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Transport Infrastructure Ireland

AECOM

NATIONAL TRANSPORT MODEL UPDATE
TRAVEL DEMAND FORECASTING REPORT

NTpM Volume 3
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1 Introduction

1.1 Overview

The National Transport Model is an all-Ireland strategic multi-modal transport model that can be used to assess and evaluate the impact of transport infrastructure, policy, demand management initiatives and strategic development plans at a local, regional and national level.

The NTpM is maintained by the Strategic and Transport Planning (STP) section of Transport Infrastructure Ireland (TII) and incorporates separate models for car traffic, freight, national rail and inter-urban bus, along with an innovative transport behaviour model which allows future transport and environmental impacts to be quantified.

A full update of the NTpM is undertaken every five years following the publication of the results of the Central Statistics Office (CSO) Census of Ireland. The latest Census of Ireland was undertaken in April 2016.

1.2 Structure of NTpM Documentation

In order to provide all the relevant detail of the National Transport Model (NTpM) in a clear and concise manner the documentation for the NTpM update 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 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 – Travel Demand 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.

This report which is referred to as the Travel Demand Forecasting Report, forms Volume 3 of the NTpM Update suite of supporting documentation. The report provides background details on the data, data sources and methodologies used to inform the development of the future year travel demand projections for the NTpM.

1.3 Model Structure

The NTpM is made up of several sub-models, each having its own unique inputs and structure:

- Demographic models are developed to estimate future year population, employment and jobs projections for each zone in the NTpM;
- Car Ownership models forecast future year car ownership and car numbers for each zone in the NTpM based on the future year demographic and economic projections;
- A Freight model is used to estimate the increase in freight demand at a national level and then to allocate this growth to zones in the NTpM with specific freight related activity;

- The Trip Attraction Generation Model (TAGM) takes the outputs of the Demographic, Car Ownership and Freight models and converts them into origin and destination zone trip ends for each mode of transport;
- A Trip Distribution Model (TDM) is used to distribute the origin and destination trip ends totals between the various zones in the model. The TDM outputs demand matrices which present the origin and destination demand (by mode) between each zone in the NTpM;
- Assignment models (Traffic, Rail & Bus) are used to assign the demand for travel represented by the demand matrices to the transport network, generating travel costs (e.g. time, distance, tolls, fares) for each mode; and
- 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).

This structure of the model is shown in the diagram in Figure 1.1.

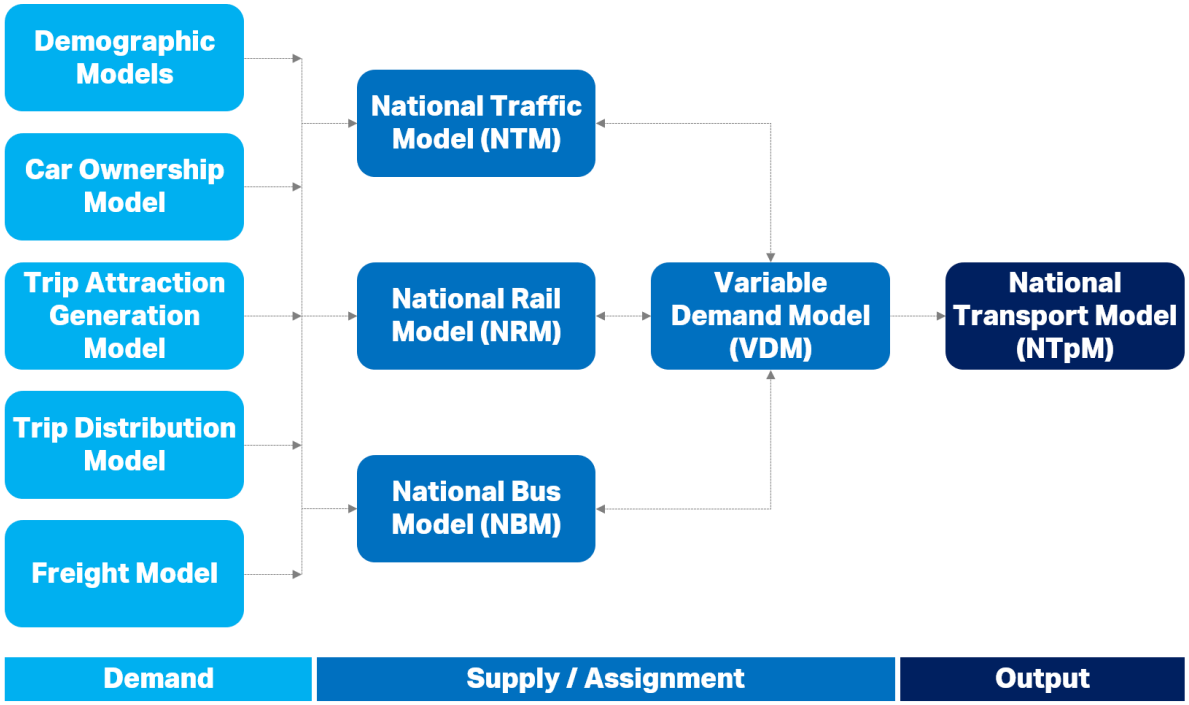

Figure 1.1 NTpM Basic Structure

1.4 Overview of Approach to Forecasting

The demand for inter-urban transport varies according to a range of different demographic and economic 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 range of demographic and economic inputs that, when incorporated into the TII TAGM, will ultimately give rise to projections of future vehicle and

passenger demand. Figure 1.2 gives a simple illustration of how the various demographic and economic forecasts work together.

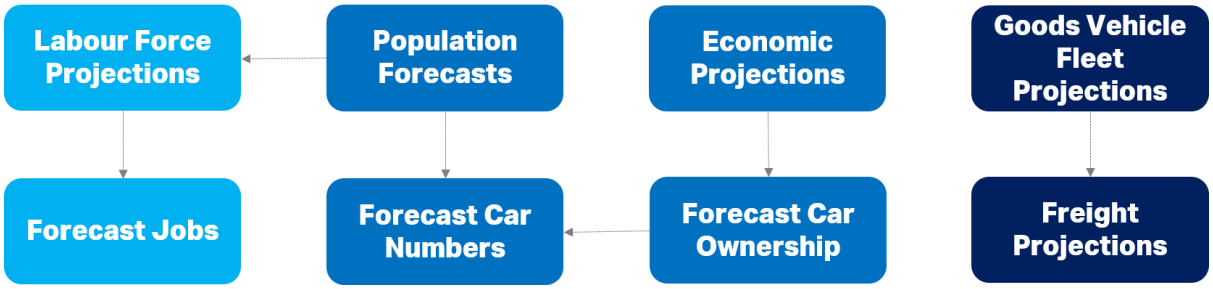

Figure 1.2 Demographic and Economic Inputs

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.

2 Population and Job Projections

2.1 Overview

This section of the report provides details on the future year spatial demographic (population & jobs) projections which underpin the travel demand projections in the updated NTpM. As part of NTpM update future year projections have been developed for three future years (2030, 2040 and 2050) and for each future year three growth scenarios have also been developed namely:

- TII Central Growth (which is the core NTpM scenario);
- TII High Growth Sensitivity; and
- TII Low Growth Sensitivity.

2.2 Background

As part of the previous update of the NTpM, a consistent linked set of population, jobs and employment projections were developed based on the Economic and Social Research Institute (ESRI) Medium-Term Review[1]. A new methodology which utilised both a top-down and bottom up approach to the overall level of growth and distribution of population, jobs and employment across the country was developed by Dr. Edgar Morgenroth of the ESRI.

Future year (2030 and 2050) population and jobs models were developed by Dr. Edgar Morgenroth and three future scenarios were developed, namely a Central growth scenario and High/Low sensitivity scenarios. The spatial distribution of future growth followed recent patterns with an emphasis of growth in the east of the country and around larger urban centres.

Since the previous version of the NTpM, the Government has published the National Planning Framework (NPF)[2]. As part of the current update of the NTpM, future year models (2030, 2040 and 2050) have been developed to provide consistency with the spatial demographic projections of the NPF.

An objective of the NPF is to move away from the 'Current Trends' scenario by supporting and investing in other regions of the country and to grow and develop the other cities of Ireland (Cork, Limerick, Galway and Waterford) so that they can provide a counter-balance to Dublin.

This is step change in the planning of Ireland's future and the NTpM has been updated by TII to reflect this. Providing consistency between the NTpM and NPF in terms of the overall projected growth and distribution of population and jobs, allows for the assessment and consistent appraisal of National Roads projects throughout Ireland against the key National Strategic Outcomes (NSOs) set out in the NPF.

2.3 Overview of National Planning Framework Projections

In January 2018, the ESRI published a report titled 'Prospects for Irish Regions and Counties – Scenarios and Implications'. The report, which was authored by Dr. Edgar Morgenroth, looked

[1] *J Fitzgerald and Ide Kearney, Economic and Social Research Institute, Medium-Term Review, 2013*
[2] *Project Ireland 2040 National Planning Framework (2018)*

at a range of alternative future spatial demographic and economic scenarios and was an important input for the production of the National Planning Framework.

The following sections provides a brief overview of the alternative scenarios considered by the ESRI and outlines how the demographic projections of the ESRI report have been used to inform the development of the NTpM future year travel demand projections. The full ESRI report is provided in Appendix A.

2.3.1 Alternative Future Spatial Scenarios

As part of the work undertaken by the ESRI in relation to the NPF, a number of alternative future spatial (demographic and economic development) scenarios were considered for 2040. These included a 'Current Trends' scenario which assumed a continuing trend of growth in the Dublin and Mid-East Regions. Additionally, five scenarios were developed to assess alternatives to the Current Trends (CT) scenario, these included:

1. Eastern and Midlands Region 68% (EMR=68%) - Where 68 per cent of the increase in population is accounted for by the East and Midland region, and where the population growth in the other regions is scaled down proportionately. Here the relatively sprawled pattern of population growth that is a feature of the CT scenario is maintained. This scenario would see the spatial development pattern dominated even more by Dublin than under the CT scenario;
2. 50:50 National Spatial Strategy (NSS) – A scenario where the population increase is roughly equally split between the East and Midland region and the rest of the country. This scenario would see some rebalancing of growth but would still let Dublin grow significantly;
3. 50:50 City – A scenario where growth is focused on the major cities within each region (termed 'City'). Here the migration patterns are altered so that counties with larger centres attract larger net inflows than under the CT scenario. This was not restricted to Cork, Limerick, Galway and Waterford but other counties with larger centres (e.g. Sligo) also received higher inflows. The increases for each county were roughly proportional to the size of their largest urban centre;
4. EMR <50% NSS - A scenario where the East and Midland region is assumed to account for less than 50 per cent of the absolute population increase over the period 2016 to 2040. Under this scenario the growth of Dublin is curtailed; and
5. EMR <50% City – EMR<50% but with growth focused on the major cities within each region.

Table 2.1 and Table 2.2 illustrate the regional distribution of population and jobs in 2040 respectively under each of the scenarios outlined above. The tables also provide the 2011 and 2016 population and jobs figures.

2.3.2 Selected ESRI Scenario for the NPF

In all scenarios, the total national population was held roughly constant in order to identify whether the changed patterns across regions were feasible. While the scenarios where absolute growth of the population was split roughly 50:50 between the Eastern and Midland regions and the rest of the country imply changes that are potentially achievable, the scenarios where less than 50 per cent of growth takes place in the Eastern and Midland region require very large changes that are unlikely to be feasible.

The analysis suggested that the '50:50' scenarios are feasible, which leaves a choice in terms of desirability between the 'NSS' and 'City' internal growth patterns. While arguments can be brought forward that would favour the more distributed 'NSS' pattern, the results of academic literature suggest that the city focused pattern is likely to yield more benefits over the long run, as this pattern would enhance the scale of the second tier cities, enabling them to benefit from agglomeration economies that smaller centres cannot gain. The '50:50 City' scenario was therefore selected for the purposes of the National Planning Framework.

Table 2.1 Population Projections Under Alternative Scenarios

Regions	2011	2016	Population ('000s)					
			CT	EMR=68% NSS	50:50 NSS	50:50 City	EMR<50% NSS	EMR<50% NSS
			2040					
Border	514.9	523.2	589.0	587.6	597.3	592.0	625.1	602.8
Midland	282.4	292.3	330.5	353.1	321.2	321.2	287.7	258.6
West	445.4	453.1	534.1	524.2	554.1	556.6	595.3	610.4
Dublin	1,273.1	1,347.4	1,639.8	1,667.9	1,592.1	1,596.3	1,485.0	1,481.2
Mid-East	531.1	560.0	707.5	732.8	685.7	685.7	609.4	597.8
Mid-West	379.3	385.0	449.4	429.9	464.2	475.3	514.2	548.7
South-East	497.6	510.3	585.4	562.4	601.4	560.9	659.3	613.8
South-West	664.5	690.6	799.2	777.2	822.1	851.8	870.0	931.3
State	**4,588.3**	**4,761.9**	**5,634.8**	**5,635.1**	**5638.1**	**5,639.8**	**5,646.1**	**5,644.6**
Northern and Western	837.4	847.4	961.6	944.5	993.7	990.8	1,076.0	1,082.4
Eastern and Midland	2209.5	2,328.5	2,839.2	2,921.1	2756.8	2,760.9	2,526.6	2,468.4
Southern	1541.4	1,585.9	1,833.9	1,769.5	1887.7	1,888.0	2,043.6	2,093.8

Source: Dr Edgar Morgenroth.

Table 2.2 Jobs Projections Under Alternative Scenarios

Regions	2011	2016	Jobs ('000s)					
			CT	EMR=68% NSS	50:50 NSS	50:50 City	EMR<50% NSS	EMR<50% NSS
			2040					
Border	178.6	196.0	238.4	237.9	239.3	238.8	250.0	242.3
Midland	99.3	109.4	135.4	143.3	133.6	132.4	121.1	110.5
West	170.1	182.2	241.7	237.7	243.3	247.8	261.1	266.7
Dublin	612.5	667.6	932.8	951.6	936.7	928.4	890.8	887.6
Mid-East	186.4	212.2	302.6	308.5	296.3	292.6	266.6	261.7
Mid-West	149.2	160.2	196.9	187.7	196.5	202.7	215.4	228.1
South-East	190.8	199.8	246.4	236.0	246.4	234.8	267.9	253.0
South-West	274.3	287.5	379.3	371.1	381.4	396.1	400.9	423.7
State	**1,861.2**	**2,015.0**	**2,673.7**	**2,673.7**	**2,673.7**	**2,673.7**	**2,673.7**	**2,673.7**
Northern and Western	310.6	332.9	420.7	412.2	422.2	426.4	455.2	457.6
Eastern and Midland	931.7	1,029.9	1,429.8	1,461.8	1,437.4	1,409.6	1,328.3	1,305.8
Southern	618.9	652.2	823.3	799.6	827.4	837.7	890.2	910.3

Source: Dr Edgar Morgenroth.

2.4 NTpM Projection Scenario

The ESRI '50:50 City' projection which underpins the spatial distribution of population and jobs under the National Planning Framework forms the core 2040 TII Central Growth scenario the NTpM. The following sections provides further detail on the NPF projections which were developed by the ESRI and how they were incorporated into to the NTpM.

2.4.1 Published National Planning Framework Population Projections

The NPF document under Section 2.3 Strategy Development states that the demographic and econometric model developed by the ESRI is a core element of the plan. In relation to the published NPF population projections it states that:

"To account for the possibility of higher net in-migration over the period to 2040 an allowance was made in the NPF to enable ambition and flexibility in planning for future growth. This means that the full achievement of the targets set out in this Framework would accommodate around 1.1 million additional people in Ireland in 2040, which is approximately 25% more than the ESRI baseline projections."

This section of the report analyses and compares the 2040 population projections as published in the NPF against the ESRI 50:50 City scenario population projections that have been used to inform the NTpM.

Table 2.3 shows the target population growth outlined in the published 2040 NPF against the ESRI projections at a regional assembly and state level. The ESRI 50:50 City scenario projections are 25% lower than the published NPF projections, with the Eastern and Midland Region having the highest absolute difference between projections of 108,000.

