285	368	320	355	437	522	610	592
Cork	282	371	325	370	435	517	590	591
Clare	243	342	326	353	428	514	589	586
Waterford	268	343	304	334	400	494	592	584
Kildare	300	378	318	358	438	513	575	572
Kerry	236	329	299	353	414	487	561	569
Westmeath	272	369	327	363	420	488	570	566
Roscommon	250	357	315	352	413	496	568	566
Tipp. South	285	369	332	371	439	519	594	562
Meath	313	383	332	376	445	507	585	562
Kilkenny	286	377	339	366	421	502	562	557
Limerick	259	345	308	344	403	475	551	556
Leitrim	223	326	304	328	394	475	555	545
Sligo	242	335	299	341	402	473	552	541
Ireland	263	342	299	342	403	476	546	540
Mayo	208	299	278	318	383	461	534	533
Longford	282	373	317	355	422	476	533	528
Offaly	255	337	291	326	398	473	547	522
Galway	227	317	282	329	392	442	523	516
Donegal	217	297	265	290	338	408	504	513
Cavan	264	371	315	352	404	463	536	510
Laois	284	372	321	358	416	476	542	509
Monaghan	255	351	296	335	393	441	499	508
Louth	257	325	272	300	347	415	484	494
Dublin	261	324	276	327	382	454	501	492

Table 3.6 below shows the rank order of the counties' car ownership levels for the census years from 1976 to 2011. Table 3.6 demonstrates that there is a high degree of stability in the rankings over time with very few large jumps in counties' ranks.

3.3 Developing County Level Models

3.3.1 Models of Car Ownership Growth

Car ownership is expected to increase with increases in income over time but is expected to reach a saturation point at which growth in car ownership tapers off and remain stable. Prior research has shown that this pattern of growth is best represented by the Gompertz and Logistic models. Both models assume an initial period of gradual annual growth that accelerates for a time, before slowing as car ownership approaches a saturation level. As such, both models also assume that the development of car ownership over time may be represented by an S-shaped curve.

However, the maximum annual growth rate, and therefore the point of inflexion, occurs sooner in the Gompertz model than in the Logistic model. Implementation of either model at the county level requires an estimated saturation level per county. The next section details the steps taken to estimate county level car ownership saturation points.

3.3.2 Identifying County Saturation Levels

3.3.2.1 Overview

County car ownership saturation levels must be based in part on the most up-to-date data on car ownership levels, as this data will give some insight into the levels that car ownership might ultimately attain.

However, current car ownership levels are also influenced by income levels. Additionally, the saturation level for a particular county is likely to be related to a range of structural variables that influence the ultimate demand for car ownership, such as the population density of the county and the provision of public transport. While car ownership will advance in each county as incomes grow, these structural variables may mean that car ownership in some counties will never ultimately reach the level of others. For example, it is known that population density negatively affects car ownership, partly because other modes, such as public transport, walking and cycling become more viable. Thus, car ownership in County Dublin, where population density is high, may never reach the levels of other counties despite the high incomes of the Dublin population. These observations prompted an approach to estimating car ownership that sought to distinguish between the effects of income on the one hand and a set of structural variables on the other.

A step process was used to determine saturation levels as follows:

- A cross sectional model of car ownership was developed for the year 2011 that related car ownership to income and a set of structural variables.
- Using this model, county car ownership was estimated for 2011, assuming all counties had the average income of the State as a whole;

- The extent to which this estimated car ownership level exceeded the average ownership level for the country as a whole was gauged; and
- This car ownership gap at normalised income levels was used to posit county car ownership saturation levels, assuming a national saturation level of 850 cars per 1,000 adults.

The approach to identifying a county-specific saturation level taken here is different to those taken in the past. Previously, counties were ranked in order of car ownership and three groups of saturation levels were created based on the rank order of the counties' car ownership. A high saturation level was assigned to the 9 highest ranking counties, a lower saturation the next group and so on.

An implication of this is that certain lower ranking counties could not be forecast as having high levels of car ownership even if there were large changes in their projected income levels. While this is the expected outcome in counties where car ownership is constrained more by land use patterns and urbanisation than by incomes, long-run forecasts for counties where car ownership is predominantly constrained by income could be underestimated if incomes were to increase.

3.3.2.2 Process of Establishing County Saturation Levels

Panel data of all counties and census years 2011 and 2006 were used to model car ownership as follows:

Car ownership is determined by need and affordability at the individual level. The affordability within a county can be measured and represented in a model by the total income per person in a county. This data is available from the CSO for the period 1991-2010. County level income data is not yet available for 2011 and was estimated using the change in the national income per person from 2010 to 2011.

The demand for cars, as distinct from and independent of affordability, is influenced by a myriad of factors and these are not always easy to measure. One such factor is the availability of alternative modes of transport, such as walking and cycling or public transport. The extent to which walking and cycling are viable alternatives to driving is captured reasonably well in measures of urbanisation and/or population density variables because levels of urbanisation correspond to the viability of walking or cycling to required amenities.

The availability of public transport, however, is not as well represented by measures of urbanisation or population density. Methods of estimating the availability of public transport tend to underestimate the extent of services available. For example, it would be possible to limit the definition to towns with an internal bus or rail service but this fails to capture inter-city buses and services between towns in the same county. For this reason, the proportion of the population using public transport derived from CSO data was used as a proxy for the availability of such services within a county.

Econometric relationships were developed between car ownership and various combinations of income, land use factors and the uptake of public transport (a full list of the data used in this phase are included in the Appendix A). A model was found to fit the data well and this was used to evaluate car ownership in each county using 2011 data.

The model determined that car ownership is a function of total income per person, the percentage of the population using public transport and 'true urbanisation'. This definition of urbanisation includes the percentage of the county's population living in towns with a population exceeding 10,000. Urbanisation and the use of public transport were found to be negatively related to car ownership while increases in income increased car ownership.

This model of car ownership was employed to estimate a synthetic car ownership level for 2011 for each county. The synthetic car ownership levels were based on county-specific data on the use of public transport and urbanisation, however national average income rather than average county income was used.

Using the average income of the State as a whole to estimate car ownership established the extent to which car ownership levels in a particular county are being constrained by that county's income levels.

The car ownership ranking of each county was established for the synthetic car ownership level and this was then compared to the actual ranking. Table 3.7 presents the results, Wicklow, which had an actual rank of 3rd in 2011 ranks 26th in the equalised income setting. Wicklow has the 5th highest income in the country and has high car ownership but the land use pattern, availability of public transport and proximity to Dublin would suggest a lower rank.

Similarly, Kildare and Cork have much lower rankings in the synthetic scenario than in reality. Adjusting for incomes, by using the normalised income level, moves Kildare to a rank of 25th. Laois, Longford and Monaghan rise 9, 9 and 8 places respectively – these counties have some of the lowest average incomes in Ireland. Car ownership levels in these counties are held back by incomes than by structural factors such as urbanisation. Thus if incomes in these counties were to advance significantly, it is likely that car ownership would grow.

In general terms, counties that have high car ownership and relatively low incomes or low car ownership and relatively high incomes tend not to move much in the rankings. Dublin, for example, had the lowest level of car ownership and the highest incomes in 2011; Dublin's ranking does not change as the predominant influence on car ownership in Dublin is land use rather than income.

Table 3.7 – Actual versus Synthetic Car Ownership

County	Actual versus Synthetic Car Ownership Rank 2011				
	Actual	Synthetic	Change	Income	Income Rank
Wicklow	3	26	-23	€23,692	5
Kildare	8	25	-17	€25,407	2
Cork	5	16	-11	€24,320	3
Laois	24	15	9	€20,961	20
Longford	19	10	9	€20,354	24
Meath	13	22	-9	€23,630	6
Westmeath	10	19	-9	€21,477	14
Monaghan	25	17	8	€19,312	25
Kilkenny	14	6	8	€20,893	21
Tipp. South	12	5	7	€22,350	10
Roscommon	11	4	7	€21,134	19
Offaly	20	14	6	€19,279	26
Mayo	18	12	6	€21,144	18
Sligo	17	11	6	€22,040	13
Leitrim	16	20	-4	€21,207	16
Wexford	4	8	-4	€21,199	17
Galway	21	18	3	€23,137	7
Clare	6	3	3	€22,145	12
Louth	26	24	2	€22,574	8
Cavan	23	21	2	€20,548	22
Limerick	15	13	2	€24,202	4
Donegal	22	23	-1	€18,697	27
Dublin	27	27	0	€27,646	1
Kerry	9	9	0	€20,545	23
Waterford	7	7	0	€22,405	9
Carlow	2	2	0	€21,383	15
Tipp. North	1	1	0	€22,201	11

This 'normalised' or synthetic rank order of counties was used to estimate the saturation levels for each county such that the national average car ownership was 850 cars per 1,000 adults and that the rank order and gap in ownership levels as given by the normalised income was preserved.

This method of setting the saturation avoids a potential misspecification inherent in the approach used in previous forecasts of car ownership. Counties with above average incomes might have high levels of car ownership despite being relatively urban, while counties with land use patterns that would suggest high car ownership are sometimes constrained by lower incomes.

Estimating saturation levels on the basis of current car ownership levels is thus subject to errors. For example, setting high saturation levels for counties with above average incomes despite the county being highly urbanised and/or having a high degree of access to public transport would be spurious.

3.3.2.3 Saturation Levels Estimated

Table 3.8 presents the average Total Income per Person (TIPP) of each county, the normalised TIPP that was applied to all counties, the predicted car ownership used to estimate the saturation level and the saturation level set for each county. As indicated previously, the saturation levels were set such that:

- The rank order based on the normalised model output was preserved;
- No single county would have a saturation level exceeding 950 cars per 1,000 adults; and
- The national average car ownership was 850 cars per 1,000 adults.

Table 3.8- Estimated Saturation Levels

County	Total Income per Person (TIPP) €	Normalised TIPP €	Normalised Predicted Car Ownership per 1,000 Adults	Saturation	Rank Normalised Predicted Car Ownership	Actual 2011 Rank
Tipp. North	22,201	23,880	614	950	1	1
Carlow	21,383	23,880	606	950	2	2
Clare	22,145	23,880	605	950	3	6
Roscommon	21,134	23,880	595	943	4	11
Tipp. South	22,350	23,880	594	940	5	12
Kilkenny	20,893	23,880	592	937	6	14
Waterford	22,405	23,880	590	933	7	7
Wexford	21,199	23,880	588	931	8	4
Kerry	20,545	23,880	587	929	9	9
Longford	20,354	23,880	586	928	10	19
Sligo	22,040	23,880	585	927	11	17
Mayo	21,144	23,880	585	926	12	18
Limerick	24,202	23,880	584	925	13	15
Offaly	19,279	23,880	582	921	14	20
Laois	20,961	23,880	580	918	15	24
Cork	24,320	23,880	578	915	16	5
Monaghan	19,312	23,880	576	912	17	25
Galway	23,137	23,880	575	911	18	21

Westmeath	21,477	23,880	573	908	19	10
Leitrim	21,207	23,880	572	906	20	16
Cavan	20,548	23,880	568	899	21	23
Meath	23,630	23,880	557	882	22	13
Donegal	18,697	23,880	547	866	23	22
Louth	22,574	23,880	545	863	24	26
Kildare	25,407	23,880	543	860	25	8
Wicklow	23,692	23,880	533	843	26	3
Dublin	27,646	23,880	441	698	27	27

3.3.2.4 Identifying the Preferred Model

Having estimated the relevant county saturation levels, the models for predicting the path of future car ownership levels were estimated.

Two causal forecasting models were tested to determine which would give the best fit: the Logistic model and the Gompertz model. Both models assume an initial period of gradual annual growth that accelerates for a time, before slowing as car ownership approaches a saturation level. As such, both models also assume that the development of car ownership over time may be represented by an S-shaped curve. However, the maximum annual growth rate, and therefore the point of inflexion, occurs sooner in the Gompertz model than in the Logistic model.

Each model was tested using historical annual car ownership data for a sample of counties. In all cases, car ownership was regressed on county income with a saturation level determined as above. The resultant values for predicted car ownership over the same period were compared to actual values using a best-fit test, which indicated that in this instance, the Gompertz model gave more accurate results.[25]

To accurately model car ownership, it is important to account for an asymmetry in the effect of income on car ownership. Increasing incomes lead to increased car ownership but car ownership is 'sticky downwards.' That is, car ownership does not respond as quickly to falling incomes as increasing incomes. This facet of the relationship was modelled by including a dummy variable for economic stability.

The model used in predicting county level car ownership included income and a dummy variable for economic stability as follows:

<u>Gompertz model</u>:

$$Log_e{}^2 \frac{S}{Y} = Log_e a + X_1 Log_e b + X_2 Log_e c$$

Where
Y = car ownership
S= saturation point
a, b and c= coefficients whose values are to be estimated
X_1= total income per person
X_2= stability dummy variable

3.3.2.5 Model Results and Statistical Testing

Table 3.9 sets out the coefficients for the county level models and the adjusted r-squared value for each regression. Income was significant at the 1% level for all of the models, while the Stability Dummy variable was significant at the 1% level for all counties except Tipperary South. The t-value for Tipperary South was -1.151 and the p-value was .265. The adjusted r-squared values are high, indicating a satisfactory

[25] In conducting this test, the predicted values were transposed back into the X, Y space.

3.3.2.5 Model Results and Statistical Testing

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Durbin Watson testing was used to assess whether autocorrelation (a relationship between values separated from each other by a given time lag) was present in the residuals (prediction errors) from a regression analysis, the testing suggested that that in the majority of cases autocorrelation was not present and in all but one of the other cases the result was ambiguous. Tipperary South was the exception with a Durbin Watson value so low as to reject the hypothesis of no autocorrelation

Table 3.9 - Model Outputs

County	Independent Variables and Parameters			Adjusted R^2
	Intercept	Income	Stability Dummy	
Carlow	0.94	-0.00012	-0.18	97%
Cavan	0.61	-0.00008	-0.11	96%
Clare	0.83	-0.00010	-0.19	97%
Cork	0.78	-0.00010	-0.16	98%
Donegal	1.26	-0.00015	-0.17	93%
Dublin	0.66	-0.00009	-0.21	95%
Galway	0.72	-0.00008	-0.11	98%
Kerry	0.80	-0.00011	-0.14	98%
Kildare	0.48	-0.00007	-0.24	96%
Kilkenny	0.65	-0.00009	-0.11	98%
Laois	0.50	-0.00007	-0.12	95%
Leitrim	0.78	-0.00010	-0.11	97%
Limerick	0.77	-0.00009	-0.19	96%
Longford	0.47	-0.00007	-0.15	96%
Louth	0.70	-0.00007	-0.25	94%
Mayo	0.73	-0.00009	-0.13	97%
Meath	0.50	-0.00008	-0.15	97%
Monaghan	0.57	-0.00007	-0.20	96%

County	Independent Variables and Parameters			Adjusted R^2
Offaly	0.60	-0.00008	-0.18	97%
Roscommon	0.63	-0.00009	-0.15	97%
Sligo	0.69	-0.00009	-0.14	97%
Tipp. Nth	0.94	-0.00011	-0.28	94%
Tipp. South	0.66	-0.00009	-0.02	99%
Waterford	1.05	-0.00011	-0.28	96%
Westmeath	0.68	-0.00009	-0.25	92%
Wexford	0.78	-0.00011	-0.13	99%
Wicklow	0.64	-0.00009	-0.34	94%

3.3.3 Income Elasticity per County

The model outputs may be used to estimate the elasticity of car ownership with respect to incomes for each county. Table 3.10 presents the results.

The income elasticity varies from low levels for Kildare (0.59), Meath (0.60) and Dublin (0.65) to high levels for Donegal (1.11), Waterford (0.95), and Tipperary North (0.84). These results suggest that where population density and or public transport availability are high, increases in income do not tend to lead to high car ownership growth levels.

The elasticity for Donegal is exceptional, indicating that a unit percentage change in incomes per capita gives rise to a proportionately greater change in car ownership. This could reflect a model misspecification, such as the omission of relevant explanatory variables other than incomes. Equally, there could be data problems e.g. arising from the fact that car ownership levels are based on licensed (taxed) vehicles only.

Table 3.10 - Income Elasticity of Car Ownership

County	Income Elasticity
Carlow	0.83
Cavan	0.68
Clare	0.80
Cork	0.74
Donegal	1.11
Dublin	0.65
Galway	0.75
Kerry	0.78

County	Income Elasticity
Kildare	0.59
Kilkenny	0.70
Laois	0.60
Leitrim	0.77
Limerick	0.77
Longford	0.58
Louth	0.74
Mayo	0.75
Meath	0.60
Monaghan	0.64
Offaly	0.67
Roscommon	0.68
Sligo	0.72
Tipp. Nth	0.84
Tipp. South	0.69
Waterford	0.95
Westmeath	0.72
Wexford	0.75
Wicklow	0.67

3.4 Economic Projections for NTpM Modelling

The county car ownership modelling process developed models that related car ownership per capita of the county to the car ownership saturation level and incomes per adult. Thus, projection of car ownership and car numbers by county requires a projection of future incomes. This was achieved by first forecasting income at the National level and then an elaboration of those projections to derive county level projections. This section of the report describes this process. It begins with a consideration of incomes per capita at the national level and proceeds to consider county income projections.