Table 2.3 National Planning Framework Population Projection

Region	2040 NPF		ESRI 50:50 City		%Diff (Abs diff)
	Pop Growth	% Share	Pop Growth	% Share	Pop Growth
Eastern and Midlands	540,000	49%	432,169	49%	25% (107,831)
Southern	380,000	35%	301,812	35%	26% (78,188)
Northern and Western	180,000	16%	143,295	16%	26% (36,705)
State	**1,100,000**	**100%**	**877,276**	**100%**	**25% (22,724)**

Table 2.4 compares the existing 2016 population for the state and each Regional Assembly against the published 2040 NPF projections and the ESRI 50:50 City projections.

As outlined previously the population projections provided by the ESRI (50:50 City Scenario) for use in the National Planning Framework were increased by the Department of Housing Planning and Local Government (DHPLG) by approximately 25% prior to the publication of the National Planning Framework. The overall population target in the NPF was increased prior to publication to *"To account for the possibility of higher net in-migration over the period to 2040 an allowance was made in the NPF to enable ambition and flexibility in planning for future growth.*

However no updated jobs projections in relation to the ESRI 50:50 City were developed by the DHPLG to account for the higher published NPF population targets. As such the population, jobs and employment projections developed by the ESRI (50:50 City Scenario) are used to inform future travel demand in NTpM as they provide a complete and consistent set of demographic projections.

The High Growth Sensitivity scenario of the NTpM accounts for a population growth of up to 6.12m (see Section 2.6), which is in excess of the published NPF population projection (5.87m) and would therefore allow for the assessment of the impact of the published NPF population projections.

Table 2.4 Population Total (2016 & 2040)

Region	2016 Population Total	2040 NPF Population Total	ESRI 50:50 City Population Total
Eastern and Midland	2.33m	2.87m (+23%)	2.76m (+18%)
Southern	1.59m	1.97m (+24%)	1.89m (+19%)
Northern and Western	0.85m	1.03m (+21%)	0.99m (+16%)
State	**4.77m**	**5.87m (+23%)**	**5.64m (+18%)**

2.4.2 Population Distribution (County Level)

Table 2.5 compares the existing 2016 population for each county of Ireland against the 2040 ESRI 50:50 City scenario county projections. The table highlights that the highest growth is in and around the large population centres, with lower growth in more rural counties and a reduction in growth in counties Roscommon and Leitrim.

Table 2.5 ESRI 50:50 City Scenario County Population Projections

County	2016 Population	2040 ESRI 50:50 City Population	2016 – 2040 Growth	2016 – 2040 Growth (%)
Carlow	56,932	64,466	7,534	13%
Cavan	76,176	84,399	8,223	11%
Clare	118,817	128,156	9,339	8%
Cork	417,211	544,774	127,563	31%
Cork City	125,657	156,171	30,514	24%
Donegal	159,192	175,393	16,201	10%
Dublin City	554,554	651,426	96,872	17%
Dun Laoghaire	218,018	256,564	38,546	18%
Fingal	296,020	355,881	59,861	20%
Galway	179,390	257,443	78,053	44%
Galway City	78,668	99,317	20,649	26%

County	2016 Population	2040 ESRI 50:50 City Population	2016 – 2040 Growth	2016 – 2040 Growth (%)
Kerry	147,707	150,802	3,095	2%
Kildare	222,504	275,218	5,2714	24%
Kilkenny	99,232	108,684	9,452	10%
Laois	84,697	91,326	6,629	8%
Leitrim	32,044	28,900	-3,144	-10%
Limerick	143,441	206,282	6,2841	44%
Limerick City	51,458	68,208	1,6750	33%
Longford	40,873	43,953	3,080	8%
Louth	129,782	158,765	2,8983	22%
Mayo	130,507	136,978	6,471	5%
Meath	194,146	241,863	47,717	25%
Monaghan	61,386	67,634	6,248	10%
Offlay	77,961	84,204	6,243	8%
Roscommon	64,544	62,791	-1,753	-3%
Sligo	65,535	77,882	1,2347	19%
South Dublin	278,767	332,315	5,3548	19%
Tipperary North	71,282	7,2608	1,326	2%
Tipperary South	88,271	9,2051	3,780	4%
Waterford	116,176	140,206	24,030	21%
Westmeath	88,770	101,619	12,849	14%
Wexford	149,722	155,310	5,588	4%
Wicklow	142,425	167,553	25,128	18%
State	**4,761,865**	**5,639,141**	**877,276**	**18%**

County level projections for 2040 are not provided in the published NPF, however as part of Project Ireland 2040, the government has produced a report titled 'Implementation Roadmap for the National Planning Framework' which provides county level population range projections up to 2031.

Table 2.6 compares the 2031 NPF population projections from this report against the 2040 ESRI 50:50 City county projections presented in Table 2.5 in terms of their overall population distribution. The comparison shows that the overall distribution of county level population is very similar.

Table 2.6 2031 NPF and 2040 ESRI 50:50 City Scenario County Population Projections

County	2040 ESRI 50:50 City Scenario	2031 NPF[3]	2040 ESRI 50:50 City Scenario (%)	2031 NPF (%)
Carlow	64,466	64,000	1.2%	1.1%
Cavan	84,399	86,000	1.6%	1.5%
Clare	128,156	134,000	2.4%	2.3%
Cork	700,945	656,500	11.9%	12.4%
Donegal	175,393	179,500	3.3%	3.1%
Dublin	1,596,186	1,54,9500	28.1%	28.3%
Galway	356,760	322,000	5.8%	6.3%
Kerry	150,802	166,500	3.0%	2.7%
Kildare	275,218	259,000	4.7%	4.9%
Kilkenny	108,684	112,000	2.0%	1.9%
Laois	91,326	95,500	1.7%	1.6%
Leitrim	28,900	36,000	0.7%	0.5%
Limerick	274,490	246,000	4.5%	4.9%
Longford	43,953	46,000	0.8%	0.8%
Louth	158,765	144,000	2.6%	2.8%
Mayo	136,978	147,000	2.7%	2.4%
Meath	241,863	225,500	4.1%	4.3%
Monaghan	67,634	69,000	1.3%	1.2%
Offlay	84,204	88,000	1.6%	1.5%
Roscommon	62,791	73,000	1.3%	1.1%
Sligo	77,882	74,000	1.3%	1.4%
Tipperary North	72,608	80,500	1.5%	1.3%
Tipperary South	92,051	99,500	1.8%	1.6%
Waterford	140,206	137,000	2.5%	2.5%
Westmeath	101,619	100,000	1.8%	1.8%
Wexford	155,310	169,000	3.1%	2.8%
Wicklow	167,553	160,500	2.9%	3.0%
State	**5,639,141**	**5,683,500**	**100%**	**100%**

[3] *The Implementation Road Map provides an lower and upper population projection for 2031. The upper range has been used to inform the comparison. The lower bound has an overall population projection of 5,519,500.*

2.5 NTpM Zone Projections

As the NPF scenario will only be achieved with significant policy changes, projections for this scenario had to be produced by calibrating the parameters of the existing population projection model (developed by Dr. Edgar Morgenroth) to generate the patterns envisaged in the NPF.

The new economic projections from the ESRI are based on a new econometric model which has a different sectoral breakdown to the previous model (used as part of the previous NTpM update) which meant that a new Small Area jobs projection model had to be constructed. For population, jobs and employment, projections were produced at the Electoral District (ED) level and were then aggregated to the NTpM zones.

The following sections set out some of the important changes in the methodology compared to that used previously in 2013 to project the population, jobs and employment for use in the previous update of the NTpM.

2.5.1 NTpM Population Projections

The CT scenario population projections were constructed using the model that was previously constructed in 2013 (see Morgenroth, 2014) for the previous update of the NTpM. Thus, as before county level projections were distributed across ED's using the parameters from a regression analysis.

The key features of the county level projections is unchanged fertility and net-migration generated consistently with the economic projections of Bergin et al. (2016). The ED projection model was found to be producing stable results and the within sample projection performance was excellent with an average projection error of just over 2%, with much of the error being explained by projection error at the county level.

The CT scenario was based on parameters that were estimated from historic data. These parameters relate the share in the county change for each ED to the previous population, population density and previous shares.

The NPF scenario however implies a significant change from historical patterns. Therefore, the standard model could not be used to generate the ED level NPF population projections, which were required for the NTpM. The approach adopted was to calibrate the parameters such that the headline targets contained in the NPF were obtained. In particular this involved changing the parameter on past population density from negative to positive. This shows the extent to which the NPF would require changed policies, as this implies that more development needs to occur in already built up areas and that densities need to significantly increase.

2.5.2 NTpM Jobs Projections

The new national economic projections from the ESRI (Bergin et al, 2016a) are based on the COSMO (Bergin et al. 2016b) model rather than on the HERMES model (see Bergin et al. 2013) that was previously used. While COSMO is more simply used it has the drawback that the sectoral coverage is much more limited. Whereas HERMES distinguished eleven sectors, COSMO distinguishes just three sectors. The three sectors are the amalgamations of standard NACE[4] sectors. The first sector incorporates all sectors where more than 50% of output is exported, and this is known as the traded sector. A second sector includes all government

[4] *Statistical Classification of Economic Activates in the European Community*

related activities such as public administration, health and education, which is known as the government sector[5]. Finally the non-traded sector contains all other activity.

As the projections were previously done sector by sector for the eleven sectors of the HERMES model, and then aggregated to total jobs in each ED the old model was no longer usable with the outputs from COSMO. However, as part of the research carried out for the NPF, county jobs projections had been constructed and these were utilised here.

In keeping with the approach used for the population projections the county change was shared out to EDs using a simple model based on econometric results where the county share of the traded sector was modelled as a function of lagged[6] jobs, lagged jobs squared and county change in jobs.

The non-traded sector shares were modelled as a function of lagged jobs, lagged jobs squared and county change, population and the lagged share. Finally, the government share was modelled as a function lagged jobs, and county change, population and the lagged share.

The specifications were arrived at following extensive experimentation where model fit and stability of projection results were the key criteria for model selection. The only factor that differs between the current trend's scenario and the NPF scenario is the distribution of the population and using the two population scenarios it was possible to generate alternative jobs scenarios.

As retail and wholesale activity not only result in commuting traffic, but also in traffic of shoppers, separate projections for retail were also required. Retail and wholesale is part of the non-traded sector in COSMO and thus not individual sector projections for this sector were available. An analysis of the geographic distribution of wholesale and retail suggests that its distribution is stable. Projections were thus produced by assuming that the share of wholesale and retail jobs remains unchanged.

2.5.3 NTpM Employment Projections

For the current trends scenario region level employment projections were available from the work done for the NPF (Morgenroth, 2018). These were distributed to the county level by assuming constant labour force participation rate differences across counties within regions, which together with the population projections was used to generate the numbers in the labour force.

Assuming constant unemployment rate differences across counties within regions it was then possible to generate the numbers unemployed and the numbers employed were then calculated as the difference between the labour force and the numbers unemployed. The same approach was then applied at the ED level where the county level variable were apportioned using the same methodology. This yields a full set of ED level results for the current trends scenario.

As no NPF employment scenario was calculated as part of the research for the NPF an alternative approach was used to construct an NPF employment scenario. This involved using the employment rate from the current trends scenario with the NPF population scenario in order to generate ED level employment for the NPF scenario.

[5] While the government sector contains mostly public sector activity some private sector activity particularly in health and education is also contained in this sector.
[6] Refers to historic trends

2.6 Low and High Growth Sensitivity Scenarios

The NPF 50:50 City scenario developed by the ESRI forms the TII Central Growth scenario of the NTpM. Sensitivity scenarios of upper and lower bound population projections were also developed for the NTpM on the basis of published CSO population projections[7] (see Figure 2.1). The following 2041 CSO population projections were used:

- High Growth Sensitivity (upper bound CSO population projection) – M1F1 (6,176,719); and
- Low Growth Sensitivity (lower bound CSO population projection) – M3F2 (5,432,927).

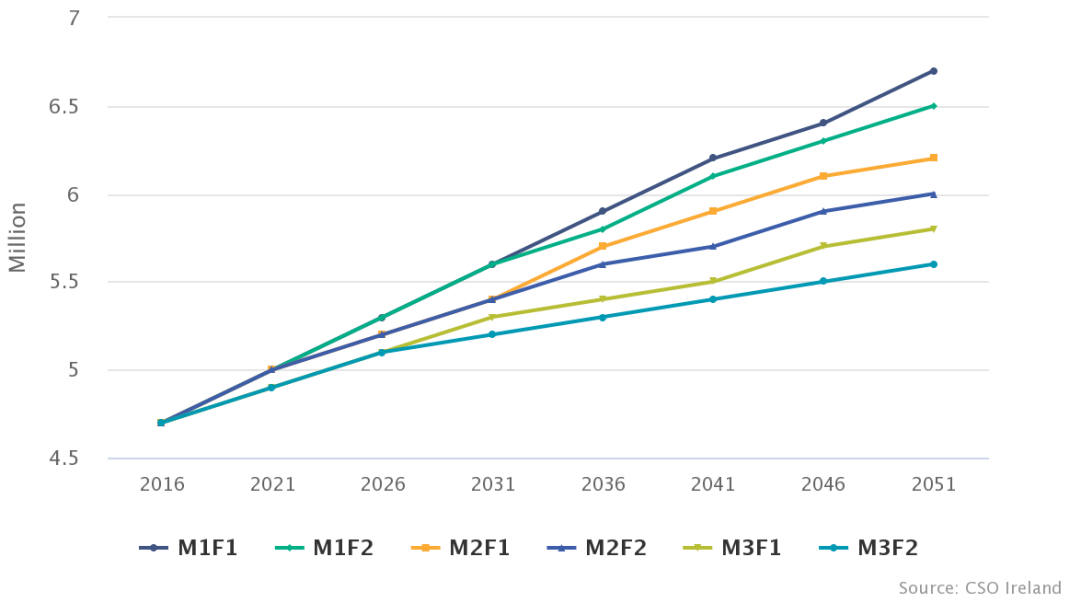

Figure 2.1 CSO Population Projections (2016 – 2051)

The jobs and employment projections for the High and Low sensitivity growth scenarios were adjusted proportionally to the population projection for use in the TAGM.

2.7 2030 and 2050 Demographic Projections

In addition to 2040, demographic projections for 2030 and 2050 were also developed for use in the NTpM. The 2030 projections were developed by linearly interpolating between the 2016 and 2040 NPF projections, 2050 projections were extrapolated using the data from the 2040 data.

2.8 Summary National Projections

A summary of the 2016 and forecast 2030, 2040 and 2050 national level projections are provided in Table 2.7, Table 2.8 and Table 2.9 respectively. The following projections are presented:

- Population; and
- Jobs/Employees.

[7] https://www.cso.ie/en/releasesandpublications/ep/p-plfp/populationandlabourforceprojections2017-2051/populationprojectionsresults/

Employment totals are not presented separately, as for each job in the country there is an equivalent employed person.

Table 2.7 2030 National Projections

Scenario	Population		Jobs	
	Total	Growth	Total	Growth
2016	4.76m	-	2.01m	-
Low	5.20m	9.2%	2.49m	23.9%
Central	5.31m	11.6%	2.54m	26.4%
High	5.56m	16.8%	2.66m	32.3%

Table 2.8 2040 National Projections

Scenario	Population		Jobs	
	Total	Growth	Total	Growth
2016	4.76m	-	2.01m	-
Low	5.41m	13.7%	2.58m	28.4%
Central	5.64m	18.5%	2.68m	33.3%
High	6.12m	28.6%	2.91m	44.8%

Table 2.9 2050 National Projections

Scenario	Population		Jobs	
	Total	Growth	Total	Growth
2016	4.76m	-	2.01m	-
Low	5.57m	17.0%	2.67m	32.8%
Central	5.90m	23.9%	2.83m	40.8%
High	6.65m	39.7%	3.37m	67.7%

2.9 Summary

Since the previous update of the NTpM, the Government has published the National Planning Framework (NPF)[8]. As part of the current update of the NTpM, future year models have been developed to provide consistency with the spatial demographic projections of the NPF. This required the updating on the existing NTpM population and jobs models to allow for the distribution of future year country levels projections down to NTpM zone level for use in the NTpM. Future models are now available for 2030, 2040 and 2050.