3.4.1 Projections of Incomes at the National Level

The NTpM modelling process requires a projection of car ownership and car numbers for the key years of 2030 and 2050. Income projections are required for the same period. Government, through the Department of Finance, makes income projections for at most five years into the future. The ESRI, however, does make longer term projections in the context of its regular Medium Term Reviews (MTRs). The latest such review was published in 2013 and this is the source of income projections to 2030.

3.4.2 The ESRI Medium Term Review

The ESRI Medium Term Review (MTR) report[26], published in July 2013, relied in part on data and analysis of the economy in the period immediately prior to that. This was a period in which the Irish economy continued to endure a recession, with great uncertainty about the path and timing of economic recovery. The ESRI adopted three scenarios as follows.

The Recovery scenario assumed that the EU economy would return to a reasonable rate of growth over the rest of the decade. It is also assumed that the continuing problems in the Irish financial sector are tackled effectively. Under these circumstances, the export sector of the economy would see its markets grow, resulting in increases in output and employment. In turn, growth in foreign demand would help produce a turnaround in domestic demand.

As firms increase their sales and their profitability, they would need to invest to continue growing. With rising real personal incomes and growth in employment, consumption would also begin growing again. Fundamental to the Recovery scenario is the fact that as unemployment will initially be high, growth will not be restrained by the growth in the labour market.

The Delayed Adjustment scenario considered what would happen if the EU economy recovered but domestic policy failed to resolve the ongoing problems in the Irish financial system, or if some other event or policy failure prevented the domestic economy from benefiting from a wider economic recovery. Such a scenario could see the economy seriously underperform its potential.

The Stagnation scenario considered the circumstances where the EU economy would not return to growth in the near future. The result would be a “zombie” decade for the EU and this would have serious consequences for Ireland. With no growth in the EU, the Irish economy, even if managed effectively, would do well to grow at one per cent a year over the second half of the decade. The unemployment rate in 2020 would remain where it was in 2008.

3.4.3 Developing Alternative Economic Scenarios

The Central Scenario

The ESRI Recovery Scenario was adopted as the central economic forecast for a number of reasons. Firstly, it represented a reasonable view of how the economy could recover from the recession. Secondly, at the time of model development, the economy appeared to be recovering more or less in line with the Scenario. Finally, it

[26] Medium Term Review: 2013-2020 10/07/2013 By John FitzGerald and Ide Kearney (eds.), Adele Bergin, Thomas Conefrey (Central Bank of Ireland), David Duffy, John FitzGerald, Ide Kearney, Kevin Timoney, Nuša Žnuderl. ISBN 97807070035 ISSN0790-9470

had the advantage of having a complementary and consistent demographic forecast. This latter property was considered very desirable as both economic and demographic variables were used in the car ownership and car numbers models, and consistency would ensure a coherent approach to forecasting.

The ESRI Recovery Scenario considered the period up to 2030 only. However, economic forecasts were required for the full period up to 2050. Economic projections for the Central Scenario post 2030 were based on the fact that full employment would be achieved by circa 2025. Growth thereafter would be determined by the growth in employment and productivity[27]. In other words:

(A)Employment growth x productivity growth = output growth (income growth)

In order to implement this approach, employment projections needed to be made. This was accomplished by extending the Recovery scenario for population growth up to 2050, deriving labour force estimates from the population estimates, and then estimating employment growth from the labour force growth by assuming unemployment rates. The approach may be characterised as follows:

(B) Population > Labour force > Employment

The analysis of output growth (income growth) required assumptions about labour productivity. Up to 2003, productivity grew by between 4 percent and 8 percent a year.[28] Since 2003, annual productivity growth slowed to between 2 percent and 4 percent. This slowdown mirrors trends elsewhere in the developed world.

While Ireland's labour productivity growth rates are weakening, they remain relatively strong in an international context. Irish productivity growth rates have averaged 2 percent per annum between 2007 and 2011 (with particularly strong growth recorded in 2009 and 2010). This compares with 1.3 percent in the US, 1 percent in the OECD and 0.4 percent in the Euro area. For the longer term, post 2030, it may be assumed that as the economy matures, labour productivity growth rates will decline towards international norms. In this context, a post 2030 productivity growth rate of 1.5% was posited. The resultant economic growth rates for the post 2030 period and before are set out in Table 3.11 below.

Table 3.11: Projected Income Growth Rates Central (Recovery) Scenario

Period	Annual Growth Rate (%)
2011-2016	1.0
2016-2021	3.5
2021-2026	2.2

[27] Productivity is an average measure of the efficiency of production. It can be expressed as the ratio of output to inputs used in the production process, i.e. output per unit of input

[28] Forfas. Ireland's Productivity Performance, 1980-2011. April 2012.

2026-2030	2.2
2030-2040	1.9
2040-2050	1.2
Period	Cumulative Growth (%)
2011-2030	52.1
2030-2050	35.8

3.4.4 The Low and High Sensitivity Scenarios

It is usual, in positing future economic scenarios, to adopt a central scenario which encompasses the most likely growth path for the economy. This is usually accompanied by high and low sensitivity test scenarios. However, neither the Delayed Adjustment of Stagnation scenarios constitute high and low sensitivities, but rather explore the consequences of a set of negative outcomes for the economy. These could not be used as a basis for alternative scenarios.

The approach adopted for high and low sensitivity scenarios was to base these on the high and low population projections, which are based on different assumptions regarding migration (see Section 3.2.2). With regard to the High Scenario, the population projection up to 2025 was very similar to the central population projection, so economic growth in line with the economic recovery scenario was adopted[29]. Thereafter, economic growth was calculated in line with the identity set out at (A) above.

With regard to the Low Scenario, population growth would be less and would tend to hold back economic growth prior to 2025, as full employment was reached by about 2021. Accordingly, the approach at (A) above was used for the entire period from 2020 to 2050. The results are set out in Table 3.11 below.

Table 3.11: Projected Income Growth Rates – All Scenarios

Period	Low Sensitivity (%)	Central (%)	High Sensitivity (%)
2011-2016	1.0	1.0	1.0
2016-2021	3.5	3.5	3.5
2021-2026	1.9	2.2	2.2
2026-2030	1.9	2.2	2.4
2030-2040	1.6	1.9	2.0
2040-2050	0.8	1.2	1.4
Cumulative Growth (%)			
2011-2030	47.5	52.1	53.0

[29] As set out in the demographic forecasting methodology.

2030-2050	26.9	35.8	40.4

3.4.5 County Income per Capita Assumptions

The economic and income growth projections at the national level have been outlined above. For the purposes of predicting car ownership, there is a need to make assumptions about the future economic growth pattern at the county level. In particular, there is a need to determine whether incomes per capita for certain counties are likely to rise at a faster rate than the national average. There are no official projections for economic growth at the county (or regional) level.

For long term projections, it is best to consider this issue in terms of regional rather than county incomes, as the latter may be unduly influenced by short term inward investment flows, which can give rise to substantial short term variations in income levels. Table 3.12 sets out the trend in incomes per capita at the regional level over the period 2000-2010.

Table 3.12: Trends in Regional Personal Income per Capita (National Average = 100)

Region	2000	2007	2010
Border	84	86	86
West	88	90	93
Mid-East	102	105	99
Mid-West	85	86	81
South-East	88	94	91
South-West	86	92	89
Dublin	121	115	116
State	100	100	100

At the beginning of the period, there was a substantial difference in regional income per capita levels, with Dublin 21% above the average and the Mid-East 2% above average. All the other regions were below the national average, with the Border and the South East being 84% and 85% of the average respectively. There was a gap of 37 percentage points between the lowest and highest regional incomes.

During the ‘Celtic Tiger’ years, there was a tendency for regional incomes to converge somewhat. By 2007, Dublin was only 15% above the average, so that the gap between the highest and lowest had reduced to 29 percentage points. There may be many reasons for this trend including the boom in construction, which is substantially local in nature, the level of social welfare transfers, and the tendency for increased separation of home and work places.

By 2010, the trend of convergence had been reversed, with the gap between the highest and lowest widening to 35 percentage points. Given the artificial nature of the economy in the boom years, it may be argued that the current (2010) relativities are more likely to hold in the future and that the drivers of convergence will be less strong. In this context, it was decided to make the neutral assumption that regional (and county) income per capita growth rates will align with the national average growth rate.

3.4.6 Economic Projections for NTpM Modelling

Car ownership was predicted for each county and year from 2011 to 2050 using the model described in Section 3.2.2 above, incorporating the projected income levels.

Three indices of projected income per adult were derived for each county by combining the income growth projections described in Section 3.3 with forecasts (low, medium and high) of the adult population for each county. The projections of the adult population were created as part of the three population scenarios estimated by the ESRI. Thus, for each county, there are three different income per adult indices applied to 2011 income levels, representing one for each of the three projected adult population-income scenarios.

The annual percentage changes were calculated for the model outputs for each county for all three scenarios. That is, an index of the change in model-predicted car ownership was generated for each county.

The index was then applied to the actual ownership in 2011 and car ownership was projected forward to 2050 on the basis of the index. This method ensures a smooth transition from the actual to the forecast data. The forecast change in car ownership for the central scenario is presented in Table 3.13 below while the change in the rank order in the central scenario over time is set out in Table 3.14.

Table 3.13 - Central Scenario Projections: Change in Car Ownership

Central Scenario: Predicted Car Ownership by County						
County	2011 (Actual)	2030	2050	Saturation	% Change 2011 to 2030	% Change 2011 to 2050
Carlow	622	735	816	950	18%	31%
Cavan	510	596	667	899	17%	31%
Clare	586	690	770	950	18%	32%
Cork	591	690	763	915	17%	29%
Donegal	513	641	733	866	25%	43%
Dublin	492	559	606	698	14%	23%
Galway	516	613	691	911	19%	34%
Kerry	569	672	751	929	18%	32%
Kildare	572	643	699	860	13%	22%

Central Scenario: Predicted Car Ownership by County						
County	2011 (Actual)	2030	2050	Saturation	% Change 2011 to 2030	% Change 2011 to 2050
Kilkenny	557	653	731	937	17%	31%
Laois	509	586	651	918	15%	28%
Leitrim	545	647	726	906	19%	33%
Limerick	556	653	728	925	17%	31%
Longford	528	602	667	928	14%	26%
Louth	494	574	642	863	16%	30%
Mayo	533	630	708	926	18%	33%
Meath	562	641	704	882	14%	25%
Monaghan	508	584	651	912	15%	28%
Offaly	522	604	673	921	16%	29%
Roscommon	566	657	731	943	16%	29%
Sligo	541	635	711	927	17%	32%
Tipp. North	634	739	813	950	16%	28%
Tipp. South	562	666	747	940	18%	33%
Waterford	584	696	777	933	19%	33%
Westmeath	566	653	721	908	15%	27%
Wexford	592	696	774	931	18%	31%
Wicklow	594	669	723	843	12%	22%

Table 3.14 - Central Scenario Projections: Change in Rank Order

Central Scenario Forecast Car Ownership Rank by County					
County	2011	2030	2050	Rank Change 2011 to 2030	Rank Change 2011 to 2050
Tipp. North	1	1	2	0	-1
Carlow	2	2	1	0	1
Wicklow	3	8	13	-5	-10
Wexford	4	3	4	1	0
Cork	5	5	6	0	-1
Clare	6	5	5	1	1
Waterford	7	4	3	3	4
Kildare	8	15	19	-7	-11

Central Scenario Forecast Car Ownership Rank by County					
County	2011	2030	2050	Rank Change 2011 to 2030	Rank Change 2011 to 2050
Kerry	9	7	7	2	2
Westmeath	10	11	15	-1	-5
Roscommon	11	10	10	1	1
Tipp. South	12	9	8	3	4
Meath	13	16	18	-3	-5
Kilkenny	14	11	10	3	4
Limerick	15	12	12	3	3
Leitrim	16	14	13	2	3
Sligo	17	18	16	-1	1
Mayo	18	19	17	-1	1
Longford	19	22	22	-3	-3
Offaly	20	21	21	-1	-1
Galway	21	20	20	1	1
Donegal	22	17	9	5	13
Cavan	23	23	22	0	1
Laois	24	24	24	0	0
Monaghan	25	25	25	0	0
Louth	26	26	26	0	0
Dublin	27	27	27	0	0

The percent change forecast from 2011 to 2030 varies between 12% and 25%, while the change forecast to 2050 varies between a minimum 22% increase in Wicklow and a 43% increase in Donegal. Donegal is exceptional in that the per cent changes forecast are considerably larger than those forecast for other counties. The 2030 forecast shows car ownership in Donegal increasing by 25%. This is 6 percentage points greater than the next largest increase of 19% in Galway. By 2050 the gap between the increase in car ownership in Donegal and the next largest is forecast to widen to 9 points, with Donegal increasing 43% compared to a 34% increase in Galway. The outperformance of Donegal reflects the model outcomes in terms of income elasticities, to which reference was made above.

The range of county car ownership levels was 492 to 634 cars per 1,000 adults in 2011, and is forecast to increase to 559 to 739 cars per 1,000 adults by 2030 and to 606 to 816 cars per 1,000 adults by 2050.

In 2011, the lowest car ownership was in Dublin at 492 cars per 1,000 adults. The forecast is that Dublin remains in this position, ranking 27th in 2030 and 2050. Dublin is forecast, in the central scenario, to have car ownership of 559 cars per 1,000 adults by 2030 and 606 cars by 2050. At the opposite end of the spectrum, Tipperary North had the highest car ownership in 2011 and continues to rank first in the table until 2030 but falls to second place by 2050.

Car ownership in Tipperary North is forecast to increase from 634 cars per 1,000 adults in 2011 to 739 cars by 2030 and 813 cars by 2050. Between 2030 and 2050, Carlow is forecast to move from the second rank position to first. Carlow is forecast to increase from 622 in 2011 to 735 by 2030 and is slightly ahead of Tipperary North in the 2050 forecast at 816 cars per 1,000 adults.

Most of the changes to the rank order of counties in terms of car ownership are forecast to be in the region of 0 to 3 places, with no change to the bottom 4 counties between 2011 and 2050. There are some notable exceptions: Wicklow ranked third in 2011 but is forecast to fall 5 places to 8th by 2030 and a further 6 places to 14th by 2050. Similarly, Kildare is forecast to drop 7 places from 8th in 2011 to 15th in 2030 and a further 4 places to 19th by 2050. Donegal is the only county forecast to make a substantial leap forward, moving up from 22nd in 2011 to 17th by 2030 and then to 9th by 2050.

3.5 Developing National Car Ownership Estimates

3.5.1 National Car Ownership

Car ownership at the national level was estimated for the years to 2050. National car ownership estimates were formed by aggregating county level forecasts. County level car ownership was converted to the number of cars for each county and scenario and the sum of these is the national number of cars per scenario. This is then combined with the corresponding national population estimate to get a national level of car ownership for each scenario. This bottom up approach allowed as much information as possible to be included in the national forecast.

Table 3.15 sets out the national projections from 2011 to 2050 in population, numbers of cars and car ownership for the three scenarios while Table 3.16 indicates the percentage changes in each of the variables from 2011 to 2030, 2030 to 2050 and 2011 to 2050.