[8] *Project Ireland 2040 National Planning Framework (2018)*

3 Car Ownership & Car Numbers Forecasting

3.1 Introduction

The purpose 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 NTpM zone levels. The forecasts cover the period 2016 to 2050 and are used to inform the forecasting of Light Vehicle (LV) travel demand in the context of the development of the NTpM.

Transport models involve the forecasting of trips as an essential element in determining overall travel demand. It has been established that the availability of cars to households is a major factor in the level of household trip-making. The availability of cars has, in turn, found to be closely related to car ownership levels. As a result, forecasting of car ownership has become a central feature of model development.

3.2 County Level Car Ownership Forecasts

The county level was chosen as the base unit of analysis with which to develop models of car ownership. This is because it is the lowest level at which economic data such as income is available. In modelling car ownership in Ireland, this assessment defines car ownership as the number of cars per adult. This has the advantage that a maximum car saturation level of one car per adult can be easily postulated.

Prior research has shown that car ownership is strongly related to income levels. Car ownership levels grow slowly from a low base, and then accelerate before reaching saturation. This pattern of growth is best represented by functional forms, such as the Gompertz and Logistic models. Both these functional forms assume an initial period of gradual annual growth that accelerates for a time, before slowing as car ownership approaches a saturation level.

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 first step in the analysis was to estimate the maximum potential saturation level to which a county could progress if income and land use factors were favourable. This was done by first estimating the maximum saturation level for the state as a whole.

3.3 Saturation Levels

3.3.1 National Saturation Level

The maximum car saturation level was estimated by assuming that all adults of driving licence age could potentially own a car, unless factors such as disability or lack of independent living intervened. Thus, it was necessary to establish the number of adults in Ireland who might be unable to, or cannot, own a vehicle in the medium to long term. These include adults who have a long term disability, have significant health problems, are incarcerated for criminal reasons,

are disqualified from driving and those living in emergency accommodation. This was calculated to be 497,963 adults[9] (13.7%) out of a total of 3,632,681 adults present in the state.

It is clear, however, that there is a certain amount of double counting in this total figure (e.g. being over 85 and living in a nursing home). The extent of this double counting is unknown. For the purpose of estimating the maximum number of adults who would never drive, this figure was rounded down to 10% of the adult population. This implies a national maximum saturation level of 900 cars per 1,000 adults. However, as this estimate is approximate, it was considered appropriate to include a number of alternative saturation levels in the development of car ownership models. Thus, three scenarios were established as follows:

- High Scenario: 900 cars per 1,000 adult's saturation level;
- Medium Scenario: 875 cars per 1,000 adult's saturation level; and
- Low Scenario: 850 cars per 1,000 adult's saturation level.

3.3.2 County Saturation Level

Car ownership levels vary across counties and car ownership levels are influenced by the income levels in a given county. As counties will attain higher income levels over time, current car ownership is not a good guide to ultimate or saturation car ownership levels. A better indication of whether one county will ultimately have a higher saturation than another would be obtained if car ownership in each county could be predicted on the basis of identical income across counties.

Income alone is not the sole determinant of ultimate saturation levels. Dublin has the highest income in the country but the lowest car ownership levels. It is very unlikely that car ownership in Dublin will progress to high levels. This is because population density negatively affects car ownership, as other modes such as public transport, walking and cycling are then more viable.

In modelling terms, structural variables refer to demographic, land-use, or other factors that may influence the ultimate demand for car ownership beyond the influence of income e.g. population density or public transport provision in a county. An approach to estimating car ownership saturation levels was adopted that sought to distinguish between the effects of income on the one hand and a set of structural variables on the other.

The process used to determine saturation levels was as follows:

- A cross sectional model of car ownership was developed for the year 2016 that related car ownership to income and a set of structural variables;
- Using this model, county car ownership was estimated for 2016, assuming all counties had the average income of the State as a whole;
- This was then used to rank and determine the gap between counties in terms of car ownership based on a common or normalised income level ; and
- This car ownership gap between counties at normalised income levels was used to posit county car ownership saturation levels, assuming that the county with the highest car ownership level would progress towards the maximum saturation level.

[9] *Disability – blindness/serious vision impairment, intellectual disability, difficulty in dressing, bathing or getting around (Census 2016), Health – aged 85 or over (Census 2016) or resident in nursing home (Dept. of Health 2016), Incarceration - prison inmate (Irish Prison Service (2016)) or Central Mental Hospital Inmate (Mental Health Commission (2017)), Licensing - disqualified drivers (Dept. of Transport (2016)) and Housing - rough sleepers and emergency housing - Census (2016))*

3.4 County Car Ownership Models

The county saturation levels were incorporated into the functional forms that were used to model county car ownership using Gompertz statistical models. At its simplest, the Gompertz model takes the following form:

$$CO = SExp(aExp(bInc))$$

Where:

- CO is Cars per adult
- S is the saturation level
- Inc is income per adult; and
- a and b are parameters to be estimated.

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 when incomes are falling compared to when incomes increase. This means that an additional independent variable, as well as income (*Inc)* must be included.

The first step in the modelling process involved the calculation of income per adult time series data for all counties for the period 1991-2016. Estimated total household income per county was provided by the CSO and divided by the total number of adults for each year. In order to create comparable data over the time period; this data was converted into an index with a base of '100' for 1991. In order to use income data in constant prices, the income per adult index was adjusted by the Consumer Price Index (CPI) (Base: December 2016).

Initial county level predictions of car ownership using income as the only independent variable failed to capture the 'sticky downwards' aspect of the relationship between declining income and car ownership. In order to accurately capture the fall in car ownership due to the reduced incomes during the recession; a new independent variable was created which calculated the difference between the county's peak income and the county's current income.

3.5 Projection of County Car Ownership and Car Numbers

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. These models were then employed to project car ownership and car numbers for each county. The latter projections were then aggregated to arrive at national-level projections and disaggregated to achieve ED-level projections.

An essential pre-requisite to making these projections is the development of assumptions about economic growth and population projections.

3.6 Economic Growth and Population Assumptions

Projections of car ownership and car numbers by county requires a projection of future incomes at the national level. There is no external source that provides a projection of overall national economic growth up to 2050. Furthermore, even if there was, there is a need for any projection of growth to be compatible with the population, labour force and employment projections already made in the context of the National Planning Framework. This suggests an approach of determining economic output growth by the following identity:

Gross Domestic Product = Employment x Labour Productivity

Employment levels can be derived from population and labour force projections and this means that economic growth can be linked to these demographic factors.

3.6.1 Population and Labour Force Projections

Under the ESRI Current Trends (CT) scenario, the population of the country is projected to grow by 900,000 persons by 2040 to reach a total population of almost 5.7m. This was the benchmark against which alternative economic and social strategies were developed. From the population and labour force projections, a rate of growth in the labour force of 1% per annum is projected up to 2040 under the CT scenario.

The NPF developed an alternative scenario (50:50 City) of targeted economic growth, focused on growing the regions, building strong regional urban centres, and increasing population density in the major conurbations. While the 50:50 City scenario has implications for the distribution of population, its assumptions in relation to the national population are the same as the CT scenario.

3.6.1 Productivity Growth

To derive a productivity estimate, it is wise to look at the longest period for which consistent data are available. This is especially the case as the recent past has encompassed an economic depression. When such depressions occur, extreme changes in productivity are witnessed as firms pare back labour resources and squeeze extra productivity from the remaining workforce. Similarly, in a post-depression period, productivity may be high as only efficient firms survive, although this effect will be nullified as the economy picks up.

Table 3.1 depicts the changes in productivity between 1998 and2014 as measured by the ratio of GDP at constant prices to employment levels (ILO figures).

Table 3.1 Productivity as measure by the Ratio of GDP at constant 2015 market prices to Employment Numbers, €000s 1998-2014

Year	Productivity	% Change
1998	72.1	-
1999	74.6	3.5
2000	78.0	4.5
2001	80.0	2.3
2002	83.1	4.2
2006	84.0	1.1
2004	87.2	3.7
2005	87.9	0.8
2006	88.3	0.4
2007	88.6	0.4
2008	84.5	-4.7
2009	87.9	3.9
2010	93.7	6.7
2011	99.1	5.8
2012	100.5	1.4
2013	99.3	-1.2
2014	105.6	6.4

Source: Derived from CSO statistics; Note: post 2014 excluded because of uncertainty about GDP estimates

Over the period 1998 to 2014 as a whole productivity growth measured 2.4% per annum. Recent analyses conducted by the CSO and the OECD have shown the growth in productivity varies by sector. Additionally, there is a significant difference in productivity between the domestic and multinational sectors, with the latter exhibiting higher productivity levels. This raises the issue of a decline in productivity growth levels from historic levels, if Ireland's ability to attract multinationals were to diminish.

3.6.2 Economic Growth Alternatives (Basic and Reduced)

If the productivity growth rate of 2.4% is coupled with labour force/employment growth rate of 1% under the CT scenario, then a GDP growth rate of 3.4% per annum is obtained over the period up to 2025. This is termed the Basic Growth assumption. It may be noted that the ESRI envisages output growth settling at 3.3% in the period 2021-2025, when the period of economy recovery has been fully completed[10].

The '50:50 City' scenario is virtually identical to the CT scenario in terms of population growth, so there is no strong case for a different assumption with regard to either productivity or GDP growth rates. Thus, based on current trends in productivity, a long term growth in productivity of 2.4% may be assumed. When this is associated with growth in the labour force and employment, long term growth rates in GDP are obtained. See Table 3.2.

However, there is the possibility that productivity growth of 2.4% per annum might not be sustained over the long term. In order to reflect this possibility an alternative Reduced Growth

[10] *Bergin et al. Ireland's Economic Outlook: Perspectives and Challenges, ESRI 2016.*

scenario was also considered. This involved a reduction in productivity growth from 2.4% to 1.5%. Again, when coupled with the predicted growth in the labour force, long term growth rates for GDP are obtained.

Table 3.2 Annual Average Growth Rates in GDP 2016-2050

Period	GDP	
	Basic Growth	Reduced Growth
2016-2020	3.4	3.4
2020-2030	3.4	2.9
2030-2040	3.0	2.1
2040-2050	2.9	2.0

Source: Compiled by the authors

3.6.3 Income per Adult

The factor driving car ownership is not GDP but income per adult. In estimating future income per adult it was assumed that total income would grow in line with GDP. When projected growth rates in GDP are associated with growth rates in the number of adults, income per adult may be derived. The results are presented in Table 3.3 for both the Basic Growth and Reduced Growth scenarios, both in terms of GDP and Income per Adult.

Table 3.3 Annual Average Growth Rates in GDP and Income per Adult, 2016-2050

Period	GDP		Income per Adult	
	Basic Growth	Reduced Growth	Basic Growth	Reduced Growth
2016-2020	3.4	3.4	2.0	2.0
2020-2030	3.4	2.9	2.0	1.6
2030-2040	3.0	2.1	2.1	1.2
2040-2050	2.9	2.0	2.3	1.4

Source: Compiled by the authors

3.7 Alternative Future Scenarios

Future car ownership and car numbers depend upon a number of assumptions and alternative projections for the variables driving them. In total there were twelve scenarios developed as part of the NTpM, which varied according to:

- The high, medium and low saturation levels assumed for car ownership at the county level;
- The alternative population distribution profiles associated with Current Trends and National Planning Framework assumptions; and
- The alternative economic scenarios arising from Basic Growth and Reduced Growth Scenarios.

These may be combined to give twelve scenarios as depicted in Table 3.4. The car ownership and car number projections consistent with any of the twelve scenarios outlined in Table 3.5 may be obtained by inputting the assumptions relevant to that scenario into the county car ownership models. Car ownership was predicted for each county and year from 2016 to 2050 using the models and incorporating the projected income levels.

Table 3.4 Alternative Scenarios for Predicting Car Ownership and Car Numbers in the NTpM

Population Distribution	Car Ownership Saturation	Economic Growth	
		Basic	Reduced
Current Trends	Low	×	×
	Medium	×	×
	High	×	×
NPF	Low	×	×
	Medium	×	×
	High	×	×

3.7.1 NTpM Scenario

The Car Ownership and Car Number scenario selected for use in the NTpM is based on the following assumptions:

- Medium saturation levels assumed for car ownership at the county level;
- National Planning Framework population distribution (in line with Government policy); and
- Reduced Growth economic scenarios (to reflect the potential for lower long term GDP/Income growth).

Table 3.5 presents projections for car ownership for each county up to 2050. This is based on the NPF scenario for population growth and the reduced economic growth scenario. The medium saturation level is also assumed.

Table 3.5 Car Ownership Projections for Scenario of NPF Population Growth, Reduced Economic Growth and Medium Saturation Level

County	Car Ownership (Per 1,000 Adults)				
	2016	2020	2030	2040	2050
Carlow	637	677	745	788	825
Cavan	536	569	634	684	739
Clare	609	651	730	786	841
Cork	596	632	697	741	781
Donegal	524	581	691	769	846
Dublin	496	520	563	589	613
Galway	553	588	658	710	763
Kerry	594	634	708	759	809
Kildare	603	635	695	738	784
Kilkenny	570	603	665	710	755
Laois	532	561	619	664	715
Leitrim	566	603	676	730	786
Limerick	575	609	671	711	747
Longford	545	575	636	684	739

Louth	522	557	630	687	751
Mayo	564	601	675	731	791
Meath	583	613	670	712	755
Monaghan	538	574	648	707	772
Offaly	560	594	662	714	772
Roscommon	645	682	758	818	875
Sligo	551	586	654	704	755
Tipperary	622	661	733	780	824
Waterford	619	667	750	803	835
Westmeath	597	635	709	764	822
Wexford	635	672	739	785	830
Wicklow	620	656	722	767	798

3.8 Projection of National and Regional Car Ownership

The NPF contains differentiates between three planning regions. Car ownership for these regions and at the national level 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 was then combined with the corresponding national adult population estimate to get a regional and 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.

With regard to 2016 car ownership per 1000 adults (Table 3.6), this is projected to grow by approximately one-third by 2050 at a National level under the NTpM scenario. The Southern Region will experience a similar growth rate, but the Northern and Western Region a significantly higher one. This reflects the low population density and higher car saturation levels assumed for counties in the latter region.

Table 3.6 Projection of Car Ownership at the Regional and National Level for Scenario of NPF Population Growth, Reduced Economic Growth and Medium Saturation Level

NPF Regions	Car Ownership (Per 1,000 Adults)					
	2016	2020	2030	2040	2050	Ratio 2050/2016
Northern & Western	554	594	671	728	786	1.42
Eastern & Midland	529	557	608	643	677	1.28
Southern	602	639	707	752	793	1.32
National	**558**	**591**	**652**	**695**	**735**	**1.32**

3.9 Electoral Division Car Ownership Projections

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.

Forecast rates of car ownership per person for each ED were calculated by inflating the estimated 2016 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 3.1shows the car numbers per ED in 2016, 2030 and 2050 for the NTpM scenario. This shows that the greatest growth in car numbers will be within or near major urban centres as these are the locations with the largest projected population growth in the National Planning Framework.

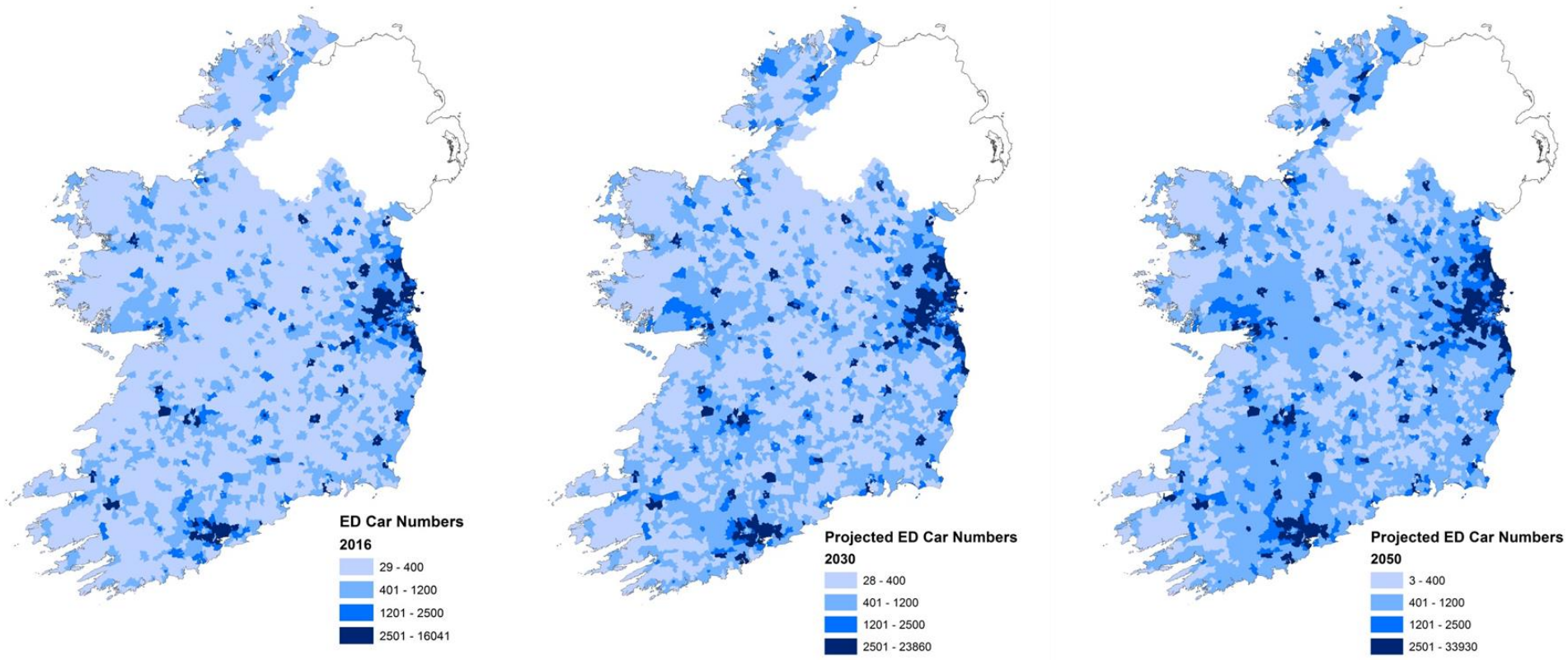

Figure 3.1 Number of Cars per ED (Reduced Income – NPF Population Forecast – Medium Car Saturation Level)

3.10 Summary

Future car ownership was modelled using a number of scenarios. These were based on different assumptions relating to population growth, economic growth and the saturation level of car ownership.

Population growth encompassed a Current Trends (CT) projection and a National Planning Framework (NPF) projection. The difference between the two projections lies in the regional distribution of population, with the NPF projection envisaging a rebalancing of the population away from Dublin and towards other major urban centres, as well as a densification of all major urban areas.

Economic growth assumptions considered a Basic Growth (BG) assumption, which assumed a continuation in the current trends in labour productivity and matched these with a projected growth in the labour force, based on CT and NPF population projections. The alternative Reduced Growth (RG) scenario envisaged that current trends in labour productivity growth could not be maintained indefinitely and assumed a decline in the rate of productivity growth post 2025.

With regard to car saturation levels, a maximum potential national potential saturation or High Saturation (HS) of 900 cars per thousand adults was postulated. A Medium Saturation (MS) of 875 cars per thousand adults and a Low Saturation (LS) of 850 were also considered.

Taken together, these options generated twelve alternative scenarios for the development of future car ownership and car numbers. Based on NPF population, RG economic growth and a medium car ownership saturation level (MS), the following conclusions were drawn as to the future course of car ownership and car numbers:

- At the national level car ownership will rise from 558 cars per thousand adults in 2016 to 652 cars per thousand in 2030, and 735 cars per thousand in 2050. These represent increases of 17% and 32% respectively.
- Over the period to 2050, car ownership in the Northern and Western region will grow at the fastest rate, from 554 cars per thousand in 2016 to 786 cars, an increase of 42%.
- With regard to car numbers, the total car population will grow from 2.0m in 2016 to 2.64m in 2030 and 3.31m in 2050. These represent increases of 30% and 63% respectively.
- Over the period to 2050, car numbers in the Northern and Western region will grow at the fastest rate from 357,000 to 620,000 or by 74%.
- With regard to counties, Dublin had the lowest car ownership level at 496 cars per thousand adults in 2016. This is predicted to rise to 613 cars per thousand adults by 2050. However, Dublin will continue to exhibit the lowest car ownership levels of any county.
- Roscommon had the highest car ownership level in 2016 and maintains this position in 2050, when it is predicted to reach its saturation level of 900 cars per thousand adults.

- The relative position of other counties changes significantly. For example Donegal had one of the lowest rates of car ownership in 2016 of 524 cars per thousand adults but is predicted to have one of the highest by 2050. This reflects the fact that the low population density of the county and the increase in income levels will encourage car ownership to grow strongly.
- The strongest growth in car numbers is predicted for the counties of Galway and Limerick, where a doubling of car numbers is expected by 2050. This largely reflects the increase in population projected for these counties and particularly their urban areas.
- The car ownership and car number projections at ED level reflect the population scenarios and the saturation levels assumed. For example under the NPF population scenario, car ownership is seen to grow strongly in urban EDs, which are a focus of this strategy.

4 Travel Demand Forecasting

4.1 Introduction

The NTpM requires forecasts of the number of trips made to and from each zone in the model classified as Light Vehicle (LV) trips, Heavy Vehicle (HV) trips or Public Transport (PT) passenger trips, for each future year (i.e. 2030, 2040 and 2050) and each growth scenario (i.e. Central, High and Low).

The NTpM Trip Attraction Generation Model (TAGM) is the tool used to convert the demographic (population, jobs and employment) and car ownership forecasts discussed in previous chapters, in addition to other independent variables, into vehicle and passenger demand trip matrices for assignment in the NTpM.

4.2 Trip Attraction Generation Model – Process

The initial starting point in the process is the development and calibration of a set of direct demand equations which are used to estimate the relationship between the number of existing origin and destination trips in a NTpM zone and observed independent variable data for that zone (i.e. demographics, car ownership, population density etc.). An overview of the process implemented in the TAGM to generate future demand matrices for the NTpM is as follows:

1) Synthetic trip ends for the base year (2016) and the relevant future year are calculated using the direct demand equations and the applicable independent variables;

2) A growth factor is then calculated for each NTpM origin and destination zone by dividing the synthetic future year trip end by the synthetic base year trip end;

3) The growth factors developed from the synthetic base and future year trips ends are then applied to the validated base year trip ends to generate future year trips ends for the NTpM;

4) The forecast trips ends are then furnessed to generate the initial demand matrices;

5) Car availability factors[11] are applied to the public transport demand matrices to generate car available and car non available demand matrices;

6) Individual trip end growth rates are then applied to each 'Special Zone' (i.e. Ports and Airports) in the NTpM. The initial demand matrices are then adjusted accordingly to account for the Special Zones forecast growth;

7) The updated future year origin and distribution trip ends and then furnessed to generate the future year trip distribution; and

8) The final future year demand matrices are then ready for assignment in the NTpM.

The process outlined above is illustrated in the flow chart in Figure 4.1.

[11] The proportion of Car Available and Non-Car Available were calculated from the 2016 POWSCAR dataset which included information on household size & composition, number of employed persons and number of cars per household. Further details are provided in NTpM Volume 1 Model Development Report.

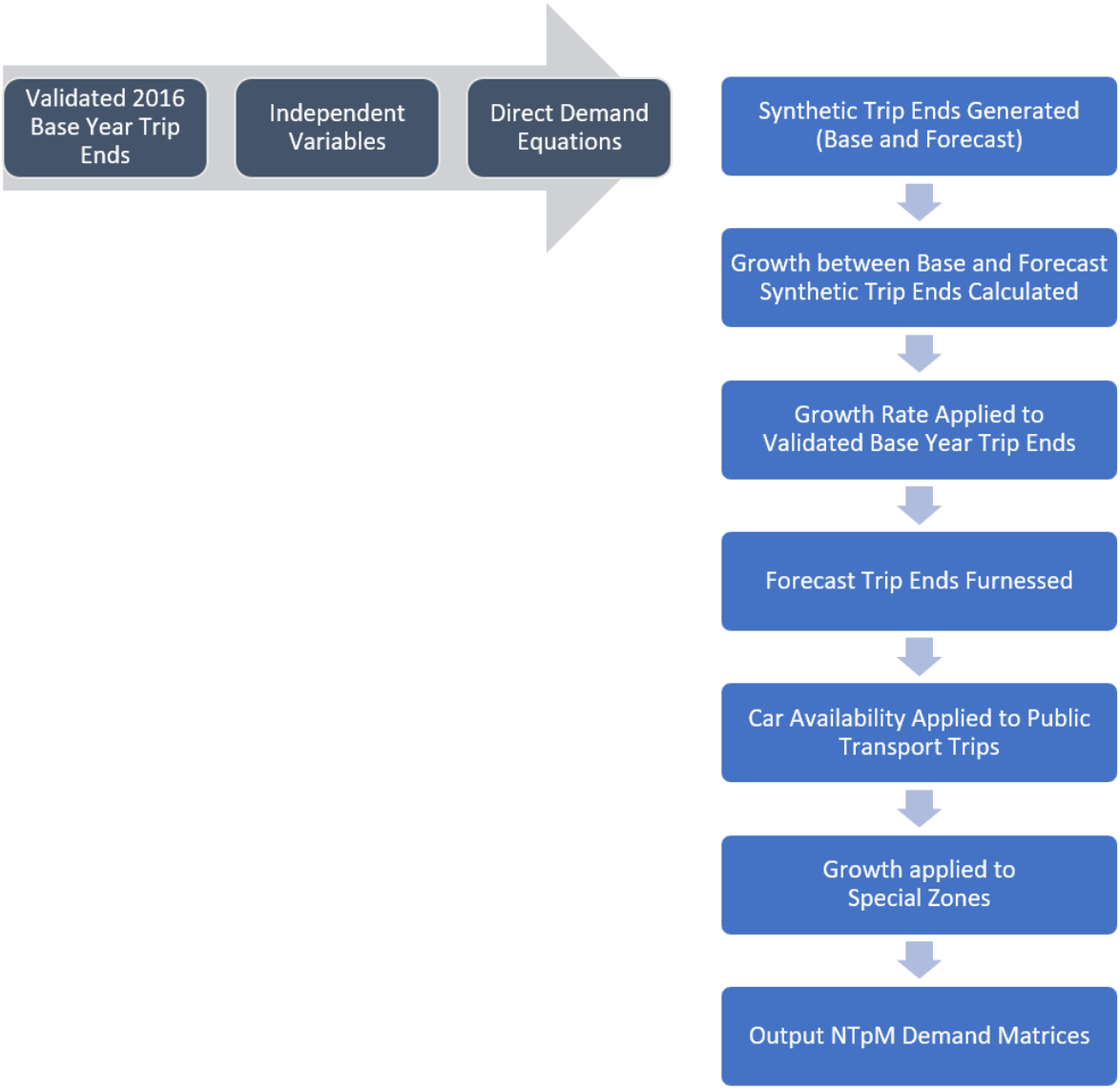

Figure 4.1 Process to Generate Future Matrices for the NTpM

4.3 Direct Demand Equations

The direct demand equations were developed using the 2016 validated NTpM trip end data and the 2016 observed demographic, car ownership and other independent variables. 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 independent variables.

4.3.1 Independent Variables

Economic and demographic data for each NTpM zone in both the base and forecast years was needed to determine the future year growth in each NTpM Origin and Destination zone. The key variables used were:

- Population;
- Jobs;

- Employment, and
- Car Ownership.

These are defined below:

- Population – Existing (2016) and forecast (2030, 2040 and 2050) population data. Produced at ED level and aggregated to NTpM zone level;
- Jobs – Number of jobs per ED. These forecasts were aggregated to NTpM zone level;
- Employment – Number of employed persons resident in each ED. This information was aggregated to NTpM zone level;
- Population of driving age, i.e. of age 17 years and older – the population of adults per NTpM zone was estimated by applying the proportion of adults in the county (as per county population forecasts) to the population of each zone within that county.
- Car Ownership – Car ownership per 1,000 people of 17 years of age or older per NTpM zone. This variable is a 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.

4.3.2 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.

4.3.3 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.

4.3.4 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:

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:

1) More urban zones (i.e. those with high population densities) have greater access to public transport, therefore have more public transport trips; and

2) 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).

Two binary or 'dummy' variables were included for the public transport trips. One was set up for zones with 0.5 or fewer trips, and the value of the 'dummy' variable for those zones was set to 1, the other was set up for Dublin, where all zones in the Dublin region were assigned a value of 1. They were 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. At the other end of the scale the low value variable picked up zones with very low volumes of public transport trips, especially in the Employers Business purpose matrices.

The Dublin 'dummy' variable acts 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 were 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.
- Econometric relationships between the number of trips made and the economic and demographic data (independent variables) for the base year (2016) were estimated. **Error! Reference source not found.**and set out the details including the dependent variables, coefficients and adjusted R-squared values for light vehicle trips and public transport trips respectively. The prefix 'LN' in the tables indicates that the data was transformed to natural logs.

4.3.5 Results

Table 4.1and Table 4.2 set out the model details including the dependent variables, coefficients and adjusted R-squared values for each model. The prefix 'LN' 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 77% and 91%, indicating a satisfactory level of fit; and
- The signs on the coefficients are as expected.

Table 4.1 Dependant and Independent Variables – Light Vehicle Trips

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	86%
			-2.29836	0.97528	-0.00008	0.00053	
		Employers' Business	Constant	LN Employment	LN Jobs Density		81%
			-4.4263	0.9651	0.1415		
		Other	Constant	Population Density	Car Ownership per Adult	LN Population	91%
			-3.9400	-0.0001	-0.0001	1.0812	
	Destination	Commuter	Constant	LN Jobs	LN Jobs Density		88%
			-3.4092	1.0649	0.12207		
		Employers' Business	Constant	LN Jobs	LN Jobs Density		85%
			-5.2917	1.0481	0.1628		
		Other	Constant	LN Population	Pop Density	Car Ownership per Adult	87%
			-3.2877	1.1561	-0.0027	-0.0025	

Dependent Variable			Light Vehicle Trips				
Time	Origin / Destination	Trip Purpose	Independent Variables and Parameters				Adjusted R^2
Inter Peak	Origin	Commuter	Constant	LN Employment	Population Density	LN Jobs	84%
			-2.4197	0.4076	-0.00005	0.6316	
		Employers' Business	Constant	LN Employment	LN Jobs	Population Density	85%
			-5.4590	0.4602	0.7134	0.0001	
		Other	Constant	Population Density	Car Ownership per Adult	LN Population	89%
			-3.5418	-0.0001	-0.0021	1.0833	
	Destination	Commuter	Constant	LN Employment	Population Density	LN Jobs	85%
			-2.4715	0.4196	-0.0001	0.6274	
		Employers' Business	Constant	LN Employment	Population Density	LN Jobs	85%
			-5.6966	0.4950	0.7068	0.0001	
		Other	Constant	Population Density	Car Ownership per Adult	LN Population	88%
			-3.6689	-0.0001	-0.0020	1.0894	

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
15 hour	N/A	Commuter	Constant	LN Population	LN Pop Sq.	LN Jobs	Car Ownership per Adult	Dublin	Low Value	84%
			6.2778	-2.3284	0.1879	0.4941	-0.0009	0.7122	-5.1536	
		Employers' Business	Constant	LN Employment	LN Jobs	LN Jobs Density	Dublin	Low Value		79%
			-3.8856	0.5711	-0.0454	0.4172	-1.1055	-2.8417		
		Other	Constant	LN Employment	Car Ownership per Adult	LN Jobs (Distribution)	Low Value			77%
			-2.2676	1.1082	-0.0029	-0.4890	-5.71			

5 Special Zones Forecasting

5.1 Special Zones (Ports & Airports)

All ports and airports outlined in the National Ports Policy[12] and National Aviation Policy[13] documents have been included as 'Special Zones' in the NTpM. The National Ports Policy categorises ports into three groups as follows:

- Port of National Significance (Tier 1) – Dublin Port, Port of Cork and Shannon Foynes Port;
- Port of National Significance (Tier 2) – Port of Waterford and Rosslare Europort; and
- Ports of Regional Significance – Drogheda Port, Dún Laoghaire Harbour, Galway Harbour, New Ross Port and Wicklow Port (and all other ports that handle freight).