Table 3.15 - National Projections

Central Scenario					
Year	Cars (millions)	Population Adults (millions)	Population (millions)	Ownership per 1,000 Adults	Ownership per 1,000 Population
2011	1.89	3.50	4.59	540	411
2030	2.56	4.08	5.07	627	504

2050	3.07	4.44	5.41	691	566
High Sensitivity Scenario					
Year	Cars (millions)	Population Adults (millions)	Population (millions)	Ownership per 1,000 Adults	Ownership per 1,000 Population
2011	1.89	3.50	4.59	540	411
2030	2.58	4.12	5.14	625	502
2050	3.19	4.59	5.61	696	569
Low Sensitivity Scenario					
Year	Cars (millions)	Population Adults (millions)	Population (millions)	Ownership per 1,000 Adults	Ownership per 1,000 Population
2011	1.89	3.50	4.59	540	411
2030	2.42	3.91	4.87	620	498
2050	2.76	4.04	4.91	685	562

Table 3.16 - Percentage Change in National Projections

Central Scenario % Change					
Year	Cars (millions)	Population Adults (millions)	Population (millions)	Ownership per 1,000 Adults	Ownership per 1,000 Population
2011 - 2030	35%	17%	11%	16%	23%
2030 - 2050	20%	9%	7%	10%	12%
2011 - 2050	62%	27%	18%	28%	38%
High Scenario % Change					
Year	Cars (millions)	Population Adults (millions)	Population (millions)	Ownership per 1,000 Adults	Ownership per 1,000 Population
2011 - 2030	37%	18%	12%	16%	22%
2030 - 2050	24%	11%	9%	11%	13%
2011 - 2050	69%	31%	22%	29%	38%
Low Scenario % Change					
Year	Cars (millions)	Population Adults	Population (millions)	Ownership per 1,000	Ownership per 1,000

		(millions)		Adults	Population
2011 - 2030	28%	12%	6%	15%	21%
2030 - 2050	14%	3%	1%	10%	13%
2011 - 2050	46%	15%	7%	27%	37%

Car ownership per adult is forecast to increase 15% to 16%, depending on the scenario, between 2011 and 2030. Ownership as at 2011 was 540 cars per 1,000 adults and is expected to increase to between 620 and 627 by 2030. Car ownership per 1,000 adults is forecast to reach between 685 and 696 cars by 2050, an increase of 27% to 29% depending on the scenario.

Table 3.17: Periodic National Growth Rates: Actual and Forecast

Period	Periodical Actual and Forecast Growth Rates								
	Car Numbers			Population			Car Ownership per 1,000 Adults		
	High	Central	Low	High	Central	Low	High	Central	Low
1976 - 1981		41%			8%			30%	
1981 - 1986		-8%			5%			-13%	
1986 - 1991		18%			3%			14%	
1991 - 1996		26%			7%			18%	
1996 - 2001		31%			11%			18%	
2001 - 2006		28%			12%			15%	
2006 - 2011		6%			7%			-1%	
2011 - 2016	3%	4%	3%	1%	1%	1%	2%	2%	3%
2016 - 2021	13%	13%	12%	5%	5%	3%	7%	8%	8%
2021 - 2026	9%	9%	5%	6%	5%	4%	3%	3%	1%
2026 - 2031	9%	9%	7%	6%	5%	4%	3%	3%	3%
2031 - 2036	8%	7%	6%	4%	4%	3%	3%	3%	3%
2036 - 2041	6%	5%	4%	3%	2%	1%	3%	3%	3%
2041 - 2046	4%	3%	2%	2%	1%	0%	2%	2%	2%
2046 - 2050	3%	2%	1%	1%	1%	-1%	2%	2%	2%

In all three scenarios, the growth rates expected in the future are lower than those experienced in the years to 2011. Growth rates in both the number of cars and car ownership are expected to decline from 2020 onwards. The growth rate in the number of cars from 2011 to 2016 is forecast at 4% in the central scenario reflecting the macroeconomic environment. It is then expected to pick up; the central scenario growth forecast for 2016 to 2021 is 13%.

However the rate of increase is expected to decline gradually from 13% for the period 2016 to 2021 to 2% for the period 2046 to 2050. Car ownership is expected to experience slower growth overall; the peak in the 5-year growth rates is from 2016 to 2021 at 8%, thereafter the central scenario growth rates decline to 3% and fall to 2% for the periods 2041 - 2046 and 2046 - 2050.

The deceleration in the number of cars and car ownership reflect the expected changes in incomes over that time. Incomes are expected to continue to increase but as the economy matures, the increases are expected to be smaller. Furthermore, as Ireland approaches saturation in car ownership a slow-down in the growth rates in car ownership is expected.

The car ownership growth rates forecast post 2040 appear close to the growth in car ownership in more mature European economies in recent years. Data on car ownership levels in Europe are relatively sparse: 2009 is the most recent year for which data is collected and the data on private cars is not updated at regular intervals. In addition, the data available on car ownership is calculated per person rather than per adult. Therefore, the car ownership data for Ireland presented below is ownership per person rather than per adult as this allows a closer comparison with the European data.

The data set out in Table 3.18 below shows that the growth from 2005 to 2009 in some of Europe's more mature economies has been muted. Average annual growth rates were in the region of 0.5% per annum. Tables 3.19 and 3.20 show the forecast car ownership per person in Ireland and the forecast average annual growth rates respectively. A gradual deceleration is expected from 2015 onwards. Between 2040 and 2050 the forecast average growth rates vary between 0.3% and 0.4% - closely resembling the expected growth in recent years in mainland Europe.

Table 3.18 - European Car Ownership per 1,000 Inhabitants [30]

Car Ownership per 1,000 Inhabitants					
Country	1995	2005	2007	2009	Average Annual % Change 2005 - 2009
Ireland	275	410	417	430	1.2%

[30] Source: Vehicle stock 1995-2009 from TREMOVE v3.3.1. Population data, 1995-2009 from Eurostat. Note FLEETS data refer to 30 EEA member countries (that is EU-27 plus Norway, Switzerland, Turkey).

Norway	384	435	447	454	1.1%
Austria	423	507	517	528	1.0%
Germany	417	531	541	551	0.9%
France	421	479	484	490	0.6%
Netherlands	367	439	445	449	0.6%
Luxembourg	711	688	696	700	0.4%
Portugal	252	350	352	355	0.4%
Italy	529	593	599	603	0.4%
Belgium	422	465	469	471	0.3%

Table 3.19 - Forecast Car Ownership in Ireland

Year	Forecast Car Ownership per 1,000 Inhabitants		
	High	Central	Low
2011	411	411	411
2015	410	410	411
2020	443	444	447
2025	469	471	469
2030	502	504	498
2035	528	530	525
2040	547	548	544
2045	558	557	553
2050	569	566	562

Table 3.20 - Growth Rates in Forecast Car Ownership

Year	Forecast Average Annual Growth Rates in Car Ownership per 1,000 Inhabitants		
	High	Central	Low
2011 - 2015	-0.1%	-0.1%	0.0%
2015 - 2020	1.6%	1.6%	1.7%
2020 - 2025	1.1%	1.2%	1.0%
2025 - 2030	1.4%	1.4%	1.2%
2030 - 2035	1.0%	1.0%	1.1%
2035 - 2040	0.7%	0.6%	0.7%
2040 - 2045	0.4%	0.3%	0.3%
2045 - 2050	0.4%	0.3%	0.3%

3.6 Forecasting Car Ownership at ED Level

3.6.1 Introduction

Electoral Divisions (ED) are legally defined administrative areas for which Small Area Population Statistics (SAPS) are published from the Census. The zones used in the NTpM are comprised of ED. Predicting car ownership and car numbers at ED level was an essential step in the development of zonal forecasts. As zones are simply groups of EDs, zone level projections are derived from aggregates of the ED level information. Additional detail on the assumptions made for the purposes aggregating ED data is available in Appendix A.

3.6.2 ED Level Car Ownership and Population Data

As there is no definitive data on car numbers at ED level, it was necessary to establish a set of base data from which forecasts could be made. The numbers of cars owned at ED level in 2011 were estimated using the number of cars reported to be available for use to each household in Census 2011.

This data include both taxed and untaxed vehicles, and taxis as well as private cars. As a consequence, the county totals were larger than the Department of Transport, Tourism and Sport's (DTTAS) actual data, which were used for the national and county forecasting models. To overcome this problem and prevent the base data on car ownership rates at ED level from being over-inflated, an adjustment was made. The estimated car numbers for each ED were aggregated for each county and these totals were compared to the DTTAS county data. The ED estimates were then re-based to reflect the relevant county totals.

ED population data for 2011 were taken from the Small Area Population Statistics (SAPS) data of Census 2011. Rates of car ownership per person for 2011 were then derived using this population data and the car numbers estimates as described above.

3.6.3 ED Level Forecasts

Forecast rates of car ownership per person for each ED were calculated by inflating the estimated 2011 rates of car ownership by the forecast growth rates in car ownership for the counties in which the EDs are located. This calculation was carried out for each of the three economic growth scenarios.

The forecast numbers of cars were then derived by applying these projected rates of car ownership to forecast population data at ED level. The ED population data used was derived from the same sources as those used for the county forecasts.

Figure 3.1 below shows car ownership per ED as at 2011 and the central forecasts for 2030 and 2050. The mapped data are per person in each ED rather than per adult since data on the number of adults per ED is not available. Figure 3.2 represents the numbers of cars for those years. Car ownership is forecast to increase across the country over time but this is more pronounced in the south of the country, in Munster and the south-east of Leinster. It is worth noting that although car ownership in Dublin is forecast to increase somewhat, car ownership in the centre of Dublin remains relatively low, even in 2050.

This reflects the level of urbanisation and access to public transport in Dublin. The forecast of the number of cars exhibits a different trend over time: the highest numbers of cars were in the urban centres, such as Dublin, Cork, Galway and Limerick where population is highest, in 2011. As these areas of high population grow and extend to a wider geographical area over time, so too does the number of cars. By 2050, the EDs with high numbers of cars are forecast to be concentrated in Dublin and surrounding counties as well as in Cork and to some extent.

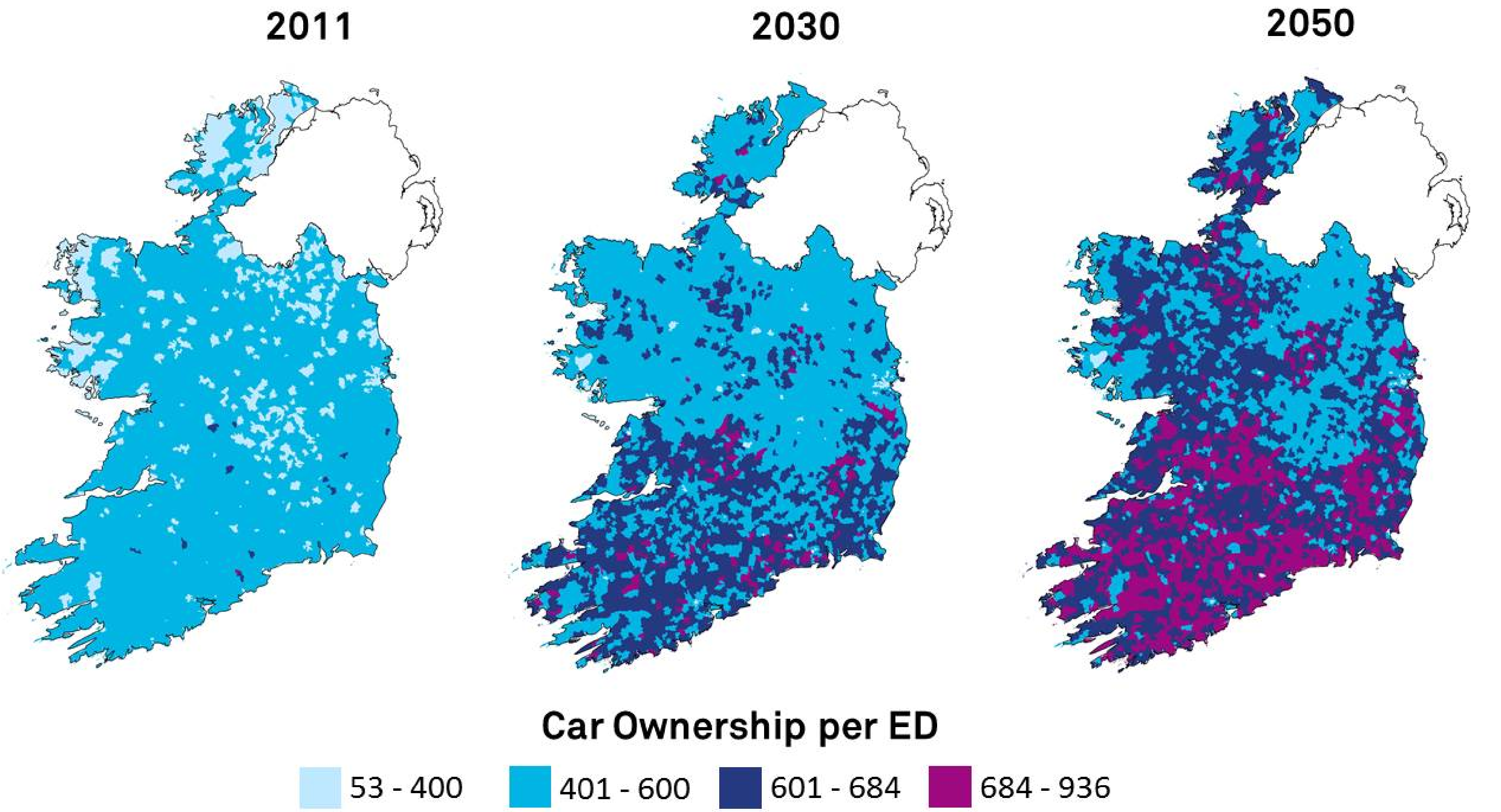


Figure 3.1 - Car Ownership per ED

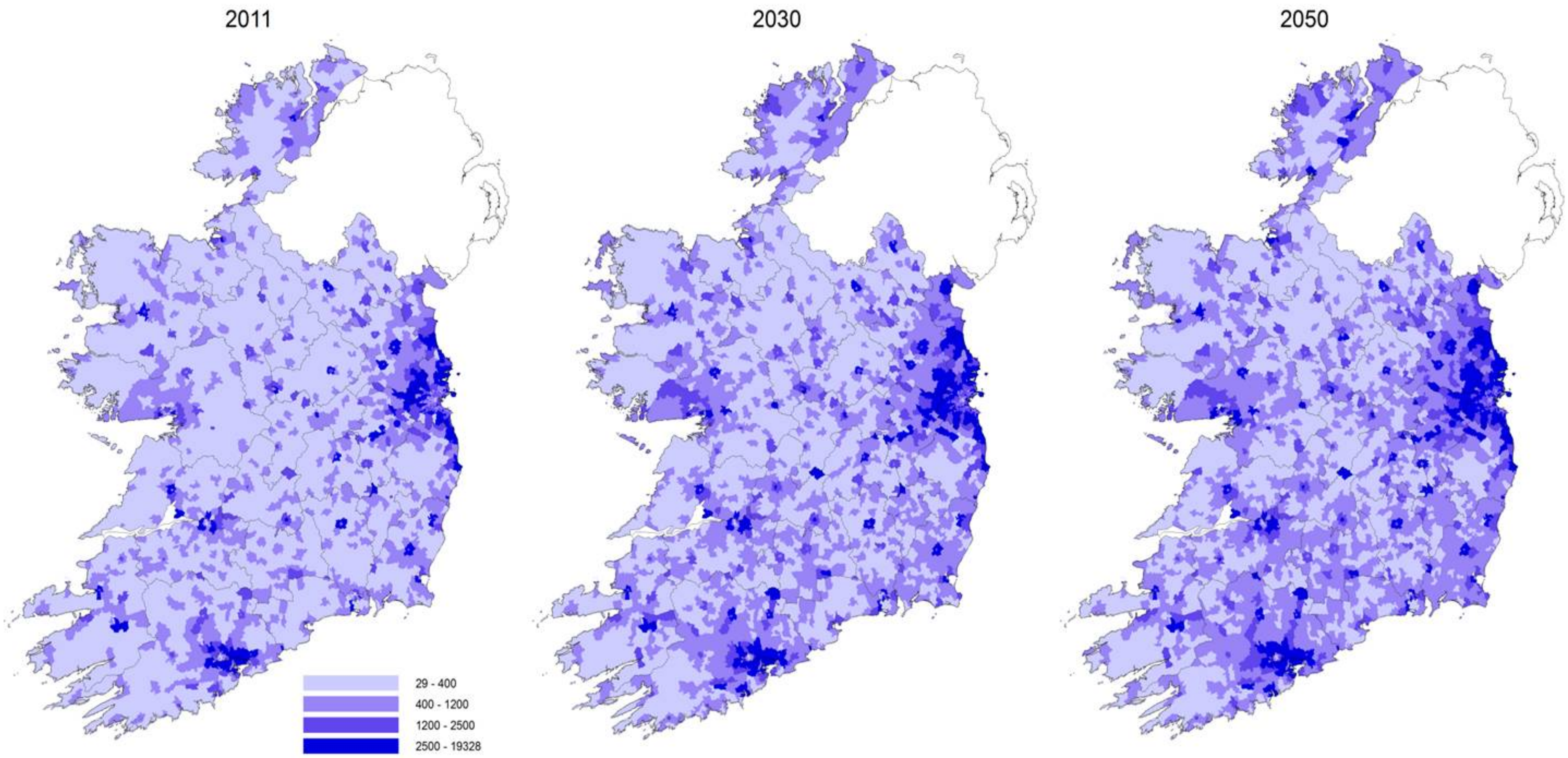


Figure 3.2 – Number of Cars per ED

3.7 Conclusions

3.7.1 Summary

The number of private cars registered in Ireland increased from 551,117 cars to 1,887,810 cars over the period 1976 to 2011. This is an average annual growth rate of 3.6%. Car ownership increased by an average of 2.1% per annum over the same period, from 262.6 cars per 1,000 adults in 1976 to 540.1 cars per 1,000 adults in 2011. Car ownership peaked in 2008 at 574 cars per 1,000 adults.