The National Aviation Policy categoriese airports into two groups as follows:

- State Airports – Dublin, Shannon and Cork; and
- Regional Airports – Donegal, Ireland West Airport Knock, Kerry and Waterford.

5.2 TAGM Treatment of Special Zones

The NTpM TAGM has been updated to allow for the flexibility of forecasting individual growth for Irish ports. The TAGM calcultates forecast trip end growth for all zones (inclusive of Special Zones) based on the Direct Demand Eqauations and zone demogrpahics/variables discussed in Section 4. Once this process is complete the TAGM then removes the calculated trip end growth rates for all Special Zones and zone specific growth rates are applied to each Special Zones.

The updated Special Zone trip ends are then added back in with the general zones trip ends to provide a complete set of trip ends for each forecast year, time period and mode. The calculation of the trip end growth factors for each Special Zone is provided in the following sections.

5.3 Special Zones Forecasting – Ports

The following sections provide an overview of the forecasting process for Ports and how the future year trip ends for each port were developed for input into the NTpM TAGM.

5.3.1 National Projections

The initial step in the process is to develop projections of the total annual tonnages for all ports for each of the forecast years in the NTpM (2030, 2040 and 2050). This was done by relating the total historic annual tonnages through ports nationally to a forecast of GDP and then projecting forward to 2050. The forecast growth nationally in terms of tonnages handled is presented in Table 5.1 for each of the NTpM future years.

[12] *National Ports Policy (2013) – Department of Transport, Tourism and Sport*
[13] *A National Aviation Policy for Ireland (August 2015) – Department of Transport, Tourism and Sport*

Table 5.1 National Growth in Tonnages Handled (All Ports)

National	Tonnages Handled (000s)			
	2016	2030	2040	2050
Tonnages Handled	50,711	57744	61931	64614
Growth (from 2016)	-	13.9%	21.5%	27.4%

5.3.2 Proportions of Tonnages Per Port

A current trends forecast for each port was then made using static port shares of total port tonnage and the results are presented in Table 5.6. This share was held constant for all forecast years for the NTpM forecasts.

Table 5.2 Forecast Tonnages Per NTpM Port

Port	% Split
Dublin	48.6%
Shannon – Foynes	21.9%
Cork	17.7%
Rosslare	4.3%
Waterford	2.6%
Drogheda	2.5%
Galway	1.2%
New Ross	0.5%
Wicklow	0.3%
Dundalk	0.2%
Total	**100%**

5.3.3 Daily HGV Movements Per Port

Based on an average vehicle weight of roll-on/roll-off freight traffic from Dublin Port (2017) of 11.281 tonnes, the total HGV movements required to move the daily demand at each port was calculated and is presented in Table 5.3.

Table 5.3 Forecast HGV Annual Average Daily Traffic Per NTpM Port

Port	Year			
	2016	2030	2040	2050
Dublin	5,821	6,809	7,268	7,620
Shannon – Foynes	2,672	3,074	3,281	3,439
Cork	2,191	2,442	2,607	2,733
Rosslare	532	590	630	660
Waterford	323	439	469	491
Drogheda	299	349	373	391
Galway	144	165	176	184
New Ross	66	94	100	105
Wicklow	37	39	41	43

Dundalk	10	22	24	25
Total	**12,096**	**14,024**	**14,969**	**15,692**

Table 5.4 presented the AADT growth rates for each port. This rates are applied in the NTpM TAGM to calculate the total daily tonnages at each port. The total daily tonnages are then converted to NTpM peak hour directional demand in the TAGM.

Table 5.4 Forecast HGV Annual Average Daily Traffic Growth Rates Per NTpM Port

Port	Year			
	2016	2030	2040	2050
Dublin	-	1.17	1.25	1.31
Shannon – Foynes	-	1.15	1.23	1.29
Cork	-	1.11	1.19	1.25
Rosslare	-	1.11	1.18	1.24
Waterford	-	1.36	1.45	1.52
Drogheda	-	1.17	1.25	1.31
Galway	-	1.15	1.22	1.28
New Ross	-	1.42	1.52	1.59
Wicklow	-	1.05	1.11	1.16
Dundalk	-	2.20	2.40	2.50
Total	**-**	**1.16**	**1.24**	**1.30**

5.4 Special Zones Forecasting – Airports

The initial starting point in the forecasting process was to identify the total growth in passenger numbers up to 2050 for each of Ireland state airports (Dublin, Cork and Limerick). The following data sources were used:

- Dublin Airport – Dublin Airport Masterplan; and
- Cork and Shannon Airport – Department of Transport, Tourism and Sport (DTTaS) 'Review of Future Capacity Needs at Ireland's State Airports (2018) – Baseline Growth Scenario.

Based on the above document's total passenger number for each NTpM forecast year (2030, 2040 and 2050) were estimated and are illustrated in Table 5.5.

Table 5.5 Passenger Growth Projections – 2030, 204 and 2050 (Irelands State Airports)

Airport	Passenger (millions)			
	2016	2030	2040	2050
Dublin	28	37	44	50
Cork	2.2	3.0	3.6	4.1
Shannon	1.7	2.3	2.8	3.3

5.4.1 Projected State Airport Peak Hour Trip Ends (Origin & Destination)

The annual passenger data presented in Table 5.5 was converted to daily passenger data by dividing by 365.

Data from a 2016 NTA survey of passengers (07:00 – 19:00) was used to calculate the road based (Car +Taxi) daily mode split (Dublin- 63% & Cork/Shannon – 83%). The proportion of daily demand travelling in the NTpM modelled time period and the directional split was also available from existing survey data and this was used to estimate the forecast origin and destination trip end data for each forecast year. Table 5.6 outlines the forecast year projections at each of the state airport for the car based on mode share (Car +Taxi).

Table 5.6 NTpM Peak Hour Growth Projections (Car & Taxi) – State Airports Airport

Mode	Time Period	2016		2030		2040		2050	
		O	D	O	D	O	D	O	D
Dublin	AM	997	1,507	1,338	2,021	1,565	2,365	1,777	2,686
	IP	1,208	1,471	1,620	1,973	1,895	2,309	2,153	2,622
Cork	AM	100	183	134	246	159	291	183	337
	IP	385	488	518	657	613	777	708	897
Shannon	AM	120	215	169	302	204	365	239	428
	IP	87	124	122	174	148	210	178	246

Table 5.7 outlines the forecast growth rates between 2016 and each NTpM forecast year.

Table 5.7 NTpM Peak Hour Growth (%) Projections (Car & Taxi) – State Airports Airport

Mode	Time Period	2016		2030		2040		2050	
		O	D	O	D	O	D	O	D
Dublin	AM	-	-	1.34	1.34	1.57	1.57	1.78	1.78
	IP	-	-	1.34	1.34	1.57	1.57	1.78	1.78
Cork	AM	-	-	1.35	1.35	1.59	1.59	1.83	1.84
	IP	-	-	1.35	1.35	1.59	1.59	1.84	1.84
Shannon	AM	-	-	1.41	1.41	1.70	1.70	1.99	1.99
	IP	-	-	1.41	1.41	1.70	1.70	1.99	1.98

Inter-urban bus passenger demand was also calculated for each forecast year at each airport based on existing mode share data.

5.4.2 Projected Other Airport Growth

For all other airports (Knock, Donegal, Kerry and Waterford) modelled as Special Zones in the NTpM a nominal future growth of 10% has been applied to all future years as no long term growth projections were available to inform the NTpM update.

5.5 Distribution of Future Growth (Special Zones)

The approach to the distribution of future growth for Special Zones in the TAGM is different to the approach adopted for all other general zones. As a starting point, the TAGM generates future year trip end demand (origin and destination) for all zones in NTpM (including Special Zone) on the basis of the direct demand equations outlined in Section 4.3. These future year trip ends are then furnessed to generate the future year trip matrices.

The TAGM then removes all future year demand to/from each Special Zone in the relevant matrices and replaces this demand with the base year trip distribution for each Special Zone (as outlined in Section 6 of the NTpM Data Collection Report) that has been factored up to reflect the growth rates presented previously.

6 Goods Vehicle Forecasting

6.1 Overview

Goods vehicle activity is an essential component of the National Transport Model (NTpM). In order to forecast goods vehicle flows for future years (2030, 2040 and 2050), 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.

6.2 Modelling Process

The approach to forecasting HGV was as follows:

- To develop measures of the transport intensity of economic growth as measured by the ratio of Heavy Goods Vehicle Tonnes Carried (HGVTC) to economic activity measures;
- To model variations in the transport intensity of growth due to structural changes in the economy;
- To complement this analysis by also modelling average kilometres per tonne as this is the other factor that has varied in the past; and
- Based on these models to predict HGVTC and derive Heavy Goods Vehicle Tonnes Kilometres (HGVKM)

The modelling process was as follows, HGVTC were predicted on the basis of Gross Value Added (GVA) in the transport generating sectors and housing activity. A measure of transport intensity was then developed (HGVTC/GVA) and this was used to predict average kilometres per tonne. HGVTC and average kilometres per tonne were then combined to derive HGVTC.

An assumption on Average Load per Vehicle Kilometre (ALVK) was then made and combined with HGVTC to derive HGV kilometres of travel. The predicted average kilometres per tonne were then used to predict the share of long distance HGV kilometres of travel.

Figure 6.1 summarises the modelling process.

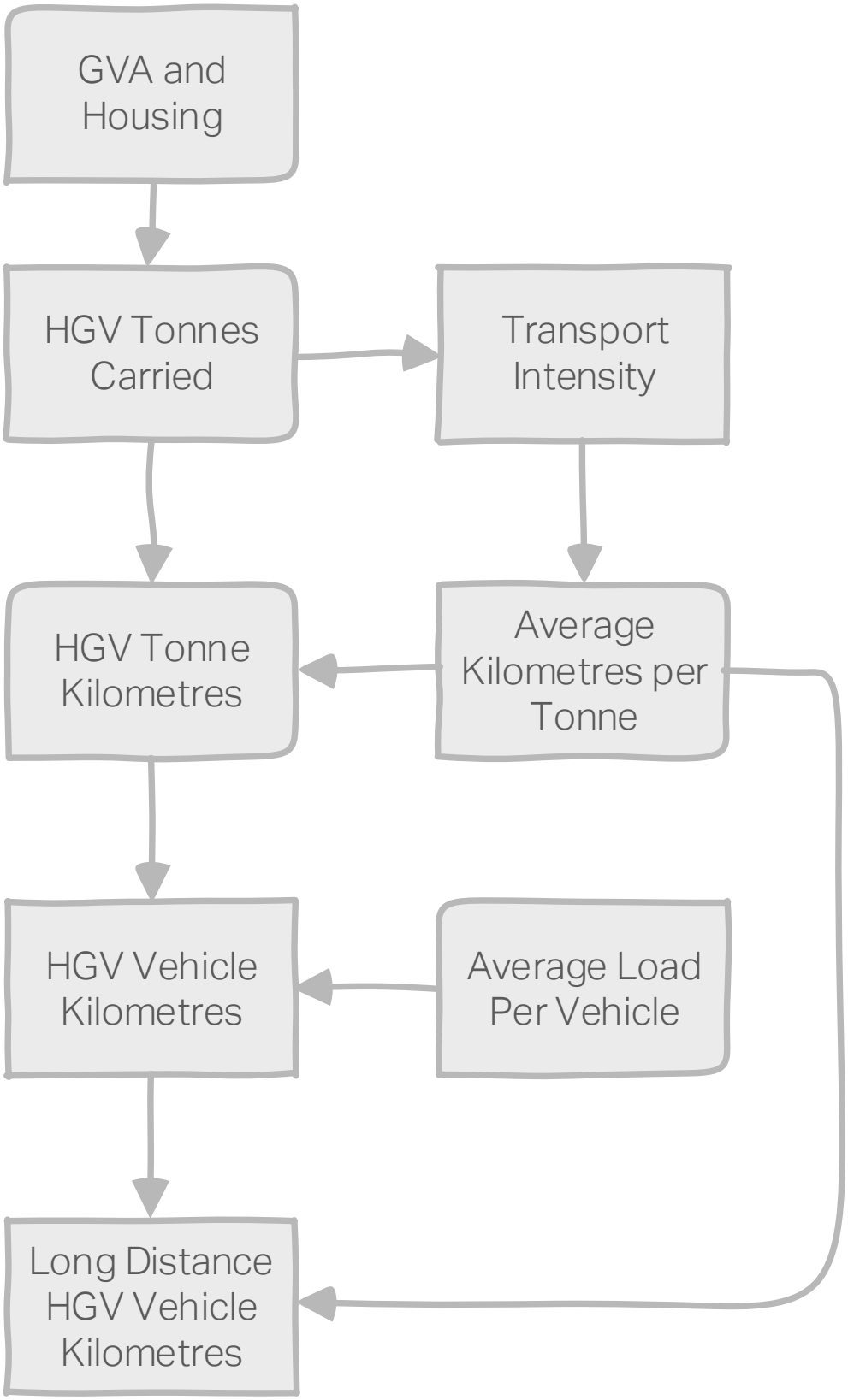

Figure 6.1 Modelling Long Distance HGV Vehicle Kilometres

6.3 Overview of Trends

Table 6.1 and Figure 6.2 present data of HGVKM and GVA between 1995 and 2014. It is clear from Figure 6.2 that HGVKM peaked in 2006/2007 and declined rapidly thereafter, as the economic recession took hold. It is useful, therefore, to consider the trends in two separate time periods 1995-2006 and 2006-2016. Consideration of the earlier period when economic growth and HGVKM were strong should be instructive in terms of forecasting for a period when economic growth has resumed.

Over the period, 1995-2006, HGVKM grew by 997m to 2242m, an increase of over 130%. This corresponds to an average annual rate of growth of 7.9%. This is a very high growth rate and largely reflects the strong economic growth of the period, which amounted to 113% in aggregate and 7.1% annually in GVA terms[14]. However, it may be seen that the rate of growth of HGVKM surpassed that of GVA in that period. As Figure 6.2 shows this is especially true of the post year 2000 period.

In the period after 2006, HGVKM declined to 1,302m in 2015 or by 42%, before rising again in 2016. The extent of the decline in HGVKM much exceeded that of the decline in GVA, which by 2011 had regained its pre-2006 level. This indicates that the relationship between the two variables changed after 2006. HGVKM suffered a collapse post-2006, from which it has yet to fully recover, despite a recovery in GVA.

Table 6.1 Trends in HGV Kilometres of Travel and GVA at Constant 2015 Basic Prices

Year	HGVKM	GVA	Year	HGVKM	GVA
1995	974	77,277	2005	2,312	157,097
1996	1,175	83,112	2006	2,242	164,530
1997	1,208	91,770	2007	2,332	173,852
1998	1,327	99,307	2008	2,207	169,222
1999	1,416	109,460	2009	1,585	164,534
2000	1,595	119,375	2010	1,457	168,020
2001	1,585	127,197	2011	1,338	173,995
2002	1,851	136,152	2012	1,316	174,087
2003	1,966	140,162	2013	1,261	176,540
2004	2,139	149,471	2014	1,307	191,028

[14] Gross Value Added at basic constant prices is a measure that is closely aligned to GDP, but unlike the latter is available on a sectoral basis.

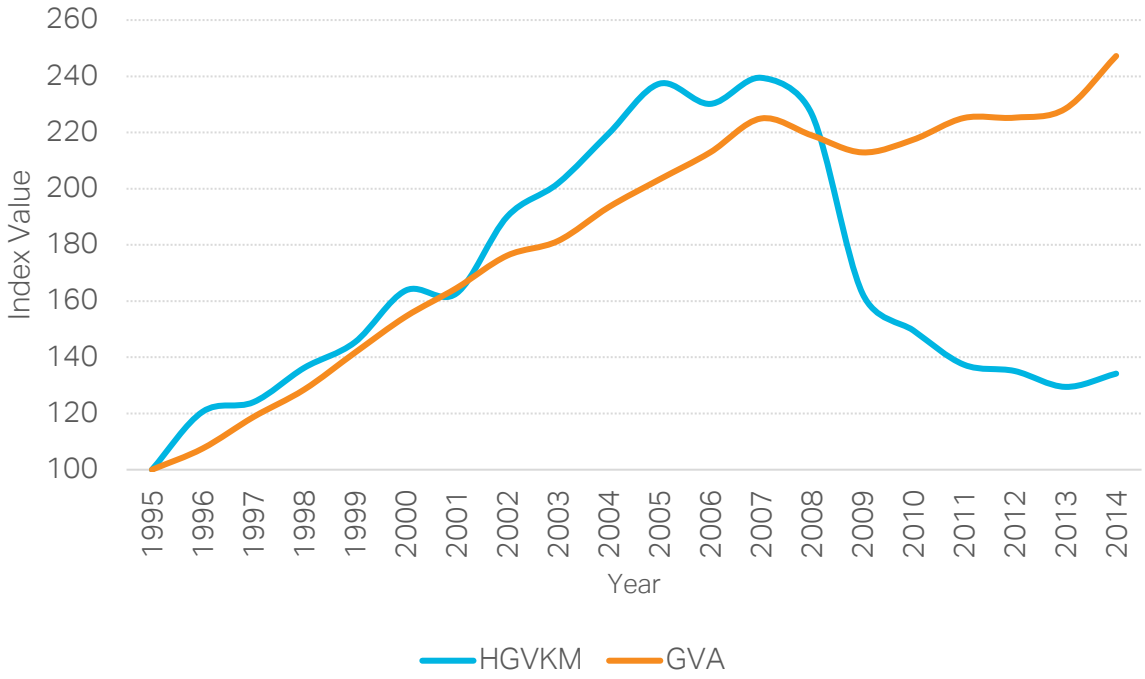

Figure 6.2 HGV Kilometres of Travel and GVA, 1995-2014 Index Values 1995 = 100[15]

6.4 Driver of Trends in HGV Kilometres of Travel

In order to better understand how GVA gave rise to growth in HGVKM, it is important to look at the underlying relationship between these two variables. HGVKM arise because of the need to transport goods. That is, HGVKM reflect the fact that economic growth produces a volume of output that needs to be transported, in the form of both inter-industry flows and from industry to the consumer.

The extent to which this gives rise to vehicle kilometres of travel depends on factors such as the distances that goods need to be transported and the average load factors.

Economic activity gives rise to tonnes of product to be carried. However, not all of it will be carried by HGVs as the rail mode and LGVs also carry goods. The average distance that each tonne is carried by HGVs, when multiplied by the tonnage gives the tonne kilometres operated by HGVs. To get HGV vehicle kilometres we need to divide tonne kilometres by the average load factor per vehicle.

6.5 Modelling Average Load per Vehicle Kilometre

Average load per vehicle kilometre has been relatively static over a long period because the tendency for some LGVs to be replaced by HGVs in the lowest unladen weight category has been offset by an increase in the proportion of HGVs in the highest unladen weight category. For the purposes of prediction, it was assumed that this would remain the case. That is average load per vehicle kilometre would remain at its 2014 level.

6.6 Modelling Long Distance HGVKM

The CSO's Road Freight Survey does not identify HGV traffic by network type. However, it does distinguish HGVKM by length of haul. It can reasonably be argued that trips with a longer trip

[15] Figure 1 was derived from CSO Statistics. Data for 2015 and 2016 are not shown as GVA in those years was distorted by the activities of multinational companies.

length are more likely to incorporate use of the National Road network and the longer the trip, the greater that use.

The Road Freight Survey distinguishes traffic by length of haul. For the purposes of analysis, short-distance travel was defined as that with length of hail less than 50 kilometres and long distance travel as greater than 50 kilometres. Figure 6.3 shows the trends in both short and long distance HGVKM over the period from 1995 to 2016.

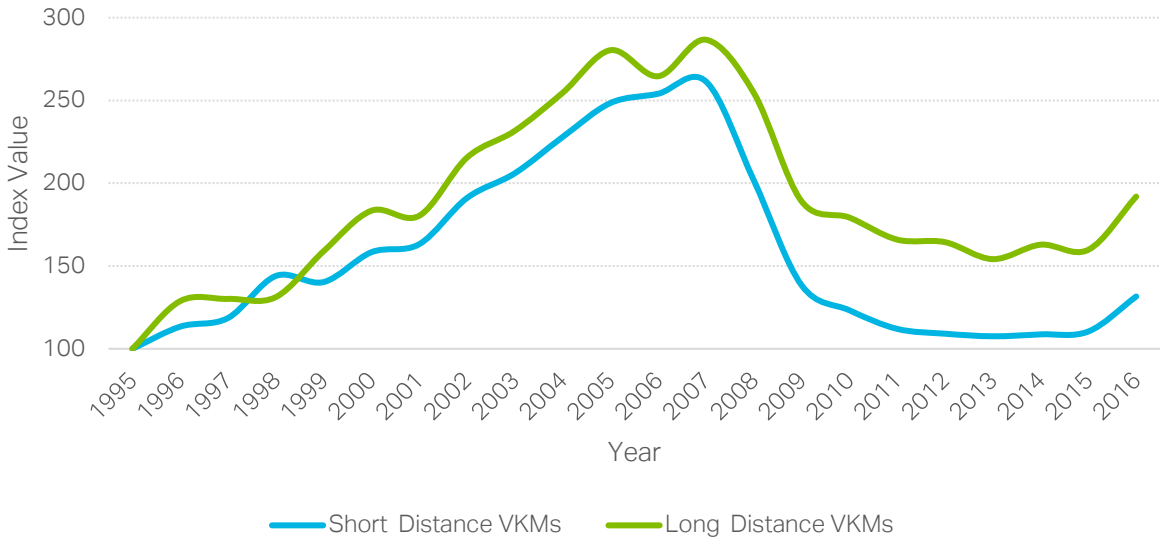

Figure 6.3 Trends in Short and Long Distance HGVKM (Index Values 1995 = 100)

In the period up to the financial crisis, long distance HGVKM grew at a slightly faster rate than short distance. During the period of the recession, however, short distance traffic suffered a more substantial decline that long distance traffic, most probably reflecting the decline in construction related haulage. There is evidence of a resurgence in both categories of traffic in 2015 and 2016.

The proportion of total HGVKM which was long distance traffic has substantially exceeded that of short distance since the onset of the financial crisis. A relationship between the proportion of long distance HGVKM and the average length of haul may be observed as per Figure 6.4.

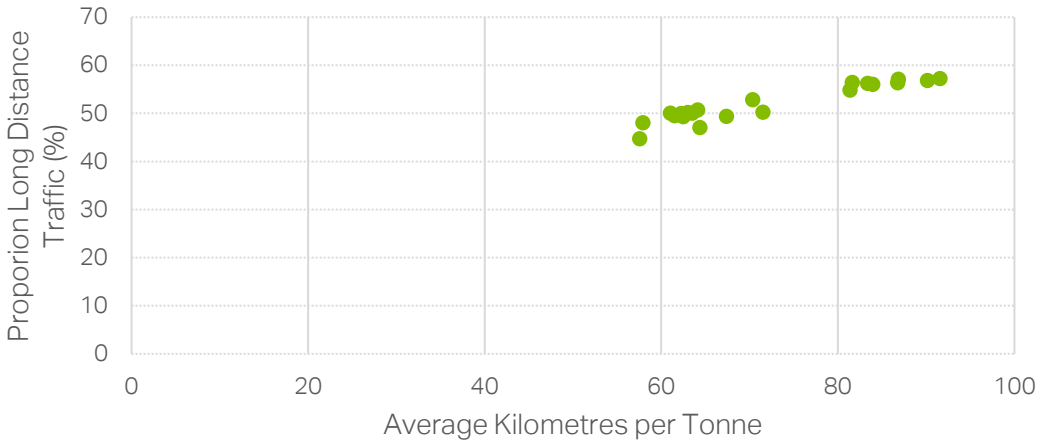

Figure 6.4 Proportion of Long Distance HGVKM (%) versus Average KM per Tonne

As average kilometres per tonne increases, so too does the proportion of that long distance HGVKM is of the total. This enabled a relationship to be developed as follows:

$$Long\ Distance\ HGVKM = 30.5965 + 0.2964\ AKMT$$

R-Square = 0.8853 F= 138.9 N=20

Where:

- Long Distance HGVKM - proportion of total HGVKM that is long distance
- AKMT - average kilometres per tonne.
- The data period was from 1995 to 2014. This shows a high level of fit (R-square = 0.8853).
- This relationship permits any prediction of total HGVKM to be split between short and long distance traffic.

6.7 Predictions of HGV KM

The modelling process can be used to make predictions of HGVKM for any future time period, based on assumptions about the development of the economy in terms of both its size and structure. In using the model, it was assumed that the predictions for long distance HGVKM are the most relevant to the National Transport Model, which is focussed on National Route Traffic.

The key inputs to any prediction are:

- The assumed growth path of the economy as measured by GVA in the transport generating sectors in particular; and
- The assumed level of activity in the construction industry in the form of housing completions.

With regard to growth in GVA in the transport generating sectors, this is related to overall GVA growth. In the period up to the financial crisis, the rate of growth in GVA in the transport generating sectors tended to fall some 10% short of that for GVA as a whole. This indicates that despite the substantial level of activity in the building and construction sector, the "dematerialisation" of the Irish economy was continuing. In making predictions up to 2040, it was assumed that this process would continue at the same rate.

The modelled data period covered 1995-2014. There is therefore a need to input into model predictions the actual economic outcomes in the period 2014-2017. This is quite difficult to do because of the disruption to measurement of GDP, GVA and other aggregates caused by the activities of multi-nationals. Based partly on the ESRI's Quarterly Commentary for Spring 2018, we have inputted a rate of growth in GDP of 4.5% per annum for the period 2014-2019. Thereafter, it is assumed that GDP will grow at 3.0%, or alternatively at 4.0% p.a.[16]

Turning to housing completions, the Government' National Planning Framework, 2040 sets out targets for housing completions. These are for the development of 300,000 housing units over a ten-year period, followed by another 250,000 units up to 2040. This scale of activity has been inputted to the model, with the assumption that there is a gradual ramp-up in activity from the 2017 base level of c. 19,000 units.

[16] This is purely for the assumption of this Report. In the context of the NTpM forecasts as a whole, there is a need to set out a consistent set of assumptions for GDP, population, employment and jobs up to the horizon of 2040.

Table 6.2 sets out predictions for long distance HGVKM base on two alternative assumptions for GVA growth post 2019 of 3.0% and 4.0% per annum respectively. The corresponding assumptions for GVA in the transport generating sectors were 2.7% and 3.6% per annum.

As may be seen, based on the recovery in the economy and in the construction sector in particular, a short-term growth rate in total HGVKM at or in excess of 7.9% p.a. is predicted. Thereafter, the rate of growth in total HGVKM moderates. Under the assumption of a 3% p.a. growth in GVA, the HGVKM growth rate moderates to 3.1% in the period 2020 to 2025 and reduces to just over 2% thereafter.

Table 6.2 Predictions of Annual Rate of Growth in Total HGVKM up to 2040

Period	GVA Growth Rate per annum	
	3.0%	4.0%
2015-2020	7.9%	8.1%
2020-2025	3.1%	4.0%
2025-2030	2.0%	3.0%
2030-2035	2.3%	3.3%
2035-2040	2.3%	3.3%

Turning to long distance HGVKM, somewhat lower but still substantial rates of growth of 7.3% to 7.5% per annum are predicted. These rates of growth moderate over the medium to long term as illustrated in Table 6.3.

Table 6.3 Predictions of Annual Rate of Growth in Long Distance HGVKM up to 2040

Period	GVA Growth Rate per annum	
	3.0%	4%
2015-2020	7.3%	7.5%
2020-2025	3.0%	3.9%
2025-2030	2.1%	3.1%
2030-2035	2.4%	3.4%
2035-2040	2.4%	3.4%

6.8 Allocation of National HGV Growth to NTpM Zones

The previous sections of the report have described the process of estimating HGV growth at a national level. In order to disaggregate the national growth projections to an NTpM zone level, the following process was put in place which utilises the relationship between the number of jobs in a zone and the level of HGV demand:

1. Develop an annual index of jobs projections (base = 2016);
2. Develop an annual index of HGV growth (base = 2016);
3. Forecast annual HGV growth per jobs (Step 2 / Step 1);
4. Establish base year trip ends per job (origin & destination);
5. Apply HGV growth per job to base year trip ends per job (Step 3 and Step 4);
6. Multiply forecast trip ends per job by forecast jobs per zone; and
7. Aggregate growth in trips ends and adjusts accordingly to national growth cap.

The process set out above was incorporated into the NTpM TAGM and used to distribute HGV growth throughout the NTpM zones.

7 Conclusion

7.1 Overview

A series of models have been developed to forecast demographic and car ownership growth for three forecast years, 2030, 2040 and 2050 and three NTpM growth scenarios, Low, Central and High. This data has been converted to vehicle and passenger trip demand matrices for use in the NTpM assignment models via the NTpM Trip Attraction Generation Model (TAGM). The TAGM has also been developed to take account of specific growth at all Ports and Airports (Special Zones) and also takes into account the projected growth in HGV demand.

7.2 Summary of National Projections

A summary of the 2016 and forecast 2030, 2040 and 2050 national level projections are provided in Table 7.1, Table 7.2 and Table 7.3 respectively. The following projections are presented:

- Population;
- Jobs; and
- Number of Cars.

Table 7.1 2030 National Projections

Scenario	Population		Jobs		No. of Cars	
	Total	Growth	Total	Growth	Total	Growth
2016	4.76m	-	2.01m	-	2.03m	-
Low	5.20m	9.2%	2.49m	23.9%	2.63m	29.6%
Central	5.31m	11.6%	2.54m	26.4%	2.64m	30.0%
High	5.56m	16.8%	2.66m	32.3%	2.65m	30.5%

Table 7.2 2040 National Projections

Scenario	Population		Jobs		No. of Cars	
	Total	Growth	Total	Growth	Total	Growth
2016	4.76m	-	2.01m	-	2.03m	-
Low	5.41m	13.7%	2.58m	28.4%	2.92m	43.8%
Central	5.64m	18.5%	2.68m	33.3%	2.99m	47.3%
High	6.12m	28.6%	2.91m	44.8%	3.01m	48.3%

Table 7.3 2050 National Projections

Scenario	Population		Jobs		No. of Cars	
	Total	Growth	Total	Growth	Total	Growth
2016	4.76m	-	2.01m	-	2.03m	-
Low	5.57m	17.0%	2.67m	32.8%	3.26m	60.6%
Central	5.90m	23.9%	2.83m	40.8%	3.31m	63.1%
High	6.65m	39.7%	3.37m	67.7%	3.36m	65.5%

7.3 Summary of Vehicle & Passenger Trip Totals

7.3.1 Light Vehicle Trip Totals

A summary of the 2016 and forecast 2030, 2040 and 2050 LV vehicle demand matrix totals for the Central , Low and High growth scenarios is provided in Table 7.4, Table 7.5 and Table 7.6, respectively. These figures provide a summary of the overall growth at a national level, these rates would vary significantly at NTpM zone level.

Table 7.4 NTpM Central Growth (LV) Trip Matrix Totals – Republic of Ireland

Scenario	AM Peak		Inter Peak	
	Total	Growth	Total	Growth
2016	419,755	-	366,178	-
2030	517,123	23.2%	443,750	21.2%
2040	544,876	29.8%	468,600	28.0%
2050	569,538	35.7%	491,182	34.1%

Table 7.5 NTpM Low Growth (LV) Trip Matrix Totals – Republic of Ireland

Scenario	AM Peak		Inter Peak	
	Total	Growth	Total	Growth
2016	419,755	-	366,178	-
2030	505,624	20.5%	434,136	18.6%
2040	522,931	24.6%	450,112	22.9%
2050	537,035	27.9%	463,526	26.6%

Table 7.6 NTpM High Growth (LV) Trip Matrix Totals – Republic of Ireland

Scenario	AM Peak		Inter Peak	
	Total	Growth	Total	Growth
2016	419,755	-	366,178	-
2030	537,406	28.0%	463,970	26.7%
2040	584,740	39.3%	508,456	38.9%
2050	653,641	55.7%	570,895	55.9%

7.3.2 Heavy Vehicle Trip Totals

A summary of the 2016 and forecast 2030, 2040 and 2050 HV vehicle demand matrix totals for the Central , Low and High growth scenarios is provided in Table 7.7, Table 7.8 and Table 7.9, respectively. These figures provide a summary of the overall growth at a national level and would vary significantly at NTpM zone level.