European car ownership data is recorded per inhabitant rather than per adult. As of 2009, the most recent year for which such data is available, Ireland ranked 19th of the 30 EEA countries. Comparing car ownership in Ireland to that in other former 15 EU Member states, Ireland ranks 12th, at 430 cars per 1,000 inhabitants, trailed only by Greece, Denmark and Portugal.

Within Ireland, there is significant variation in car ownership from county to county. Tipperary North had the highest level of car ownership at 634 cars per 1,000 adults in 2011 while Dublin had the country's lowest level of car ownership at 492 cars per 1,000 adults.

In recent years, the change in the economic environment brought about a decline in car ownership; following a peak of 574 cars per adult in 2008, car ownership fell to 540 cars per adult in 2011. However, the decline in car ownership has not been as dramatic as the economic downturn. This reflects international evidence that economic growth drives car ownership but that car ownership does not respond as quickly to a decline in incomes as it does to an increase.

In order to generate forecasts, econometric models were developed for each county relating car ownership to incomes and county saturation levels. Three income forecasts were estimated (low, central and high) for each county. The central forecast was based on the ESRI's Medium Term Review Recovery Scenario. The low and high comparators were derived from this central scenario, reflecting a more (high) and less (low) optimistic view of future economic conditions and populations.

The per cent change expected in the central forecast from 2011 to 2030 varies between 12% in Wicklow and 25% in Donegal, while the change forecast per cent change to 2050 varies between a 22% increase in Wicklow and a 43% increase in Donegal. The range of county car ownership levels was between 492 and 634 cars per 1,000 adults in 2011 for Dublin and Tipperary North respectively. The range is forecast to increase to between 559 (Dublin) to 739 (Tipperary North) cars per 1,000 adults by 2030. By 2050, Carlow is forecast to replace Tipperary North at the top spot at 816 cars per 1,000 adults, while Dublin remains at the bottom of the table with 606 cars per 1,000 adults.

National car ownership estimates are aggregates of the county level estimates. The forecast is for between 15% and 16% increases in car ownership per adult by 2030 depending on the scenario. A further 10% to 11% is expected in the period 2030 to 2050, contributing to an expected 27% to 29% change overall between 2011 and 2050.

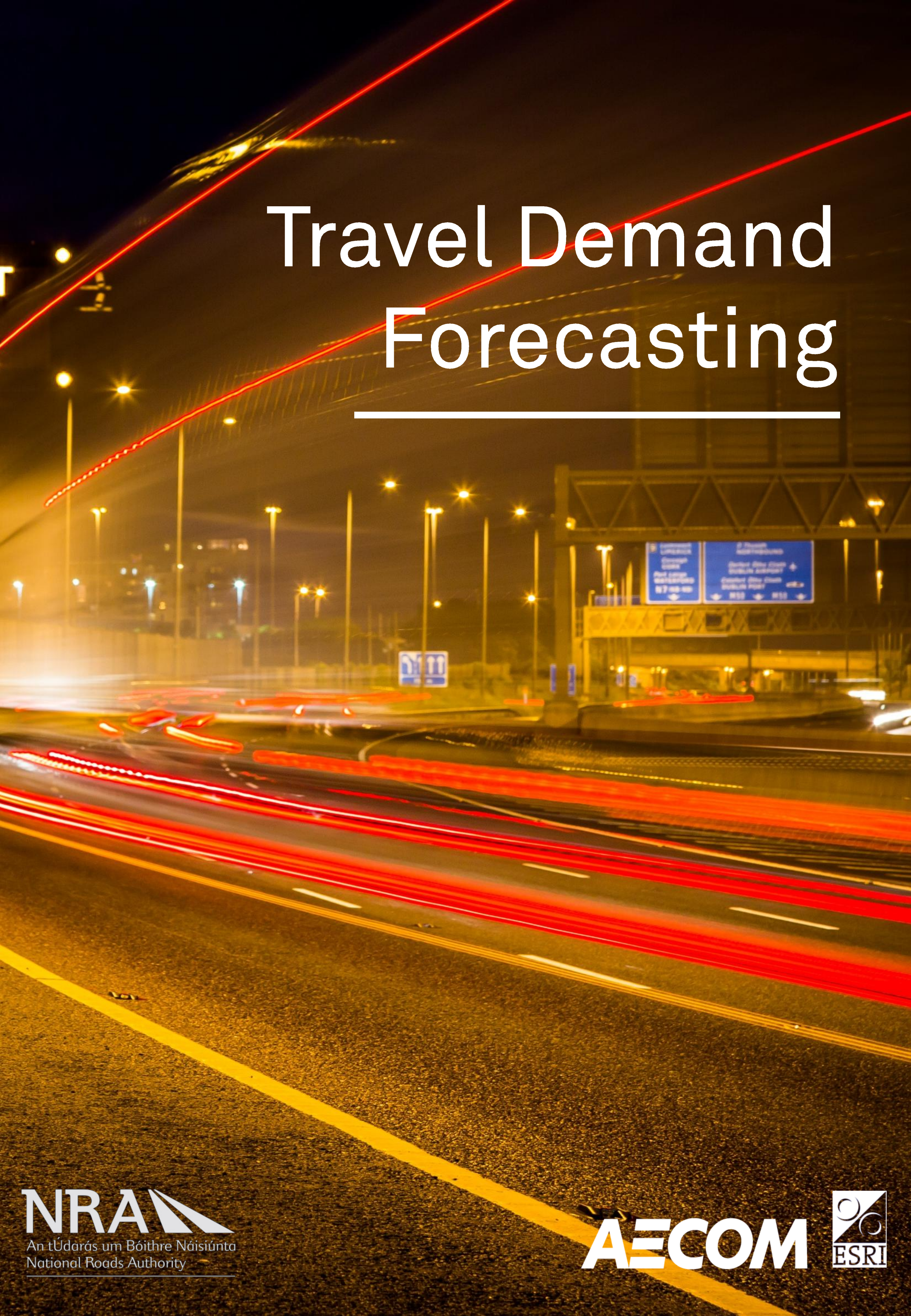
Finally, ED-level car ownership was estimated by applying county-level per cent changes to each ED within the relevant county. The results show that car ownership becomes much higher in the south of the country over time. Although car ownership in Dublin grows, car ownership in the centre of Dublin remains low in the long-run reflecting high population density and the availability of public transport. The number of cars, like population and employment, becomes more spatially concentrated over time.

3.7.2 Key Results

The key results of the car ownership assessment are provided below.

- The central forecast estimates that car ownership in Ireland will grow 15% by 2030 and 27% by 2050.
- Car ownership in Ireland was 540 cars per adult in 2011 and the central forecast estimates car ownership of 627 by 2030 and 691 by 2050.
- The number of cars in Ireland is expected to increase from 1.89 million in 2011 to 2.56 million by 2030, representing a 35% increase in the central forecast and to 3.07 million, a 62% increase, by 2050.
- The central forecast for car ownership at county level is for increases of between 12% (Wicklow) and 25% (Donegal) from 2011 to 2030 depending on the county.
- The central forecast range of county level percentage increases forecast for 2011 to 2050 is 22% (Wicklow) to 43% (Donegal).
- Dublin had the lowest car ownership in the country, at 492, in 2011 and remains at the bottom of the table in the central forecast for 2050, with 606 cars per 1,000 adults.
- Tipperary North had the highest car ownership in 2011 at 634 and is forecast to rank 2nd, at 813, in the central forecast by 2050.
- Carlow is forecast to have the highest car ownership by 2050, at 816 cars per 1,000 adults in the central forecast.
- Car ownership at ED level is expected to be more concentrated in the south of the country over time, while the highest numbers of cars will be in the urban centres where population and employment are expected to be highest.

Travel Demand Forecasting



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4.0 Travel Demand Forecasting

4.1 Introduction

The National Transport Model requires forecasts of the number of trips made to and from each zone classified as light vehicle (LV) trips or public transport (PT) passenger trips. Separate forecasts are required for all permutations of origin and destination trips for each trip purpose and time period.

Information on 2013 trips was available from the validated base year models for each NTpM zone. Data was categorised by whether the trip recorded was a light vehicle or public transport trip, by the purpose of the trip (commuter, employers' business or other), by time period (AM Peak, Inter-Peak or 15 hour) and by whether the trip was an origin or destination trip.

Econometric relationships were developed between each category of trip and a number of demographic variables. This analysis provided a series of robust models that were used to create the forecasts of numbers of trips.

This section of the report outlines the data used in the econometric analysis, the expected effects of these variables on numbers of trips, and the econometric models that were found to best fit the data.

4.1.1 Independent Variables Economic and Geographic Data

Economic and demographic data available for each NTpM zone in both the base and forecast years was needed to determine the forecasts. The key variables used were:

- Population;
- Jobs;
- Employment; and
- Car Ownership.

These are defined below:

- Population – Existing and forecast population data. Produced at ED level and aggregated to NTpM zone level.
- Population of driving age, i.e. of age 17 years or older - The population of adults per NTpM zone was estimated by applying the proportion of adults in the county (as per the county population forecasts) to the population of each zone within that county.
- Employment - Number of employed persons resident in each ED. This information was aggregated to NTpM zone level.
- Jobs – Number of jobs per ED. These forecasts were aggregated to NTpM zone level.

- Car Ownership - Car ownership per 1,000 people of 17 years of age or older per NTpM zone. This variable is the combination of the population of adults per zone as described above and the number of cars per zone (aggregated from ED level)

A number of additional variables were required:

- Population density: population per square kilometre;
- Employment density: employed persons per square kilometre; and
- Jobs density: jobs per square kilometre.

4.2 Econometric Modelling

Econometric relationships between the number of trips made and the economic and demographic data (independent variables) were estimated. For each category of data, there was a prior expectation of how the demographic and spatial data would affect the dependent variable. This was the starting point in estimating the econometric relationships. The expected effects of the independent variables on the number of trips are outlined below. An example, describing the variables that were expected to affect light vehicle AM peak commuter trips and the expected direction of these effects, is also presented.

4.2.1 Scale Variables

Certain variables were expected to grow almost in direct proportion to the number of trips made. These variables are population, employment and/or jobs. For example:

- The larger the population of a zone, the greater the number of trips of all kinds originating from that zone;
- The greater the number of jobs, the greater the expected number of destination commuter trips; and
- The greater the employment in a zone the greater the number of origin commuter trips.

These variables could be used as the sole predictors for each zone. That is, the econometric relationship between the number of trips and the population (or other scale variable depending on the category of trip being predicted) alone could be used to forecast trips for all zones. This measure would not allow for the nuances of other effects such as the greater availability of public transport in more densely populated areas. For this reason, multivariate regressions were employed and additional information was included.

4.2.2 Other Variables

Additional variables were included to improve the quality of the forecast. The variables and their expected effects on various trip types are as follows:

Jobs in 'distribution': number of jobs in retail and wholesale trade in the zone. This was used as a proxy for the extent to which a zone would attract trips for recreational purposes such as shopping trips. Car ownership is expected to have a positive effect on light vehicles trips originating from a zone and to have a negative effect on trips made by public transport.

Population density indicates the extent of urbanisation while jobs density gives an indication of the industrialisation of a zone. Population and population density are expected to be highly correlated as are employment density and employment so including both in the model is not expected to improve the model in most cases. Nevertheless, for certain categories of trips, there is additional information to be gleaned from these variables.

Population density is a measure of urbanisation and this represents a number of effects:

i) More urban zones (i.e. those with high population densities) have greater access to public transport, therefore have more public transport trips; and
ii) Urban areas are likely to have more recreational and leisure facilities and it is expected that trips will be made to and from such amenities

Jobs density is useful in determining destination commute trips – commuters' destinations are, by definition, zones with jobs. However, the density of those jobs can suggest greater access to public transport and a greater number of employers' business trips (both origin and destination).

A binary or 'dummy' variable for Dublin was included because, particularly in the case of public transport, the options available within Dublin are significantly different to those available elsewhere. Furthermore, Dublin has many more tourism and specialised services available than other areas.

This variable would act as a proxy for these Dublin-specific effects that are not captured elsewhere in the data. In general, it is expected that 'Dublin' would have a positive relationship with the number of trips. That is, if the effect of the zone being in Dublin is significant, it is expected that for two identical zones, one in Dublin and the other not, the zone in Dublin would have a greater number of trips. It is worth noting that population density and jobs density are likely to capture most of these effects and these variables are not expected to be jointly significant.

Example: Expected Effects of Independent Variables on Light vehicle, AM Peak, Origin, Commuter Trips

- Employment would very accurately predict origin commuter trips in the AM Peak, however some employees will travel by car, some will walk or cycle and others will use public transport. In addition, not all employees will depart in the AM peak hour. Nevertheless, employment is expected to be a very good predictor of such trips and the relationship is expected to be positive.

- Measures of population may also have a significant positive effect but employment is expected to be the better predictor.
- Car ownership would have a positive effect: the greater the level of car ownership the more likely the residents of that zone are to use light vehicles to commute.
- Population density, as a proxy for the availability of public transport, could have a significant negative relationship with the number of origin light vehicle commuting trips. The greater the density, the more likely that public transport is available and thus density is expected to have a negative relationship with trips made in light vehicles.

4.2.3 Results

The following tables set out the model details including the dependent variables, coefficients and adjusted R-squared values for each model. The variables are almost all significant at the 1% level, with a minority significant at 5% or 10% levels. The prefix ‘LN’ in Tables 4.1 and 4.2 below indicates that the data was transformed to natural logs. All of the dependent variables were natural log transformed.

- The models have adjusted R-squared values between 73% and 98%, indicating a satisfactory level of fit;
- All variables in all models are significant at a minimum 10% level and are typically significant at the 1% level; and
- The signs on the coefficients are as expected.

Table 4.1 - Dependant and Independent Variables

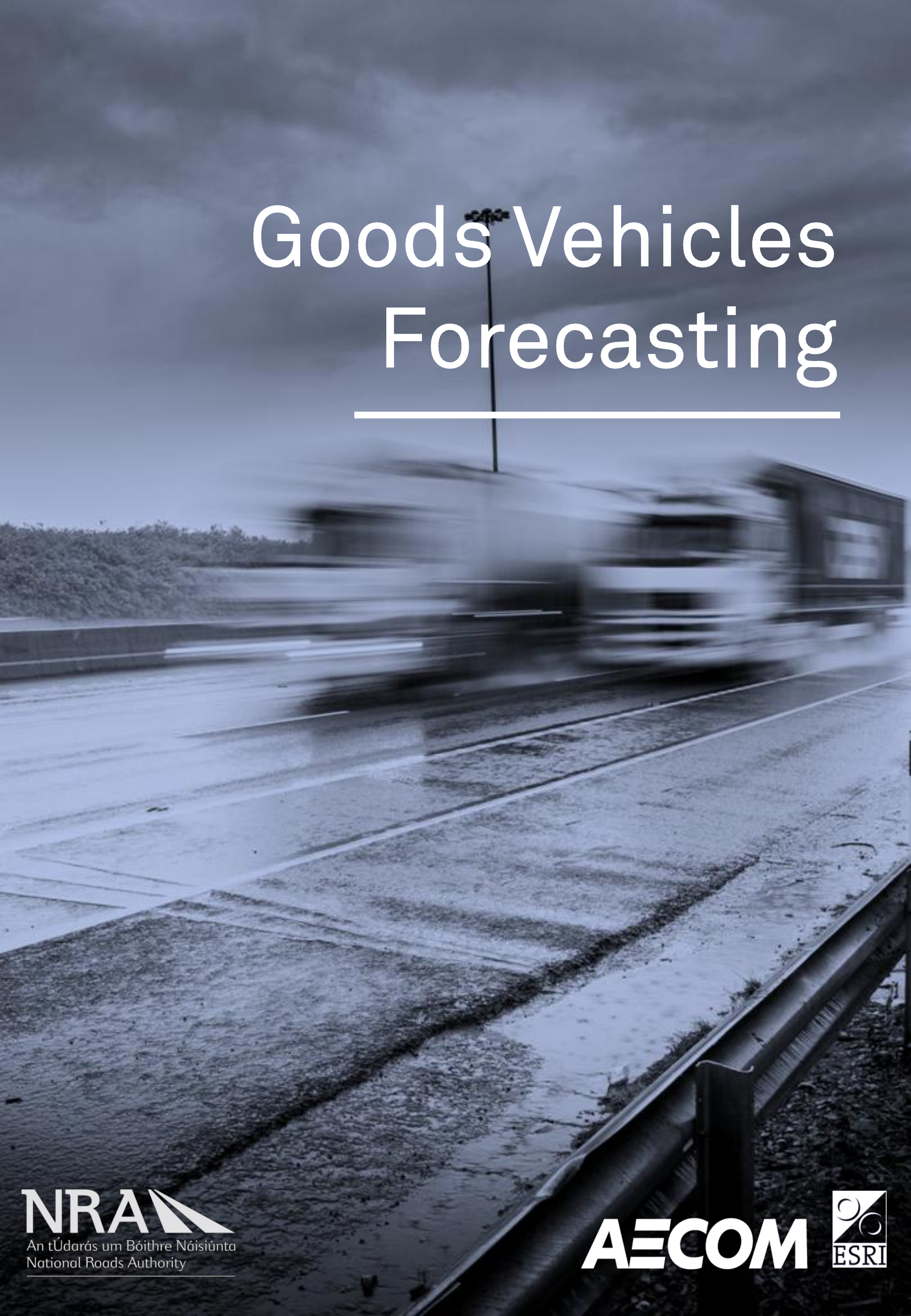
Dependent Variable			Light Vehicle Trips					
Time	Origin / Destination	Trip Purpose	Independent Variables and Parameters					Adjusted R^2
AM Peak	Origin	Commuter	Constant	LN Employment	Population Density	Car Ownership per Adult		98%
			-2.85	1.08	-0.0001	0.0007		
		Employers' Business	Constant	LN Employment	Population Density*			80%
			-3.58	0.97	0.0000			
		Other	Constant	Population Density	Car Ownership per Adult	LN Population		96%
			-5.65	0.00	0.0007	1.1416		
	Destination	Commuter	Constant	LN Jobs	Jobs Density			97%
			-3.41	1.20	-0.0001			
		Employers' Business	Constant	Jobs Density*	LN Jobs			77%
			-2.24	0.00	0.8080			
		Other	Constant	LN Population	LN Jobs (Distribution)			94%
			-4.27	0.97	0.0915			
Inter Peak	N/A	Commuter	Constant	LN Employment	Population Density	LN Jobs		93%
			-4.00	0.56	-0.0001	0.5545		
		Employers' Business	Constant	LN Employment	LN Jobs	Population Density		73%
			-2.12	0.42	0.4296	0.0000		
		Other	Constant	Population	Car Ownership	LN Population		87%

Dependent Variable			Light Vehicle Trips						
Time	Origin / Destination	Trip Purpose	Independent Variables and Parameters						Adjusted R^2
				Density	per Adult				
			-3.37	0.00	0.0004	0.9664			

Table 4.2 - Dependant and Independent Variables

Dependent Variable			Public Transport Passenger Trips						
Time	Origin / Destination	Trip Purpose	Independent Variables and Parameters						Adjusted R^2
15hr	N/A	Commuter	(Constant)	LN Population	LN Population^2	LN Jobs	Car Ownership per Adult*	Dublin	73%
			-17.81	3.08	-0.11	0.54	-0.001	1.84	
		Employers' Business	(Constant)	LN Employment	LN Jobs	Car Ownership per Adult	Jobs Density	Dublin	80%
			-7.66	0.91	0.27	-0.001	0.0001	-0.72	
		Other	(Constant)	LN Employment	Car Ownership per Adult	LN Jobs (Distribution)**			82%
			-4.58	1.19	-0.001	0.06			

**Indicates variable is significant at the 5% level*
***Indicates variable is significant at the 10% level*
All other variables are significant at the 1% levels



Goods Vehicles Forecasting

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5.0 Goods Vehicle Forecasting

5.1 Introduction

Goods vehicle activity is an essential component of the National Transport Model (NTpM). In order to forecast goods vehicle flows for future years, estimates of the future goods vehicle fleet size are required.

The term Goods Vehicles (GV) includes both Heavy Goods Vehicles (HGV) and Light Goods Vehicles (LGV). HGVs are defined as vehicles with unladen weight of 2 tonnes or more, while light goods vehicles are the goods vehicles of less than 2 tonnes. This analysis ultimately forecasts the change in the HGV fleet by the forecast years, 2030 and 2050, but data on the broader GV fleet is used to arrive at that forecast.

Section 5.2 sets out the historic trends in the GV fleet in Ireland and changes in the number of goods vehicles (GV) and heavy goods vehicles (HGV) between 1988 and 2012. Changes in the composition of the fleet, trends in the proportion and number of vehicles in each un-laden weight (ULW) category since 1988 are discussed in section 5.3.

Section 5.4 outlines the data available on activity in the sector and provides a picture of the dynamics of goods vehicle activity over time. The data presented includes the change in total vehicle kilometres travelled (VKT), average kilometres per vehicle (AVKT), as well as kilometres travelled by length of haul.

Changes in the total carrying capacity (CC) of the fleet over time and the relationship between CC and the wider economy are detailed in Section 5.5. This provides the rationale for using GDP as the measure of economic activity that best aligns with GV activity. This is followed by the results of an econometric analysis of the relationship between the CC of the GV fleet and GDP.

A forecast of the number of vehicles in the fleet in the forecast years, 2030 and 2050, is presented. An alternative methodology and the resulting forecasts are considered and compared with the output from the preferred methodology.

5.2 Goods Vehicle Fleet Size

There has been significant growth in the Goods Vehicle (GV) fleet in Ireland since the 1980s and this corresponds to the economic growth during that time. As shown in Figure 5.1 below, growth has been more pronounced in the GV fleet as a whole than in the fleet of private cars. However, HGVs have grown at a much slower rate than GVs as a whole. The trend has been for increasing use of LGVs compared to HGVs.

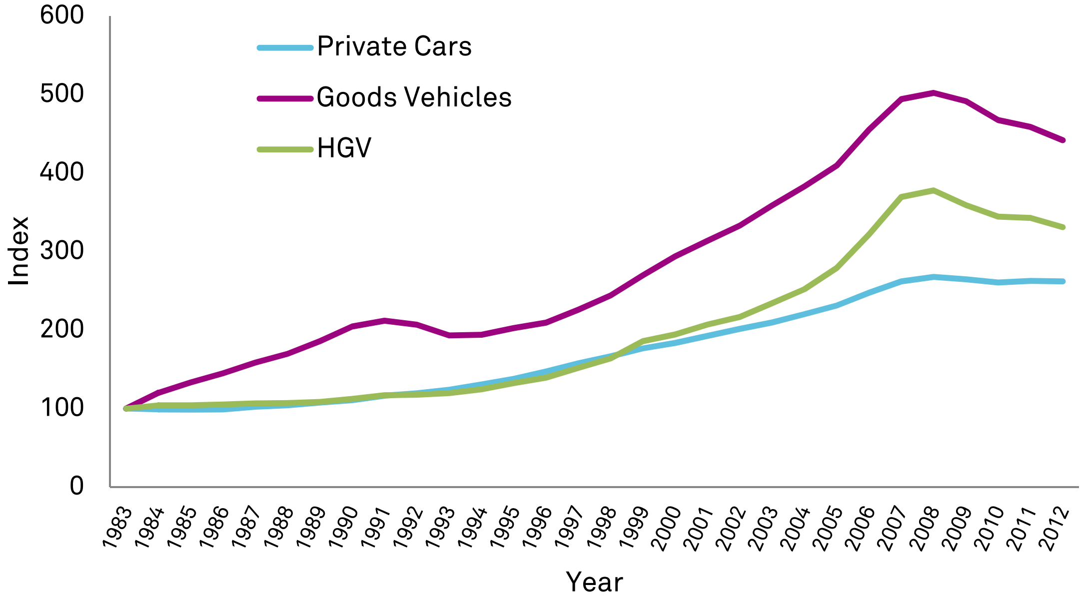

Figure 5.1 – Index of Growth in Goods Vehicles and Private Cars 1983-2012

The GV fleet increased each year from 1992 to a peak in 2008; thereafter it has declined each year in response to the challenging economic conditions. The GV fleet has dropped 12% since its peak in 2008, from 351,000 vehicles in 2008 to 309,000 in 2012. This 12% change in the fleet equates to over 42,000 vehicles; 74% of these were LGVs reflecting the large proportion of LGVs in the fleet.

Table 5.1 sets out the annual numbers of private cars and goods vehicles in thousands for the years 1983 to 2012.

Table 5.1 – Increase in Vehicle Fleet 1983 - 2012

Thousands of Vehicles 1983 - 2012			
Year	Private Cars	Goods Vehicles	Heavy Goods Vehicles
1983	719	70	23.1
1984	711	84	24.1
1985	710	93	24.1
1986	711	101	24.3
1987	737	111	24.7
1988	749	119	24.7
1989	773	130	25.0
1990	796	143	25.9
1991	837	148	27.0
1992	858	145	27.2

Thousands of Vehicles 1983 - 2012			
Year	Private Cars	Goods Vehicles	Heavy Goods Vehicles
1993	891	135	27.6
1994	939	136	28.8
1995	990	142	30.6
1996	1,057	147	32.2
1997	1,134	158	35.0
1998	1,197	171	37.8
1999	1,269	189	42.9
2000	1,319	206	44.9
2001	1,385	220	47.8
2002	1,448	233	50.0
2003	1,507	251	54.0
2004	1,583	268	58.2
2005	1,662	287	64.4
2006	1,779	319	74.3
2007	1,883	346	85.3
2008	1,924	351	87.2
2009	1,902	344	82.9
2010	1,873	327	79.5
2011	1,888	321	79.2
2012	1,883	309	76.4

5.3 Fleet Composition

The goods vehicle fleet is comprised of 5 categories based on the aggregation of the 27 categories set out in the Irish Bulletin of Vehicle and Statistics[31]. The 5 categories are as follows:

- LGV – Light Good Vehicle (<2 Tonnes);
- 2 to 5.1 Tonnes;
- 5.1 to 10.1 Tonnes;
- 10.1 to 15.2 Tonnes; and
- >15.2 Tonnes.

Tables 5.2 and 5.3 below demonstrate that while all categories of goods vehicle have seen an increase in total numbers, there have also been significant changes in the

[31] Department of Transport, Tourism and Sport (DTTAS) – Irish Bulletin of Vehicle and Driver Statistics 2012

fleet composition.

The largest per cent increases (and smallest decreases in the period 2008 to 2012) were seen in the higher and lower end of the HGV fleet. The growth in very large and small goods vehicles reflects a trend towards more specialised haulage.

Table 5.2– Number of Goods Vehicle by Unladen Weight Category

Number of Goods Vehicles by ULW Category						
Category	1988	1993	1998	2003	2008	2012
LGV	93,868	107,526	132,987	197,077	264,062	232,759
2 - 5.1	10,121	10,456	15,102	26,010	56,326	54,921
5.1 - 10.1	9,988	10,658	12,467	13,010	12,220	8,848
10.1 - 15.2	4,531	6,353	9,911	14,127	16,680	10,987
15.2+	103	171	352	901	2,015	1,650
Total Fleet	118,611	135,164	170,819	251,125	351,303	309,165

Table 5.3– Change in the Number of Goods Vehicle by Unladen Weight Category

% Change in Number of Goods Vehicles by ULW Category					
Category	1988-1993	1993-1998	1998-2003	2003-2008	2008-2012
LGV	15%	24%	48%	34%	-12%
2 - 5.1	3%	44%	72%	117%	-2%
5.1 - 10.1	7%	17%	4%	-6%	-28%
10.1 - 15.2	40%	56%	43%	18%	-34%
15.2+	66%	106%	156%	124%	-18%
Total	14%	26%	47%	40%	-12%

The change in the composition of the GV fleet is set out in Table 5.4. The share of LGVs in the overall GV fleet increased from 67% in 1983 to a peak of 82% in 1991 but had fallen to 75% by 2012.

Within the heavy goods category, the trend has been to move away from the mid-sized vehicles to those at the larger and smaller end of the spectrum. Vehicles between 5.1 and 15.2 tonnes ULW have been in decline as a proportion of the total fleet for some time. In 1983 these categories comprised 18% of the fleet but by 2012 comprised only 7% of the fleet. There was also a substantial increase in the proportion of the heaviest vehicles (>15.2 tonnes unladen weight) and to a lesser extent for the category 10.1-15.2 tonnes unladen weight. The proportion of vehicles of greater than 15.2 tonnes ULW increased from 0.1% to 0.6% over the period 1983 to 2012.

Table 5.4– Goods Vehicle Fleet Composition by Unladen Category

Fleet Composition by ULW Category					
Year	LGV	2 - 5.1	5.1 - 10.1	10.1 - 15.2	15.2+
1983	67%	15%	13%	4.7%	0.1%
1984	71%	13%	11%	4.2%	0.1%
1985	74%	11%	10%	4.0%	0.1%
1986	76%	10%	10%	3.9%	0.1%
1987	78%	9%	9%	3.8%	0.1%
1988	79%	9%	8%	3.8%	0.1%
1989	81%	8%	8%	3.9%	0.1%
1990	82%	7%	7%	4.0%	0.1%
1991	82%	7%	7%	4.1%	0.1%
1992	81%	7%	7%	4.2%	0.1%
1993	80%	8%	8%	4.7%	0.1%
1994	79%	8%	8%	5.0%	0.1%
1995	78%	8%	8%	5.3%	0.1%
1996	78%	8%	8%	5.6%	0.2%
1997	78%	9%	8%	5.7%	0.2%
1998	78%	9%	7%	5.8%	0.2%
1999	77%	9%	7%	6.7%	0.3%
2000	78%	9%	6%	6.2%	0.3%
2001	78%	9%	6%	6.1%	0.3%
2002	79%	10%	6%	5.8%	0.3%
2003	78%	10%	5%	5.6%	0.4%
2004	78%	11%	5%	5.5%	0.4%
2005	78%	12%	4%	5.7%	0.4%
2006	77%	13%	4%	5.8%	0.5%
2007	75%	15%	4%	5.5%	0.5%
2008	75%	16%	3%	4.7%	0.6%
2009	76%	17%	3%	3.9%	0.5%
2010	76%	17%	3%	3.7%	0.5%
2011	75%	18%	3%	3.6%	0.5%
2012	75%	18%	3%	3.6%	0.5%

The trend towards heavier vehicles is undoubtedly driven by economies of scale, the increase in maximum permissible weights and the potential for unitisation that they offer. The causes of the trend towards lighter vehicles are more difficult to discern, but may include:

- An increase in services sector activity, giving rise to a demand for smaller payloads;
- A change in distribution networks away from direct distribution;
- An increased emphasis on just-in-time delivery, giving rise to a need for increased delivery frequency using lower payloads; and
- More recently, a trend towards direct consumer purchasing via the Internet.

There is now some evidence of increased stability in the size structure of the goods vehicle fleet. The years 2006 – 2012 saw little change in the composition of the fleet. However, this is most likely due to the fact that few new vehicles entered the fleet in this period, leading to stagnation in its composition.

5.4 Average Vehicle Kilometres Travelled

Average vehicle kilometres travelled (AVKT) is defined as the average number of kilometres travelled annually by a vehicle and is a measure of the utilisation of the fleet. The following charts show the annual AVKT for GVs for the period 2000 to 2012 and the annual AVKT for HGVs versus LGVs for the period 2008 to 2012. AVKT per goods vehicle is sourced from the CSO 'Transport Omnibus' and is based on odometer readings from the Commercial Vehicle Roadworthiness Testing Service. It includes vehicle kilometres driven by Irish registered vehicles in both national and international jurisdictions. [32]

The evidence is that average kilometres per vehicle (AVKT) rose to a peak in 2004. The increase in average kilometres most probably reflects the strong economic growth experienced at that time. Thereafter AVKT fell somewhat, with more a more rapid decline since 2008. A plausible explanation for the decline in average kilometres post 2004 is that the trend towards larger vehicles peaked in 2003/2004, so that the increasing number of light vehicles in the fleet started to reduce the average kilometres. Another possible factor is that more investment in the fleet was possible and more vehicles were added to the fleet. This had the effect of reducing AVKT at the time when total GV activity was at its highest point. From 2008 the economy and goods vehicle activity declined rapidly but the number of vehicles did not fall as quickly and thus AVKT reached a new low of 19,700 kilometres.

AVKT for GVs decreased 19% from the peak of 24,300 kilometres in 2004 to 19,700 in 2012 as illustrated in Figure 5.2. AVKT for GVs decreased 14%, from 22,600 in 2008 to 19,700 in 2012, as shown in Figure 5.4. This change is comprised of a 16% drop in HGV AVKT and an 11% decline in LGV AVKT. The average annual percentage change in HGV AVKT was -4.2% during this time, while LGV AVKT declined less dramatically at an

[32] HGV specific AVKT is not available from the Road Freight Transport Survey and the CSO does not publish a long time series of this data.

average -2.9% per annum. It is unlikely that the peak level will be reached in the future, as this was probably due to exceptionally positive economic conditions. An increase of no more than 10% from 2011 levels is envisaged.