Table 7.7 NTpM Central Growth (HV) Trip Matrix Totals – Republic of Ireland

Scenario	AM Peak		Inter Peak	
	Total	Growth	Total	Growth
2016	8,919	-	9,382	-
2030	13,419	50.5%	13,488	43.8%
2040	15,597	74.9%	15,666	67.0%
2050	19,003	113.1%	19,067	103.2%

Table 7.8 NTpM Low Growth (HV) Trip Matrix Totals – Republic of Ireland

Scenario	AM Peak		Inter Peak	
	Total	Growth	Total	Growth
2016	8,919	-	9,382	-
2030	13,904	55.9%	14,622	55.9%
2040	16,073	80.2%	16,896	80.1%
2050	19,214	115.4%	20,190	115.2%

Table 7.9 NTpM High Growth (HV) Trip Matrix Totals – Republic of Ireland

Scenario	AM Peak		Inter Peak	
	Total	Growth	Total	Growth
2016	8,919	-	9,382	-
2030	14,348	60.9%	14,348	52.9%
2040	17,639	97.8%	17,719	88.9%
2050	24,039	169.5%	26,891	186.6%

7.3.3 Passenger Trip Totals

A summary of the 2016 and forecast 2030, 2040 and 2050 passenger demand matrix totals is provided in Table 7.10, Table 7.11 and Table 7.12, respectively. These figures provide a summary of the overall growth at a national level and would vary significantly at NTpM zone level.

Table 7.10 NTpM Low Growth (PT) Passenger Trip Matrix Totals – Republic of Ireland

Scenario	Inter Urban Bus (15hr)		Heavy Rail (15hr)	
	Total	Growth	Total	Growth
2016	117,655	-	140,704	-
2030	152,680	29.8%	179,876	27.8%
2040	164,116	39.5%	192,277	36.7%
2050	175,687	49.3%	202,219	43.7%

Table 7.11 NTpM Central Growth (PT) Passenger Trip Matrix Totals – Republic of Ireland

Scenario	Inter Urban Bus (15hr)		Heavy Rail (15hr)	
	Total	Growth	Total	Growth
2016	117,655	-	140,704	-
2030	157,399	33.8%	186,340	32.4%
2040	174,034	47.9%	205,863	46.3%
2050	191,183	62.5%	222,871	58.4%

Table 7.12 NTpM High Growth (PT) Passenger Trip Matrix Totals – Republic of Ireland

Scenario	Inter Urban Bus (15hr)		Heavy Rail (15hr)	
	Total	Growth	Total	Growth
2016	117,655	-	140,704	-
2030	168,011	42.8%	201,393	43.1%
2040	195,581	66.2%	235,601	67.4%
2050	233,573	98.5%	286,052	103.3%

8 Appendices

8.1 Appendix A – Prospects for Irish Regions and Counties Scenarios and Implications

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SCENARIOS AND IMPLICATIONS

EDGAR L. W. MORGENROTH

ESRI ECONOMIC & SOCIAL RESEARCH INSTITUTE

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CHAPTER 1

Introduction

While the likely future development paths of national economies are regularly analysed, the prospects of regional economies receive far less attention. In Ireland short-term prospects of the national economy are provided by the ESRI (McQuinn et al., 2016), the Central Bank (Central Bank, 2017) and the Department of Finance (Department of Finance, 2017) among others, and medium-term projections are published by the ESRI (see FitzGerald and Kearney, 2013; Bergin et al., 2016a). In contrast the only regional projections that are periodically published are those on population and labour force produced by the Central Statistics Office (CSO, 2013).[1]

Projections of development paths, both in terms of the population and economic activity, provide an important prerequisite to the efficient planning of infrastructure and public services, highlight policy challenges and identify policy trade-offs. For example, projections about the numbers of children in the future should facilitate the timely development of appropriate school infrastructure. Likewise an understanding of the likely growth in economic activity allows policymakers to set out appropriate public capital budgets in order to address corresponding infrastructure needs. Importantly, such analysis can also highlight potential undesirable developments, such as housing market risk (e.g. FitzGerald et al., 2005) or potential constraints such as the possible lack of available bank finance to fund the expansion of the Irish housing stock to accommodate a growing population (Duffy et al., 2016).

While the available aggregate projections provide important insights they cannot account for the fact that both the population and economic activity are not evenly spread throughout the country. Indeed, differing spatial distributions of the population and economic activity can impact on aggregate (national) development. The international literature has shown that the degree to which activity is concentrated in urban centres affects aggregate productivity (Henderson, 2003).

The spatial distribution of the population and economic activity also impact on the cost of providing public services. For example, a large number of children concentrated in one area might be accommodated in a small number of large

[1] Population and Labour Force Projections are produced by the CSO after every Census, as the Census provides the required baseline data to update population projections.

schools while a similar number of children residing in a more spread out pattern might only be practicably accommodated in a larger number of small schools. If the per pupil cost of building a new school decreases with school size, then a more dispersed population requiring more smaller schools will result in higher costs.

Knowing that the economy will expand in the future does not help in identifying where new infrastructure is needed. For this, robust projections at the regional or local level are required. There are thus a number of reasons why projections of key variables at the regional or county level are important. An important aspect is that projections should be realistic, grounded in evidence and consistent with national projections, rather than based on aspiration. They should also reflect underlying market interaction (see Morgenroth, 2013). To achieve this goal one needs to utilise a model that is based on actual data and that ensures consistency.

However, model building at the regional or county level is not a trivial exercise. A significant issue is the lack of data. While macroeconomists can draw on a full set of National Accounts, a complete set of regional accounts is not available to researchers interested in regional development. Regional data are also often published with a significant time lag. Data availability varies for different regional scales, with more data being available at the regional level than at the county level.[2] A second issue is that in order to generate consistent projections one needs to use some form of model. Even relatively simple regional models that cover a comprehensive set of variables are more complicated than comparable national models as each variable has to be modelled for each region. A model for just four variables for the eight former NUTS 3 planning regions would require the estimation of 32 equations. It is therefore not surprising that regional projections have not been published for Ireland.

[2] The regional dimension considered in this report encompasses the NUTS 3 planning regions; Border, Dublin, Mid-East, Midland, Mid-West, South-East, South-West and West. The Border region consists of Cavan, Donegal, Leitrim, Louth, Monaghan and Sligo. Dublin consists of the four Dublin local authorities. The Mid-East consists of Kildare, Meath and Wicklow. The Midland region consists of Laois, Longford, Offaly and Westmeath. The Mid-West comprises Clare, Limerick and Tipperary North Riding. The South-East consists of Carlow, Kilkenny, Tipperary South Riding, Waterford and Wexford. South-West consists of Cork and Kerry and finally the West consists of Galway, Mayo and Roscommon. The report also covers the three NUTS 2 regions namely the East and Midland region (EMR) which is made up of Dublin, the Mid-East, the Midland regions plus Louth; the North and West region which made up of the West and Border regions minus Louth; and the South region which consists of the South-East, South-West and Mid-West regions.

CHAPTER 2

Summary of findings

This report takes a first step towards providing consistent projections for key variables at the regional and county level and provides projections for a number of these variables up to 2040. This work is an important input for the production of the National Planning Framework (NPF), which will replace the National Spatial Strategy (NSS). The Department of Housing, Planning and Local Government published a paper entitled *Issues and Choices* as part of the consultation process on the National Planning Framework (see Department of Housing, Planning, and Local Government, 2017). The Issues and Choices paper sets out the main issues to be addressed by the NPF and posed a series of question in relation to the future spatial patterns on which the Department of Housing and Planning sought submissions.[3] The projections set out in Chapters 4 and 5 of this paper provide an important context in that they identify the likely development patterns under a 'current trends' scenario, where no effort is made to change the patterns of development that have been observed in the past.

As the development of a fully specified integrated regional model for Ireland is hampered by data gaps the approach used here is to consider those variables for which data are available and which help inform the planning process. These include population, employment and the location of jobs. Trends in these variables have important implications, for example, for the number and location of new housing units required, the type and amount of new infrastructure required, commuting patterns and the resulting transport requirements etc., all of which are central to efficient planning.

Given these limitations it is also beyond the scope to explicitly incorporate the interaction with Northern Ireland in the model. These are particularly important for Donegal, but are also relevant for other Border counties. It is also beyond the scope of this report to consider the potential impact of Brexit at the regional level. It should however be noted that early research by Morgenroth (2017) shows that Brexit is likely to have regionally differentiated effects and that a hard Brexit could hit counties Cavan and Monaghan particularly hard due to the importance of the agri-food sector in these counties.

[3] www.ireland2040.gov.ie.

The objective of Chapter 4 is to provide some baseline projections on what is termed here a 'current trends basis'. This assumes that the development patterns of the recent past are maintained in the future and there are no policy interventions to change these. Chapter 5 considers a set of alternative scenarios. These alternative scenarios are generated as projections under different assumptions.[4] By setting out and quantifying alternative spatial development paths it is possible to assess the implications of these scenarios, whether they can be achieved and what sort of policy actions would be needed to achieve them. As the models developed are relatively simple, they do not incorporate all determinants of spatial patterns and their impact at different spatial scales. Chapter 6 of this report therefore also reviews the international, and where available, the national literature on the key market mechanisms that operate in modern economies and identifies their implications for spatial planning.

The empirical approach used to develop the projections is based on relatively simple regression techniques to model variables for individual regions but to constrain the results to aggregate to the projections provided in the recent ESRI Economic Outlook (see Bergin et al., 2016a). The population is modelled using the modelling technique used by the CSO to construct national and regional population projections and these are constrained to aggregate to the population projections produced as part of the ESRI Economic Outlook. In contrast to the CSO projections the model used is at the county level. Likewise the jobs and employment projections are also produced at the county level.

As the Economic Outlook baseline only provides projections to 2030, the last ten years in the projection horizon are linearly extrapolated forward to 2040. It is important to note that the projections should not be taken as a forecast, but as a scenario that might arise given a set of assumptions and unchanged modelling parameters. This is important as the projections are subject to significant uncertainties. However, the chosen approach ensures consistency with the national baseline, given that the sum of a regional variable has to add to the national baseline. The lack of fully worked alternative scenarios at the national level that might encompass higher and lower growth than that in the baseline, as for example in Wren et al. (2017), means that such high and low scenarios are not produced in this report. Additionally, producing regional scenarios for two further national scenarios would result in 18 different scenarios being produced. It should however, be noted that the national baseline scenario considered here is

[4] There is an important distinction between a projection and a forecast. A projection is a scenario that is constructed under a set of assumptions about the future – it is thus hypothetical and a set of different projections can be produced under alternative assumptions. A forecast is a prediction of the future.

a relatively benign scenario which would see Irish GDP grow by 3 per cent or more each year until 2040.[5]

Given that the current trends scenario entails the continuation of existing spatial development trends, these are outlined with respect to a range of variables in Chapter 2, which also shows the data availability and gaps. The analysis leads to a number of findings:

- As regional output measures are subject to the same distortions affecting Irish GDP, they may not accurately reflect the underlying regional economic trends. They show increasing differences between the regions.
- Household income measures track the economic cycle better, and there have been periods of both convergence and divergence for real per capita income over the period 1991 to 2014. Since 2010 per capita income growth has been faster in the regions with higher income levels.
- The significant population growth between 1991 and 2016 was not evenly spread, with the Mid-East region in particular registering significantly faster population growth. This has contributed to a growing share of the population residing in the Greater Dublin Area, including spillovers in Louth and Midland counties.
- Age dependency rates have increased, but over the period the child age dependency rate exceeded the old age dependency rate, highlighting the still favourable age structure in Ireland. As deaths are increasing while births are falling, the natural increase of the population is declining. This is most pronounced in the Midland and South-West regions.
- Employment, the number of persons resident in a region that are employed, has grown significantly since the early 1990s. The recovery in employment has been stronger since the economic crisis in 2008 in the Dublin, Border and South-East regions than elsewhere, although the level of employment has not reached peak levels in any region yet.
- While the unemployment rate across the regions follows a very similar time path, there are differences between the regions. On average over the full period, the highest unemployment rates were recorded in the Border, South-East and Midland regions. The lowest rates were recorded in the Mid-East, Mid-West and West.
- The data relating to the location of jobs show that the highest growth rates in this variable in the 2002 to 2006 period were achieved in Meath, Leitrim and Kildare. However, those counties that experienced the fastest growth in the 2002 to 2006 period also on average experience a greater decline in the 2006 to 2011 period.

[5] The projections in this report are consistent with the mid-range results reported in Wren et al. (2017).

Chapter 3 provides projections of the population, employment and the number and location of jobs under a current trends scenario. The chapter also briefly outlines the modelling approaches taken. The main findings from this analysis are:

- Population projections are produced on the basis of constant 2016 fertility rates (F1) which at 1.81 children per female is now below replacement. The CSO mortality rates utilised in the projections are those used by the CSO and the international migration projections are from the ESRI Economic Outlook. Net migration is assumed to run at on average just over 8,000 per year and from 2021 onwards net migration is assumed to run at 12,500 per annum.
- Projections are produced for each county and over the period 2016 to 2040 the national population is projected to increase by almost 900,000 persons to 5.634 million.
- Population growth is projected to be greatest in and around the major cities and in particular Dublin, with the population share of the Dublin and Mid-East regions projected to increase to 41.7 per cent from 40 per cent, with significant growth also projected for Louth.
- Old age dependency is projected to increase significantly throughout the country but is projected to be highest in the Border and South-East regions.
- Employment projections for the sectors defined in the ESRI Economic Outlook are developed using econometric modelling and produce results for employment, unemployment and the labour force that are consistent with the working age population projected using the population projection model.
- Under the 'current trends' scenario, above average (1.4 per cent) employment growth rates are projected particularly for the Mid-East and to a lesser extent in the South-West, West and Border regions.
- Jobs, i.e. where jobs are located, are also projected using econometric modelling, but due to the limited data series available for jobs, the results need to be interpreted with caution.
- Dublin and the Mid-East are projected to have above average jobs growth. The jobs growth in the South-West and West is projected to be just under the national average, which is largely due to the influence of Cork and Galway. Overall the projections imply economic divergence across the regions, with Dublin in particular growing significantly faster.

Chapter 5 sets out five alternative demographic scenarios to the current trends scenario. One scenario considers a situation where the East and Midland region

grows more than under the current trends scenario. Such a scenario implies that the greater Dublin area will be even more dominant that it currently is. Other scenarios are developed in the chapter where population growth is equally shared between the East and Midland region and the rest of the country and where the growth is concentrated outside the East and Midland region. For the latter two possibilities a more compact city orientated growth pattern and one where growth is more even are also considered. The results of the analysis includes:

- The scenario results show significant deviations of the projected population from the current trends scenario, while the differences for jobs are much more modest.
- The analysis shows that scenarios that encompass more dramatic changes in the spatial patterns are unlikely to be feasible and that they also have undesirable implications.
- A more modest redistribution of growth is feasible, such as that envisaged under the scenario where growth is roughly equally split between the East and Midland region and the rest of the country. This scenario would reduce some of the pressure on the greater Dublin region and while still allowing this to grow significantly.
- The research evidence suggests that the development of scale in the larger cities would have not just regional benefits but would also have macroeconomic benefits. This suggests that the city focused pattern ought to be pursued by policy.
- The results have important implications for policy. Firstly, the even growth scenario still envisages substantial growth in Dublin and surrounding counties. Such growth requires a significant increase in the housing stock.
- If the aim is to increase the scale of second tier cities then this needs to be facilitated by appropriate infrastructure development in the cities rather than between cities, so that the growth can be accommodated in the cities.
- The development pattern needs to be compact and sprawl which is facilitated by infrastructure development between cities should be avoided.