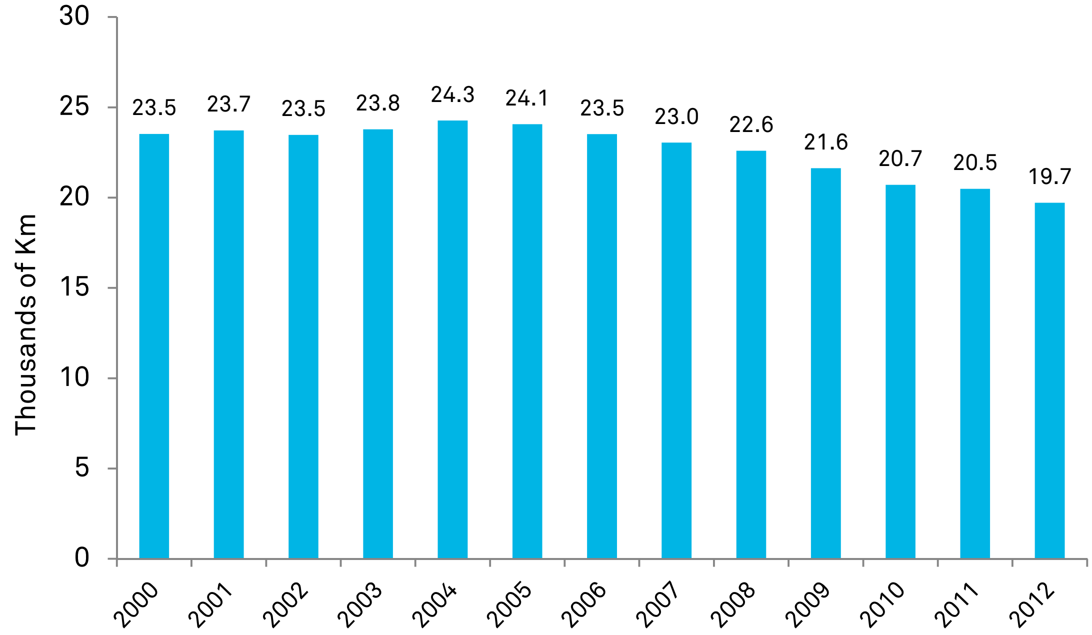

Figure 5.2 – Average Vehicle kilometres Travelled: All Goods Vehs: 2000 -2012

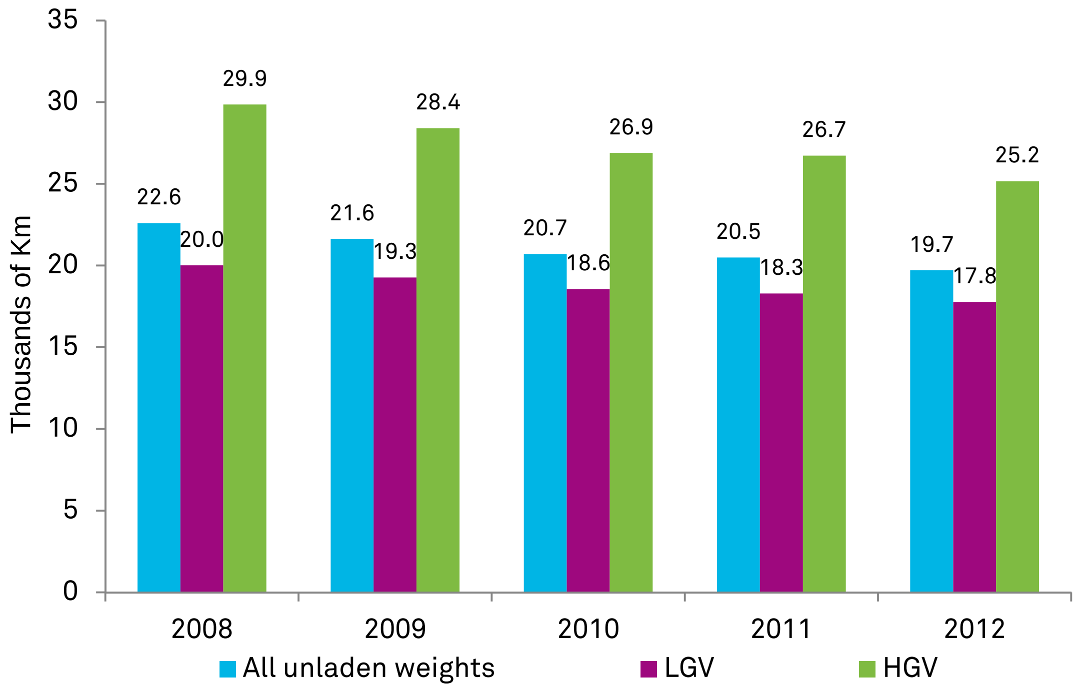

Figure 5.3 – Average Vehicle kilometres Travelled by Goods Vehicle Type

The number of kilometres travelled is recorded by category of length of haul (Figure 5.4) and by the type of work done by vehicle (Figure 5.5). More kilometres are covered in short journeys (of less than 10 kilometres) than in other lengths of haul. This was particularly true during the construction industry boom, as a large number of HGV journeys were made between building sites, as shown in Figure 5.4.

As set out in Table 5.5, the proportion of kilometres covered by long haul journeys (151 kilometres or more) has also increased, from 22% in 1995 to 38% in 2012, while journeys of 10-150km comprise 27% of the total in 2012 compared to 42% in 1995.

This echoes the fleet and carrying capacity analysis; more specialised haulage is developing with increases in small vehicles and shorter journeys coupled with increases in long and heavier hauls. The share of kilometres covered on journeys of 10 kilometres or less has not significantly increased, indicating that the shift is coming through the mid-level journeys being replaced with longer hauls.

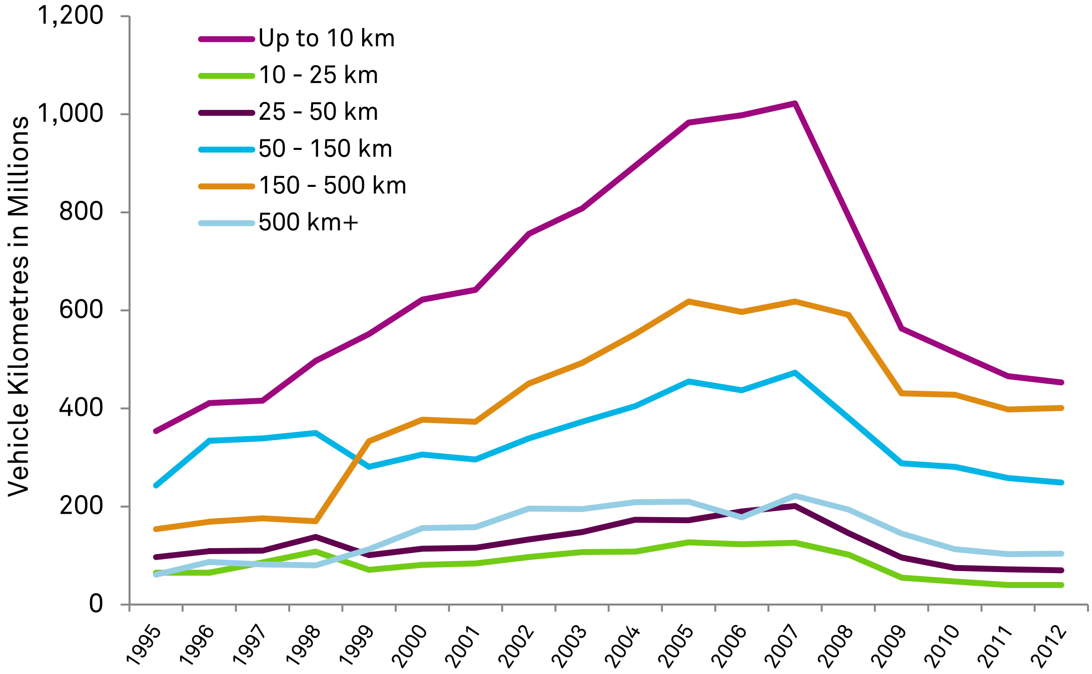

Figure 5.4 – Vehicle kilometres (millions) by Length of Haul 1995 – 2012

Table 5.5– Proportion of Vehicle Kilometres Travelled by Length of Haul

Proportion of Vehicle Kilometres Travelled by Length of Haul						
Year	Up to 10 km	10 - 25 km	25 - 50 km	50 - 150 km	150 - 500 km	500 km+
1995	36%	7%	10%	25%	16%	6%
1996	35%	6%	9%	28%	14%	7%
1997	34%	7%	9%	28%	15%	7%
1998	37%	8%	10%	26%	13%	6%
1999	38%	5%	7%	19%	23%	8%
2000	38%	5%	7%	18%	23%	9%
2001	38%	5%	7%	18%	22%	9%

Proportion of Vehicle Kilometres Travelled by Length of Haul						
Year	Up to 10 km	10 - 25 km	25 - 50 km	50 - 150 km	150 - 500 km	500 km+
2002	38%	5%	7%	17%	23%	10%
2003	38%	5%	7%	18%	23%	9%
2004	38%	5%	7%	17%	24%	9%
2005	38%	5%	7%	18%	24%	8%
2006	40%	5%	8%	17%	24%	7%
2007	38%	5%	8%	18%	23%	8%
2008	36%	5%	7%	17%	27%	9%
2009	36%	3%	6%	18%	27%	9%
2010	35%	3%	5%	19%	29%	8%
2011	35%	3%	5%	19%	30%	8%
2012	34%	3%	5%	19%	30%	8%

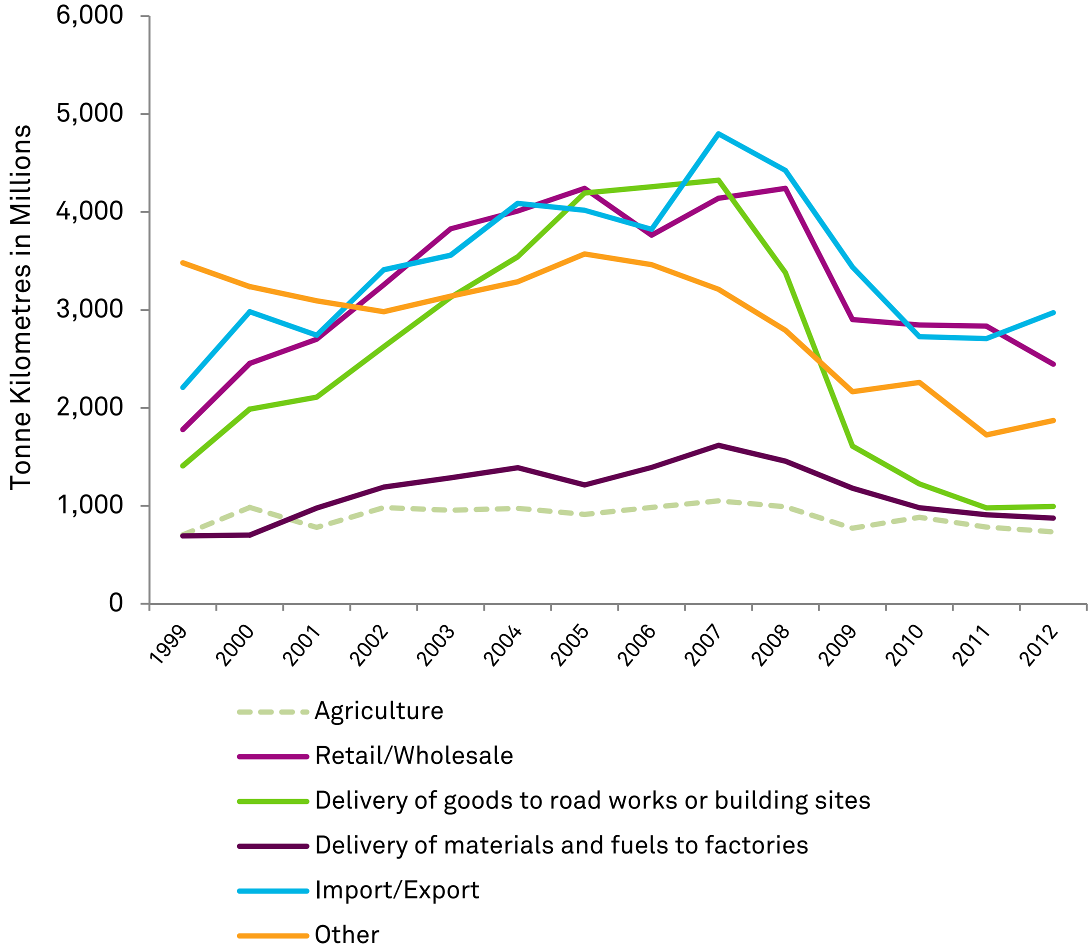

Figure 5.5 – Vehicle Tonne kilometres (millions) by Type of Work 1999 – 2012

Table 5.6 shows the recent trend in total vehicle kilometres travelled by length of haul. The peaks occur in 2005 and 2007. Vehicle kilometres in all categories are lower in 2012 than they were in 2001 and in most cases are more than 50% below the peak. Total vehicle kilometres travelled in 2012 was lower than it had been since 1997.

Table 5.6– Vehicle Kilometres Travelled by Length of Haul

Vehicle Kilometres (in millions) by Length of Haul							
Year	Up to 10 km	10 - 25 km	25 - 50 km	50 - 150 km	150 - 500 km	500 km+	Total
1995	354	65	97	243	154	61	974
1996	411	65	109	334	169	87	1,175
1997	416	86	110	339	176	82	1,209
1998	497	108	138	350	170	80	1,343
1999	552	71	101	281	333	113	1,451
2000	622	81	114	306	377	156	1,656
2001	642	84	116	296	373	158	1,669
2002	756	97	133	339	451	196	1,972
2003	808	107	148	373	493	195	2,124
2004	895	108	173	405	552	209	2,342
2005	983	127	172	455	618	210	2,565
2006	998	123	190	437	597	178	2,523
2007	1,022	126	201	473	618	222	2,662
2008	793	102	146	381	591	194	2,207
2009	563	55	96	288	431	145	1,578
2010	514	47	75	281	428	113	1,458
2011	466	40	72	258	398	103	1,337
2012	453	40	70	249	401	104	1,317

5.5 Forecasting Goods Vehicle Fleet Size

5.5.1 Overview

Good vehicle kilometres of travel are a function of both goods vehicle numbers and the average annual distance travelled. As has been seen, there is a sufficiently long time series of vehicle numbers with which to develop a forecasting model for the numbers in the fleet. However, this is not the case for average annual kilometres, for which a short times series only is available. The approach taken was to develop forecasts of goods vehicle numbers.

As has been demonstrated, while vehicle numbers have grown over time, the composition of the fleet has also been subject to change. This means, for example, that economic growth may not be fully reflected in the number of vehicles, if there is a strong trend towards heavier vehicles with larger carrying capacities. This further suggests that there is likely to be a closer and more precise relationship between economic growth and the total carrying capacity of the fleet.

In light of these observations, the carrying capacity of the goods vehicle fleet was forecast and this was combined with the future size distribution of the fleet to estimate vehicle numbers.

There are no published data on the carrying capacity of the goods vehicle fleet. Accordingly, an estimate was made on the following basis:

- For any given year, the number of goods vehicles in each unladen weight class was identified;
- Using data from manufacturers' vehicle specifications, the typical carrying capacity of vehicle at each unladen weight class was established;
- The typical carrying capacity at each unladen weight class was multiplied by the numbers of vehicles in that class and aggregated.

Figure 5.7 depicts the estimated trend in carrying capacity of the total goods vehicle fleet for the period 1983 to 2012.

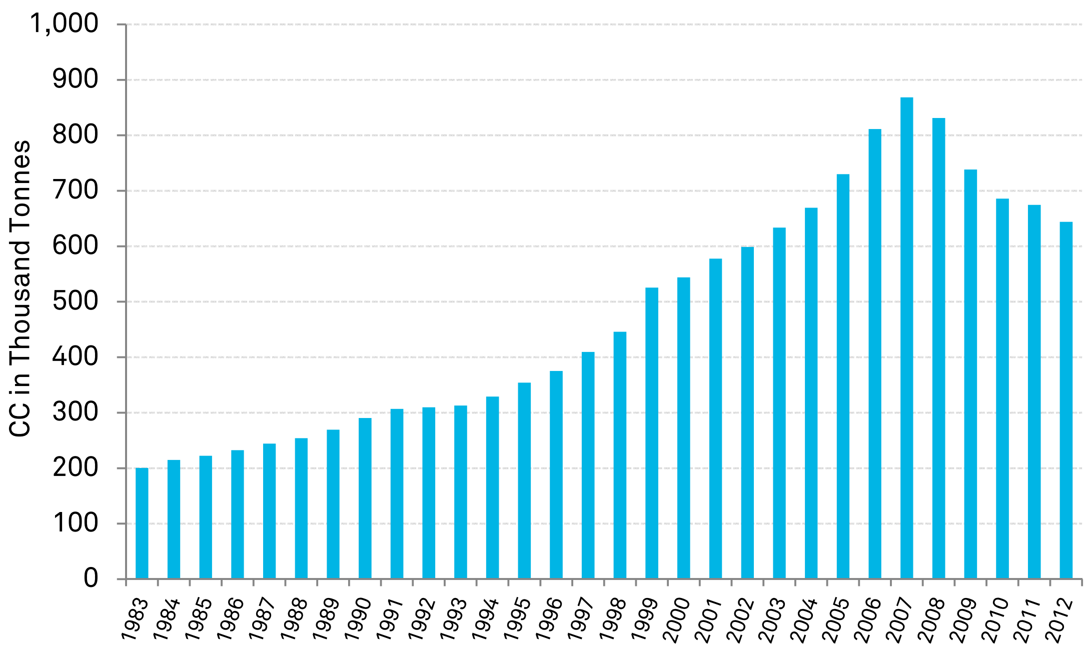

Figure 5.7– Total Carrying Capacity of Goods Fleet 1983 - 2012

The carrying capacity of the fleet (CC) increased steadily before peaking in 2007 and has declined 26%, from 868,000 tonnes in 2007 to 644,000 tonnes in 2012. The fall in carrying capacity has been more extreme than the fall in the number of vehicles, due to the changing composition of the fleet. Light goods vehicles (less than 2 tonnes ULW) accounted for only 11% of the lost CC during that period (despite comprising 74% of the decline in number of vehicles). Conversely, the heavier goods vehicles (those of 10 tonnes ULW or more) made up only 14% of the vehicles lost but represented 66% of the decline in total CC.

A similar pattern is seen in the change in the CC of the HGV fleet. However the HGV fleet CC has declined 31% to 454,000 tonnes since the peak of 662,000 tonnes in 2007 (compared to the 26% decline in the total fleet CC). 70% of the 207,848 tonnes of carrying capacity which were lost in the decline between 2007 and 2012 was the result of the reduction in the number of vehicles of ULW between 10 and 15 tonnes

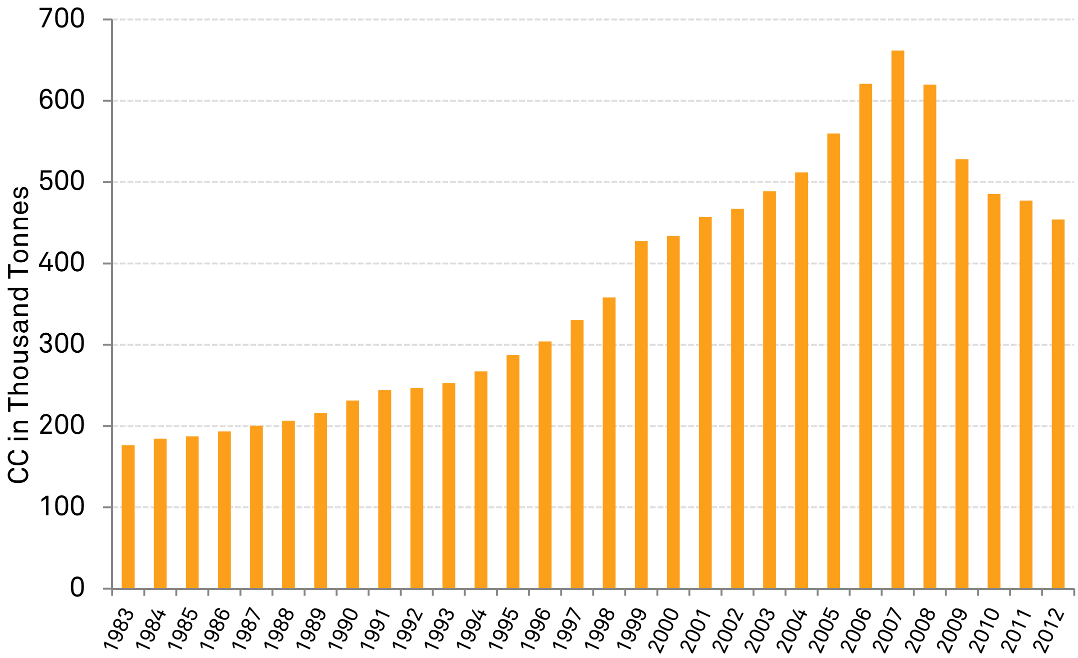

Figure 5.8– Total Carrying Capacity of Heavy Goods Fleet 1983 – 2012

5.6 Forecasting the Carrying Capacity of the Fleet

5.6.1 Introduction

As indicated above, the first step in the process was to develop a relationship between carrying capacity and economic growth. To do this, econometric relationships were developed between carrying capacity and a number of economic aggregates.

5.6.2 Carrying Capacity and Economic Growth Measures

In general terms, there is a strong correlation between the carrying capacity (CC) of the goods vehicle (GV) fleet and GDP. The crude elasticity of CC to GDP is a little above unity at 1.1. This remains broadly true for the periods 1983-1993 and 1993-2008. As shown in Figure 15.4, changes in CC have been very much in line with changes in GDP since 1983. More recently, changes in CC have been more dramatic than in the wider economy.

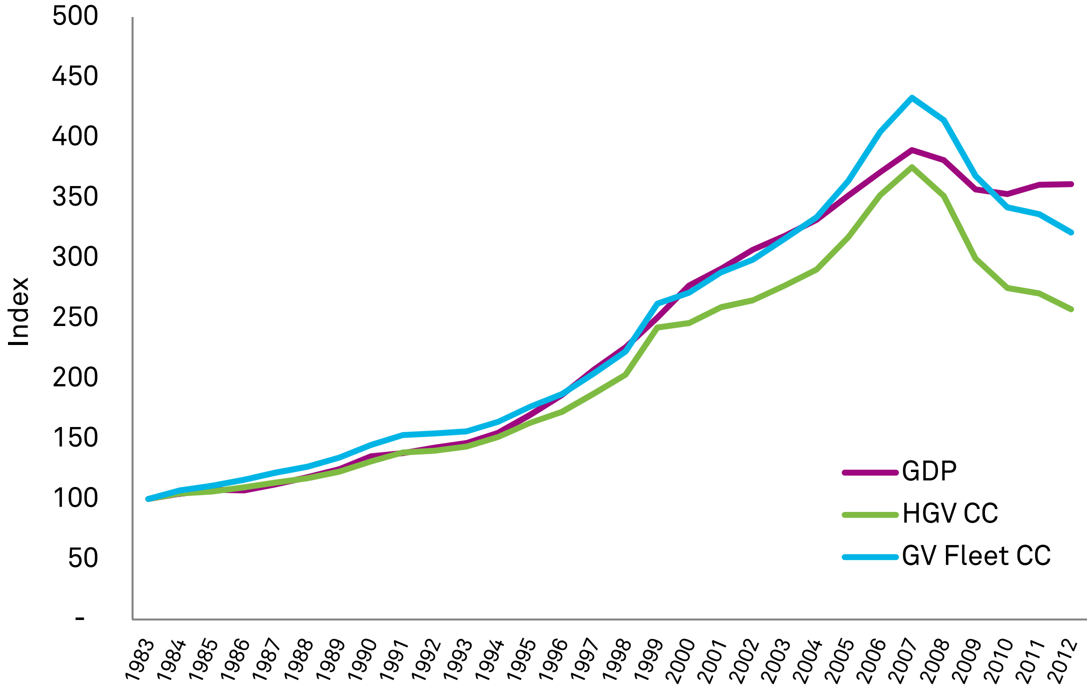

Figure 5.8– Total Carrying Capacity versus GDP Index: 1983 – 2012

It is often held that the growth of the services sector will mean that changes in GDP will have less of an impact on goods transport demand than heretofore. There is no evidence of this to date in the Irish data. Econometric testing undertaken for this study demonstrated that economic aggregates that exclude service sector activities do not provide better modelling outcomes.

Some possible explanations for the absence of a decline in the goods transport intensity of GDP include:

- Manufacturing sector continues to have a strong presence in the Irish economy;
- Much of manufacturing activity derives from multinational companies with a high import and export activity, which is transport intensive;
- Some service sub-sectors are relatively freight intensive; and;
- The small role played by rail freight in the Irish context.

Other economic aggregates that have been used previously included the additional impact of imports; this was not shown to be of benefit to the model in this case. The likely reason for this is the changing composition of imports; imports are now comprised of significantly more services than goods imports. This is a relatively new development as illustrated in Figure 5.9.

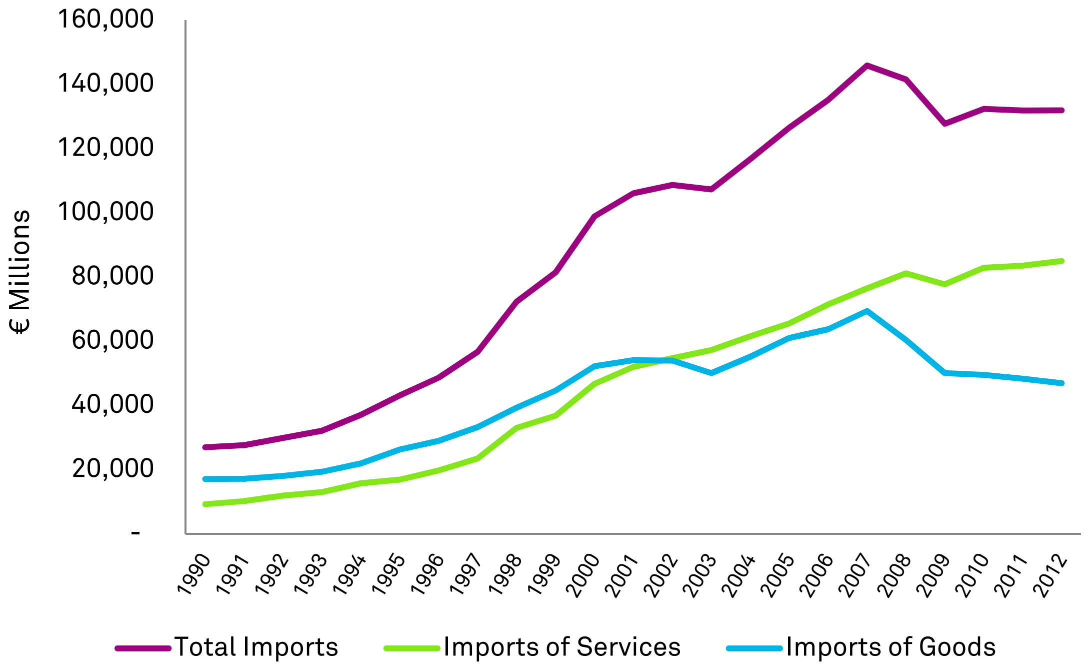

Figure 5.9 – Imports 1990 – 2012

However, the question remains as to whether a historic relationship between GDP and vehicle numbers is likely to be replicated in the future. Data from UK indicates that the once close relationship between GDP and transport activity decupled in the post 2000 period.

Further research is needed in this area, most notably in defining and measuring suitable economic aggregates. However, the recommended approach for the moment is to utilise a model based on GDP.

5.6.3 Econometric Models of Carrying Capacity and Economic Activity

The relationship between Carrying Capacity (CC) and economic activity was estimated using a log-linear model. Both the independent and dependent variables are converted to natural logs; this allows the coefficient on the dependent variable to be interpreted directly as an elasticity.

The models of CC and economic activity are as follows:

$$\ln Y = 2.02 + 0.96 \ln X \qquad (1)$$
$$\text{Adjusted } R^2 = 98.9\%$$

Where
Y = the Carrying Capacity of the GV fleet
X = GDP

Model (1) above indicates that CC is expected to increase at a rate of 0.96 times the increase in GDP. That is, the relationship between the growth rates of GDP and CC was near one to one in the period 1983 – 2012.

As discussed above the effect of imports on GV activity has been addressed in previous studies. Model (2) below identifies the relationship between CC and GDP plus imports. The elasticity in this case is 0.78, i.e. CC is expected to increase at a rate of 0.78 times the increase in GDP plus imports.

$$\ln Y = 3.62 + 0.78 \ln X \qquad (2)$$
$$\text{Adjusted } R^2 = 98.6\%$$

Where
Y = the Carrying Capacity of the GV fleet
X = GDP + Imports

Feeney (1985)[33] estimated that the relationship between total goods vehicle CC and economic activity (GDP plus imports) for the period 1960 to 1980 was 1.25, i.e. growth in CC had been 1.25 times the percentage increase in economic activity. Goodbody Economic Consultants (1998)[34] estimated a value of 1.14 for the period 1970 to 1985 and a much lower 0.58 for the period 1985 to 1996; however that analysis used a measure of economic activity that excluded the services sector. A similar exercise (using GDP plus imports as the explanatory variable) undertaken with the present dataset finds an elasticity of 0.82 for the period 1983 to 1996, while truncating the dataset to include only the period 1996 to 2012 yields an elasticity of 0.88. The broader measure of economic activity, i.e. GDP inclusive of the services sector, exhibits much more stability in the relationship with the fleet CC over time.

Following on from the analysis in the previous section; imports of goods are deemed to be a better predictor of the future demand for GVs than overall imports. An econometric analysis of GDP plus goods imported was also undertaken. The inclusion of goods imports increases the elasticity to 0.88 (from 0.78 for GDP plus total imports). However, as the data series of goods imported is only available to 1990, this elasticity represents the years 1990 – 2012.

$$\ln Y = 2.51 + 0.88 \ln X \qquad (3)$$
$$\text{Adjusted } R^2 = 97.5\%$$

Where
Y = the Carrying Capacity of the GV fleet
X = GDP + Goods Imports

Comparing the models (1) to (3) it would appear that (1), with an adjusted R^2 of 98.9%, has greatest explanatory power. However the differences in effectiveness between the three models are very small. There are readily available and reliable forecasts of

[33] Forecasts of Goods Vehicle Numbers, An Foras Forbatha, B.P. Feeney, Mar 1985
[34] Revised Forecast of Size and Structure of Commercial Vehicle Fleet 1996 – 2011, Goodbody Economic Consultants, Sept 1998

GDP for the forecast period; this fact, combined with the greater explanatory power of model (1) indicated that model (1) would be the most useful in this context. Thus, the elasticity of 0.96 was used to forecast the change in the HGV fleet. The forecast methodology is set out in the following section.

5.6.4 HGV Fleet Forecast

Two approaches to forecasting the HGV Fleet present themselves:

- Forecast based on an assumption that the size distribution of the fleet and that average VKT per unladen weight class will remain the same; or
- Forecast the future size distribution of vehicles and the future average VKT per unladen weight class.

At present, there is a lack of data with which to understand the forces driving both the size distribution and the average VKT per unladen weight class. Because of this, the former approach was taken. Further research into the second method may pay dividends if further data becomes available.

Thus it is assumed that there will be no change to the composition of the fleet and no change to average kilometres travelled. The change in VKT will therefore be driven by increases in the number of vehicles in the fleet, rather than by changes in the composition or utilisation of the fleet.

The most tractable approach to forecasting vehicle numbers is on the basis of GDP, which is a readily available economic aggregate. Econometric tests have shown that this variable performs as well as other more complex economic aggregates. The preferred approach to forecasting is to first forecast carrying capacity, and then to derive vehicle numbers using an assumed size distribution. For the purposes of the forecast, it is assumed that the fleet composition will remain constant as at 2012. This approach is theoretically no different to predicting the number of vehicles directly. The advantage of first forecasting CC and then converting to a forecast of the number of vehicles is that it affords the opportunity to estimate forecast scenarios reflecting changes in the composition of the fleet if necessary.

The relationship between GDP and the CC is expected to continue as it did between 1983 and 2012, i.e. a 0.96% change in fleet size is expected for each per cent change in GDP. This relationship was derived using model (1) set out in Section 5.6.3. CC is then projected forward to 2030 and 2050 based on the GDP forecast. The total forecast CC is then shared amongst the ULW categories of vehicle, assuming no change to the composition of the fleet.

GDP is forecast to increase between 47% and 53% by 2030 and between 87% and 115% by 2050. A summary table of the expected change in economic activity is given below. Three economic scenarios are presented. These scenarios correspond to the three economic scenarios developed from the ESRI Medium Term Review and Population forecasts, as described in Sections 3.4.2, 3.4.3 and 3.4.4.

The corresponding changes in the CC of the goods vehicle fleet are also set out. CC is expected to increase by between 45% and 50% by 2030 and by between 82% and 108% by 2050.

Table 5.7– Forecast % Change in GDP and CC

Cumulative % Change in GDP			
Year	High	Central	Low
2030	53%	52%	47%
2050	115%	106%	87%
Cumulative % Change in CC			
Year	High	Central	Low
2030	50%	49%	45%
2050	108%	100%	82%

The tables below show the cumulative per cent change in the size of the fleet by the forecast years 2030 and 2050.

Table 5.8– Forecast % Change and Size of HGV Fleet

Cumulative % Change in HGV Fleet Size			
Year	High	Central	Low
2030	50%	49%	45%
2050	108%	100%	82%
Projected HGV Fleet Size			
Year	High	Central	Low
2030	114,659	114,011	110,704
2050	158,637	152,813	139,004

Table 5.9 provides a breakdown of the forecast number of HGVs by ULW category.

Table 5.9– Forecast Number of Vehicles by Unladen Weight Category

Forecast Number of Vehicles by ULW Category (thousands)				
Tonnes	Year	High	Central	Low
2 – 5.1	2030	82.4	82.0	79.6
	2050	114.0	109.8	99.9

5.1 – 10.1	2030	13.3	13.2	12.8
	2050	18.4	17.7	16.1
10.1 – 15.2	2030	16.5	16.4	15.9
	2050	22.8	22.0	20.0
15.2 +	2030	2.5	2.5	2.4
	2050	3.4	3.3	3.0

The fleet is forecast to increase between 45% and 50% by 2030 and by between 82% and 108% by 2050. Growth in the HGV fleet, in all three scenarios, is projected to be lower than the growth experienced to date. The HGV fleet increased some 230% from 23,085 vehicles in 1983 to 76,406 in 2012, an average of 4% per annum. The growth forecast in the future is in the region of 1.6% to 2% per annum depending on the scenario. Slower growth in HGVs is to be expected in the long-run for several reasons:

- Growth in the economy is not expected not accelerate in the way that it has since the 1980s;
- There are limits to the volume of HGV traffic that would be tolerated in practice, particularly in light of environmental concerns; and
- Improvements in the infrastructure used by HGVs would allow a more specialised approach to freight. Such improvements are to be expected with greater use of distribution centres and growth in the use of ICT in the freight sector.

The following chart illustrates the historical and forecast changes in the HGV fleet. Figure 5.10 represents an index of the three scenario forecasts for the HGV fleet from 1983 to 2050. It is expected that the HGV fleet will return to growth and continue to grow to 2050 in line with the forecast recovery from the current economic environment.

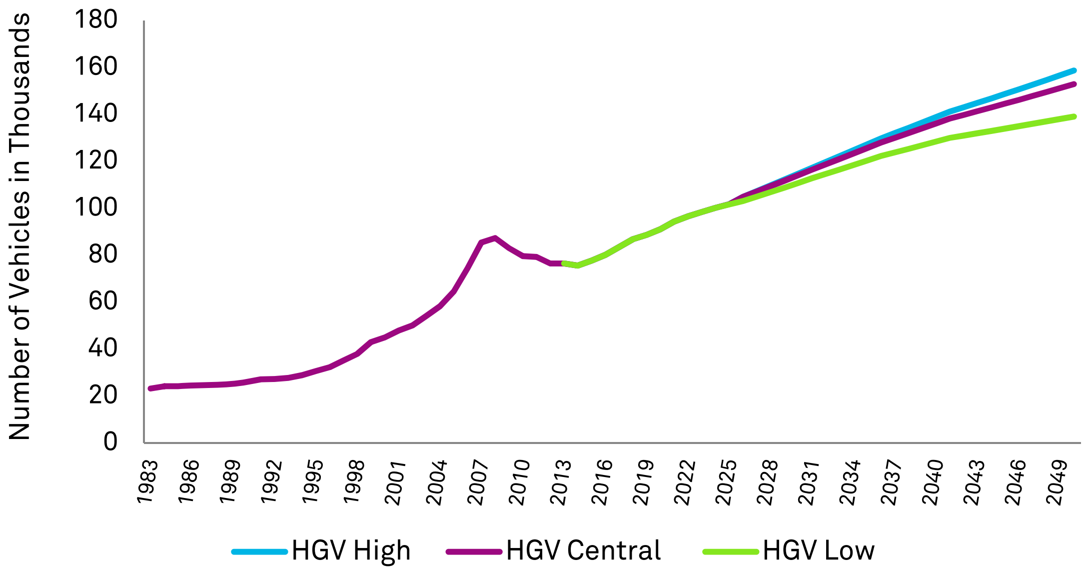

Figure 5.10– HGV Fleet 1983 - 2050

Table 5.10 presents the forecast number of vehicles in the HGV fleet from 2013 to 2050 – the lowest point for all three scenarios being 2014, at 75,000 vehicles.

Table 5.10– HGV Fleet 2013 - 2030

HGV: Forecast Number of Vehicles (thousands)			
Year	High	Central	Low
2013	76	76	76
2014	75	75	75
2015	78	78	78
2016	80	80	80
2017	83	83	83
2018	87	87	87
2019	89	89	89
2020	91	91	91
2021	94	94	94
2022	96	96	96
2023	98	98	98
2024	100	100	100
2025	102	102	102
2026	105	105	103
2027	107	107	105
2028	110	109	107
2029	112	112	109
2030	115	114	111
2031	117	116	113
2032	120	119	115
2033	122	121	116
2034	125	123	118
2035	127	126	120
2036	130	128	122
2037	132	130	124
2038	134	132	125
2039	136	134	127
2040	139	136	128

HGV: Forecast Number of Vehicles (thousands)			
Year	High	Central	Low
2041	141	138	130
2042	143	140	131
2043	145	141	132
2044	147	143	133
2045	149	144	134
2046	151	146	135
2047	153	148	136
2048	155	149	137
2049	157	151	138
2050	159	153	139

5.7 Alternative Vehicle Numbers Forecast

The forecasting method developed in this Report may be used to develop alternative scenarios for future GV and HGV numbers

If the current trend towards both heavier and smaller vehicles were to continue, i.e. if these categories of vehicle were to grow at a faster rate than other categories in the coming years, a different fleet composition would be expected by 2030 and 2050. The following tables set out the composition of the fleet that would be expected by 2030 and 2050 and growth rates that were assumed in each category of vehicle in order to make this prediction.

The forecast average annual per cent changes are lower in the 5 to 15 tonne categories than in larger and smaller goods vehicles. However, the differentials in the growth rates chosen for this exercise were less extreme than they had been in the past. For example, vehicles of ULW of 15.2 tonnes or more experienced average annual growth of 13% from 2013 to 2050. A forecast reflecting continued growth at this rate was deemed to be unrealistic. Instead an annual per cent increase of 5% was used.

Table 5.11– % Change in Number of Vehicles by Weight Category

% Change in Number of Vehicles by Weight Category					
Average Annual % Change	**LGV**	**2-5.1**	**5.1-10.1**	**10.1-15.2**	**15.2+**
1983 – 2012	6%	6%	0%	5%	13%
1992 – 2012	3%	9%	-1%	3%	13%
Forecast 2013 - 2050	2%	3%	1%	1%	5%
Composition of Fleet					

Composition	LGV	2-5.1	5.1-10.1	10.1-15.2	15.2+
2012	75%	18%	3%	4%	1%
Forecast 2030	73%	21%	2%	3%	1%
Forecast 2050	70%	24%	2%	2%	2%

The forecast change in the CC for the fleet is necessarily the same in both approaches. The resulting change in the number of vehicles, however, is quite different. The following table compares the forecast cumulative per cent growth rates and number of vehicles predicted. By 2030, the low forecast percentage change in the size of the fleet using the alternative approach is higher, at 59%, than the high scenario in the preferred approach of 50%. For 2050, the alternative low scenario is almost identical to the preferred central outcome.

Table 5.12– Preferred versus Alternative Approach

Cumulative % Change in HGV Fleet Size						
Year	Preferred Approach			Alternative Approach		
	High	Central	Low	High	Central	Low
2030	50%	49%	45%	65%	64%	59%
2050	108%	100%	82%	128%	120%	100%
Projected HGV Fleet Size						
Year	Preferred Approach			Alternative Approach		
	High	Central	Low	High	Central	Low
2030	114,659	114,011	110,704	126,054	125,342	121,706
2050	158,637	152,813	139,004	174,403	168,000	152,818

5.8 Conclusions

Since the 1980s, strong growth in the GV fleet has reflected increases in real GDP. More recently, the challenges in the economic environment have been coupled with a decline in the fleet. A forecast of the size of the fleet can therefore be estimated by quantifying the extent to which the GV fleet moves in line with GDP. That is, the elasticity of the fleet to GDP can be combined with economic forecasts to forecast changes in the fleet.

While goods vehicle numbers have grown over time, the composition of the fleet has also been subject to change. This suggests that there is likely to be a closer relationship between economic growth and the total carrying capacity (CC) of the fleet. Therefore a forecast of the CC of the fleet was first estimated and this was then converted to a forecast of the number of vehicles.

An econometric analysis of the relationship between CC and economic activity was undertaken. Econometric testing showed that GDP, rather than other, more complex, economic aggregates would be most suitable for use in this analysis. An elasticity of

0.96 was found in the 1983-2012 data and this was used in the CC forecast. That is, for every per cent change in GDP, a 0.96% change was expected in the CC of the GV fleet. The model has excellent explanatory power, with an adjusted R^2 of 98.9%, reflecting the highly correlated relationship between the CC of the fleet and GDP. Nevertheless, it is possible that the relationship will not be as strong in the future and further research is needed to determine the best model for predicting CC.

The CC of the GV fleet was then forecast based the modelled elasticity and a readily available forecast of GDP. A forecast of the number of vehicles per ULW category was then derived from the CC forecast. There is limited data with which to understand the forces driving the size distribution in the HGV fleet available. Therefore, for the purposes of converting the CC forecast to a forecast of the number of vehicles, it was assumed that there would be no change to the composition of the fleet. Thus each ULW category of vehicle was deemed to hold the same proportion of the total CC in 2030 and 2050 as in 2011. In addition, the average tonnes of CC for each ULW category were assumed to remain unchanged. The resulting forecasts of fleet size are as follows.

Depending on the forecast scenario, the size of the fleet is forecast to increase between 45% and 50% by 2030 and by between 82% and 108% by 2050. Growth in the HGV fleet, in all three scenarios, is projected to be lower than the growth experienced to date. The HGV fleet increased some 230% from 23,085 vehicles in 1983 to 76,406 in 2012, an average of 4% growth per annum. The growth forecast in the future is in the region of 1.6% to 2% per annum depending on the scenario. An alternative scenario, in which the current trends in the changing composition of the fleet continue, finds more dramatic changes in the number of HGVs by 2030 (increasing 59%, 64% and 65% in the low, central and high scenarios respectively) and 2050 (increasing 100%, 120% and 128% in the low, central and high scenarios respectively).

There is relatively little data available on the drivers of average kilometres travelled. Therefore this was also assumed to remain constant over time. Thus the change in total vehicle kilometres travelled will be driven by increases in the number of vehicles in the fleet, rather than by changes in the composition or utilisation of the fleet. Since no change in the composition of the fleet and no change in AVKT have been assumed, the forecast percentage changes in the number of vehicles are equivalent to the forecast percentage changes in total kilometres travelled.

5.9 Key Results

The key results of the car ownership assessment are provided below.

- The central forecast estimates that the number of HGVs will increase by 49% by 2030 and by 100% by 2050.
- The high sensitivity forecast estimates that the number of HGVs will increase by 50% by 2030 and by 108% by 2050.
- The low sensitivity forecast estimates that the number of HGVs will increase by 45% by 2030 and by 82% by 2050.

Conclusions

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6.0 Conclusion

6.1 Overview

A series of models have been developed to forecast demographic growth, car ownership and HGV fleet size for two forecast years, 2030 and 2050. The demographic and car ownership models provide forecast data at NTpM zone level, while HGV forecasts are provided at a national level.

This forecast data has been used to inform the development of forecast travel demand matrices for the NTpM across various modes of travel and trip purposes.

6.2 Summary of National Forecasts

A summary of the 2011 and forecast 2030 and 2050 national level projections are provided in Tables 6.1 and 6.2. The following projections are presented:

- Population;
- Jobs;
- Number of Cars; and
- HGV Fleet Size.

Table 6.1 – 2030 National Projections

Growth	Population		Jobs		No. of Cars		HGV Fleet	
	Total	Growth	Total	Growth	Total	Growth	Total	Growth
2011	4.59m	-	1.83m	-	1.89m	-	0.076m	-
Low	4.87m	6%	2.06m	13%	2.42m	28%	0.110m	45%
Central	5.07m	10%	2.18m	19%	2.56m	35%	0.114m	49%
High	5.14m	12%	2.20m	20%	2.58m	37%	0.115m	50%

Table 6.2 – 2050 National Projections

Growth	Population		Jobs		No. of Cars		HGV Fleet	
	Total	Growth	Total	Growth	Total	Growth	Total	Growth
2011	4.59m	-	1.83m	-	1.89m	-	0.076m	-
Low	4.94m	8%	1.94m	6%	2.76m	46%	0.139m	82%
Central	5.42m	18%	2.17m	19%	3.07m	62%	0.152m	100%
High	5.62m	22%	2.30m	26%	3.19m	69%	0.158m	108%

Appendix A

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Appendix A – Car Ownership Forecasts

Panel data used in setting county saturation levels

A dataset was assembled for the years 2006 and 2011 using Census and other data. For each county and both years, the data included were as follows:

- Car ownership: This is based on the number of registered cars as per the Bulletin of Vehicle Statistics published annually by the Department of Tourism, Transport and Sport and the number of adults in the county based on the Census
- Income: Total income per person in Euro as published by the CSO. The value for 2011 was estimated using national data since the latest available data was 2010.
- Population Density: Number of persons per 1,000 metres squared of land. Area data was provided by Ordnance Survey Ireland. The areas used are exclusive of water bodies such as large rivers, lakes, estuaries, ponds and reservoirs. Population is as per the Census.
- Urbanisation: As defined and published by the CSO. The number of people in urban areas (i.e. towns with a population of 1,500 or more). Source: CSO, Census 2011, 2006
- True Urbanisation: Defined as the percentage of the county's population living in towns with a population exceeding 10,000. Source: CSO, Census 2011, 2006
- Percent of households with children. Source: Census 2011, 2006
- Percent population aged 65 or older. Source: Census 2011, 2006
- Percent of population using public transport. Source: Census 2011, 2006

ED to NTpM Zone translations

In the cases of Wexford, Carlow, Dundalk and Drogheda towns, the estimates of car ownership are grouped to the level of the town rather than ED. The reason for, is that the population projections per ED are based on the ED borders defined as at the 1991 Census but the data on the number of cars per ED that corresponded directly to those 1991 borders was not available for 2011. In most cases, the borders are unchanged (from 1991 to 2011) and this posed no difficulty. However, due to alterations in the ED composition of Wexford, Carlow, Dundalk and Drogheda towns, it was necessary to aggregate the data to the level of the town as per Table 5.1 below.

For example, Wexford consisted only of E14004 in 1991 but was split into three EDs by 2011. The population *projections* available correspond to the 1991 borders. In contrast, the data on the number of cars and population in 2011 were split into the three EDs. Thus, these were summed to create one estimate of car ownership for Wexford in 2011. This was then inflated using the Co. Wexford percentage change over time and could be converted to an estimated number of cars using the population projection for E14004.

In these cases, the 2011 population of the entire group (e.g. Carlow) and the 2011 total number of cars for the entire group (e.g. Carlow) are combined to get an overall 2011 level of car ownership. This is inflated in the same way as the ED level car ownership using the change in the county projections to give group car ownership projections to 2050. This was then converted to the number of cars using the projected populations for the entire group. The entire group aggregated to get the population projections would be the set of (1991) EDs that corresponds spatially to the (2011) EDs listed below.

As zones are simply groups of EDs, zone level projections are derived from aggregates of the ED level information.

Amalgamated Electoral District Groups

CSO ED	ED NAME	Car Ownership Dataset
10001	Fair Gate	Drogheda
10002	St. Laurence Gate	Drogheda
10003	West Gate	Drogheda
10041	St. Peter's	Drogheda
10047	St. Mary's	Drogheda
10004	Dundalk Urban No. 1	Dundalk
10005	Dundalk Urban No. 2	Dundalk
10006	Dundalk Urban No. 3	Dundalk
10007	Dundalk Urban No. 4	Dundalk
10023	Castletown	Dundalk
10027	Dundalk Rural	Dundalk
10030	Haggardstown	Dundalk
E14004	Wexford No. 1 Urban	E14004
E14005	Wexford No. 2 Urban	E14004
E14006	Wexford No. 3 Urban	E14004
E01001	Carlow Urban	Carlow
E01019	Carlow Rural	Carlow