The analysis in Chapters 4 and 5 considered some implications of alternative spatial development patterns, such as the increased long distance commuting under the current trends scenario. However, the data limitations mean that many key economic channels that impact on spatial patterns are not explicitly reflected in these results. A criticism of the National Spatial Strategy (NSS) was that it did not adequately consider the implications of market interaction and the wider economic impact of spatial development patterns which contributed to the modest impact of the NSS (see Morgenroth, 2013). It will therefore be important

for the National Planning Framework to reflect the key insights from the relevant research.

Chapter 5 considers both the determinants of spatial patterns and their impact at different spatial scales with reference to the international, and where available, the national literature. In doing so the paper aims to identify key market mechanisms that operate in modern economies and implications for spatial planning. The main findings of the chapter are:

- Agglomerations are pervasive due to efficiency benefits, have a limited spatial extent, appear not to cross national borders and only occur at higher densities.
- Economic activity can also be excessively concentrated in one centre, which reduces efficiency and thus has a negative effect on national economic performance. This research has also shown that too little agglomeration is bad for national economic performance.
- Importantly, the literature shows that the mechanisms that generate agglomerations may not necessarily generate outcomes that are economically and socially optimal. This points to the important role of policy to address market failures. This is particularly important in the context of the finding that the spatial patterns tend to be self-reinforcing.
- The literature on urban hierarchies suggests that the range and value functions carried out by urban centres is dependent on their scale with larger centres providing a larger range and higher value functions.
- The Irish urban system is dominated by the scale of Dublin relative to other centres, which implies that the second tier cities are unable to provide the range of functions to their hinterland seen in cities of similar rank in other countries. This reinforces the dominance of Dublin and limits the development potential of the other regions.
- An important aspect of spatial development patterns is the functioning of the housing market and its interaction with individuals' residential location decisions. Research shows the role of so-called 'fundamentals', such as income and demographic change, in driving local house prices.
- The limited literature on this for Irish local housing markets suggests that house prices respond more to demographic change than other factors.
- Residential location decisions are made on the basis of access to jobs, house prices and amenities. New research for Ireland shows that if areas with the highest value in terms of jobs and amenities are not affordable, then individuals choose to locate as close to those areas as they can afford, which results in sprawl.

- Developing the scale of second tier cities is likely to yield significant benefits both from a regional and national development perspective.
- Increased scale also implies increased demand for housing, which in turn implies increased house prices, which will lead to sprawl and could undermine efforts to increase the scale of the second tier cities. The only way to effectively address this is to ensure that housing supply is significantly expanded in the cities. It is also imperative to ensure that residential development is accompanied by the development of amenities that will attract residents.
- The implication for policy is that the required infrastructure be put in place in the cities, and that development of infrastructure between cities which fosters sprawl be limited. Consideration also needs to be given to measures to restrict unsustainable sprawl.

Chapter 7 summarises the results and provides some commentary on possible implications of the projections for planning. The analysis provides insights for planning policy and raises questions about the implications of the projected development patterns that are relevant for the National Planning Framework. Importantly, the projections are produced under the assumption that the resulting requirements in terms of housing and infrastructure needs are met and that the projected pattern does not affect the national projections. The main findings include:

- Scale economies inherent in larger urban centres or conurbations result in higher productivity, reduce the cost of providing infrastructure, and allow for a greater diversity of economic activities, which have been found to be growth enhancing. This would suggest that the projected development patterns, being focused on the large urban centres would be growth enhancing.
- The projected patterns under the current trends scenario imply significant sprawl, which has the potential to undermine the positive effects of agglomeration.
- With economic activity concentrating due to agglomeration economies and individuals choosing to live around these agglomerations, there is increasing mismatch between residential location and job location. The projected patterns imply a significant increase in commuting across regions, particularly to Dublin.
- To accommodate this type of spatial development pattern would require significant investment in transport infrastructure, and in particular public transport infrastructure in and around the cities on which growth is focused.

- The projected increase in the population implies an increase of the number of households by more than 500,000, which will need to be housed. As the increase in households is particularly concentrated in Dublin and the Mid-East as well as Cork and Galway, which are areas that have already been identified as having housing shortages, housing completions in these areas need to grow significantly.
- While there are benefits from agglomeration, an excessive concentration in one urban centre has been found to negatively affect national growth. Economic activity in Ireland may already be too concentrated in Dublin, and the projections suggest that the dominance of Dublin is set to increase further.
- Deconcentration can be achieved through investment in interregional infrastructure, fiscal decentralisation and the strengthening of local and regional political autonomy.
- The development of counter-poles to Dublin is likely to increase national growth, but given the size of Ireland and the fact that agglomeration economies only arise for urban areas of significant size, the optimal number of counter-poles is small.

Overall the analysis suggests that the NPF should aim to achieve a modest rebalancing of growth between the East and Midland region and the rest of the country and that the focus should be on the growth of the second tier cities.

CHAPTER 3

Recent trends

In this chapter, trends in key variables across regions and counties are reviewed, which help identify the development paths that are currently in train. In the subsequent chapter some of the series are projected into the future in order to highlight likely future developments under a current trends scenario.

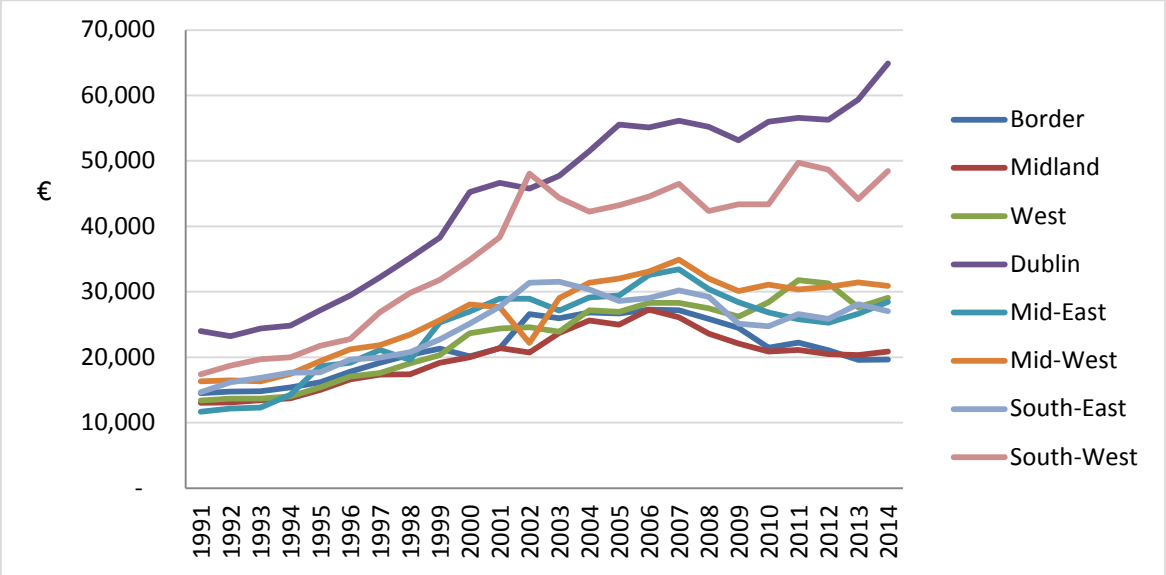
3.1 OUTPUT

Gross domestic product (GDP) is the most widely used variable by which the performance of economies is measured internationally. This applies as much to regions as national economies, and indeed the EU determines Structural Funds eligibility on the basis of regional GDP.

It is useful to consider trends in regional performance as measured by gross value added (GVA), as this is often referred to in discussions about regional development in Ireland. Figure 3.1 shows real GVA per capita over the period 1991 to 2014. The graph shows that Dublin and the South-West have been outperforming the other regions in terms of both the level and growth of per capita GVA. This reflects both the underlying real activity but also the fact that both Dublin and the South-West have attracted more multinational enterprises than the other regions. Data from the CSO Census of Industrial Production for 2012 indicate that about 63 per cent of all output produced by multinationals in industry was produced in the Dublin and South-West regions.[6] The two regions with the lowest per capita GVA are the Midland and Border regions. Interestingly, the West has experienced more rapid growth and has improved its relative position by two places among the eight regions. The South-East in contrast, which had the third highest per capita GVA in 2002 is now ranked fourth from the bottom. The economic crisis affected the Mid-East region significantly and this region suffered the largest reduction in per capita GVA due to the economic crisis. However, all regions have experienced at least some growth since the recession. In the case of the South-West however, per capita GVA has been highly variable since 2007.

[6] The most recent regional and county statistics from the CSO Census of Production are for 2012.

FIGURE 3.1 REAL GROSS VALUE ADDED (GVA) PER CAPITA, 1991 - 2014



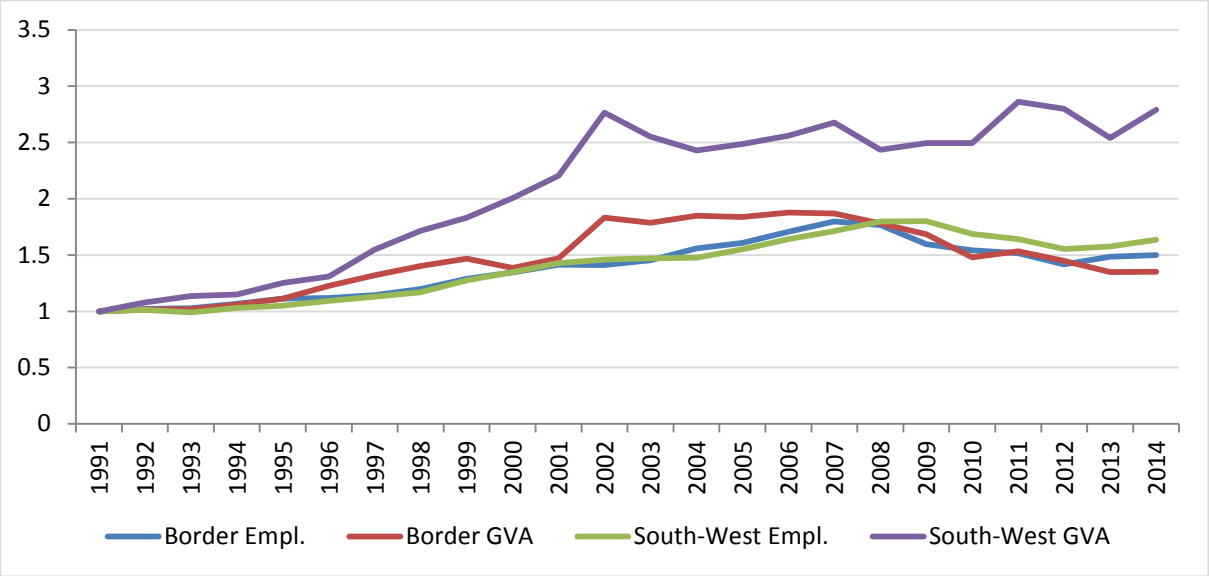
Source: Author's calculations using data from CSO County Incomes and Regional GVA.

While GDP is an appropriate measure for most economies, for Ireland this variable is subject to significant distortions. In particular recent developments with regard to contract manufacturing – the so-called patent cliff in the pharmaceutical sector, the redomiciling of companies to Ireland for tax reasons, and the significance of the aircraft leasing sector – have made the interpretation of Irish National Accounts more difficult (see FitzGerald, 2015). Even before these issues arose, GDP was often considered an inappropriate measure of Ireland's economic performance due to the impact of transfer pricing by multinational companies which raises the value added generated in Ireland. These issues are even more pronounced at a regional level as the multinational companies responsible for driving these distortions are predominantly located in Dublin and to a lesser degree Cork and Galway. Given these shortcomings, GDP or its regional measure gross value added (GVA), are not ideal measures of regional economic performance of Irish regions.

Figure 3.2 illustrates the problem by showing employment and per capita real GVA for the Border and the South-West regions relative to their 1991 levels. This shows that real GVA per capita in the Border region, while more volatile than employment, tracks the trend in employment closely. In contrast, for the South-West region real per capita GVA has grown considerably faster than employment, which follows a similar trend to that of employment in the Border region. While some of the faster growth might be explained by faster productivity growth in the South-West, it is likely that distortions due to the significant presence of multinational firms, particularly pharmaceutical firms in the Cork area, are driving the differences between GVA and employment. This means that while GVA might be a useful variable for some regions, it is less suited to measure the relative

performance of all regions. A partial adjustment is possible using the methodology suggested by O'Leary (2001), but a more complete treatment of the issues requires the development of a new indicator as suggested by ESRG (2016).

FIGURE 3.2 REAL GVA PER CAPITA AND EMPLOYMENT RELATIVE TO THEIR 1991 VALUES



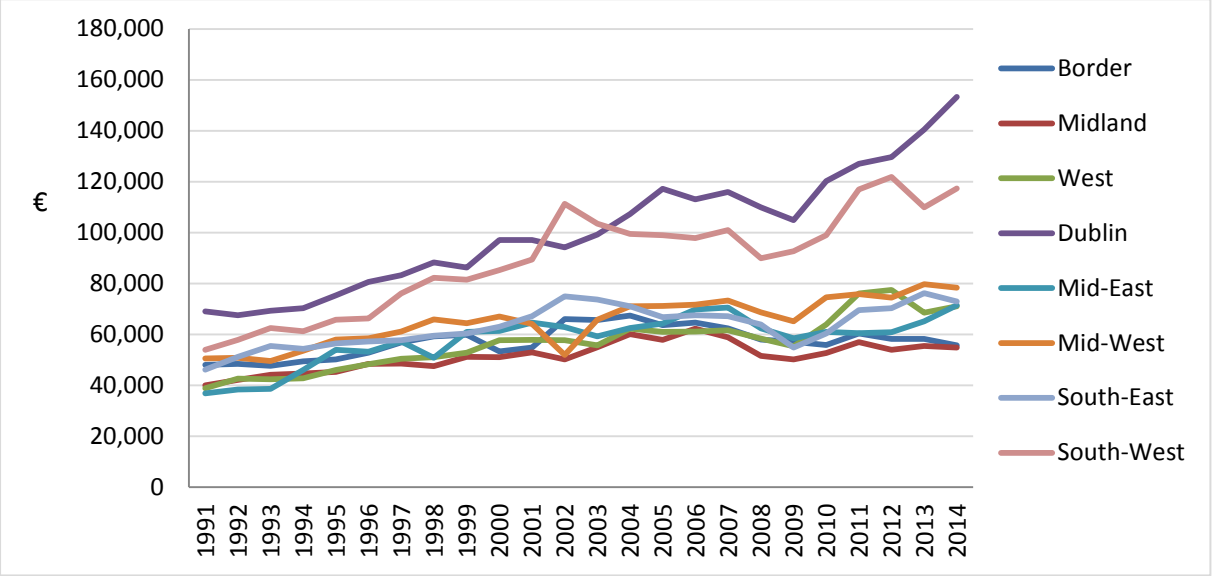
Source: Author's calculations using CSO QNHS and CSO County Incomes and Regional GDP.

Dividing total GVA by employment yields a measure of productivity. Time series data on regional employment are available from the CSO Quarterly National Household Survey (QNHS), but they identify employed people by region of residence rather than region of where they are employed.[7] It should be noted that in addition to the drawbacks of using GVA, productivity measures suffer from mismeasurement due to commuting across regional boundaries. Thus for regions that benefit from net-commuting flows, such as Dublin, productivity is overestimated, while for regions like the Mid-East from which many people commute to Dublin, productivity is underestimated.

Figure 3.3 shows a steady increase in productivity across all regions. Comparing the graph with Figure 3.1 it is noticeable that the Mid-East ranks considerably worse for productivity than per capita GVA, which points to the bias introduced due to the nature of the employment measure. Again, the trends indicate a process of divergence with the high performing regions experiencing faster productivity growth than those with a lower starting productivity in 1991. Also noticeable is the drop in productivity in the immediate wake of the economic crisis.

[7] A full analysis of regional productivity was carried out by Morgenroth (2007), who showed that divergence in GVA was substantially due to divergence in productivity at the regional level, and that these in turn were due to differences in the industrial structure of regions and in particular the importance of multinational enterprises.

FIGURE 3.3 LABOUR PRODUCTIVITY BY REGION, 1991 - 2014



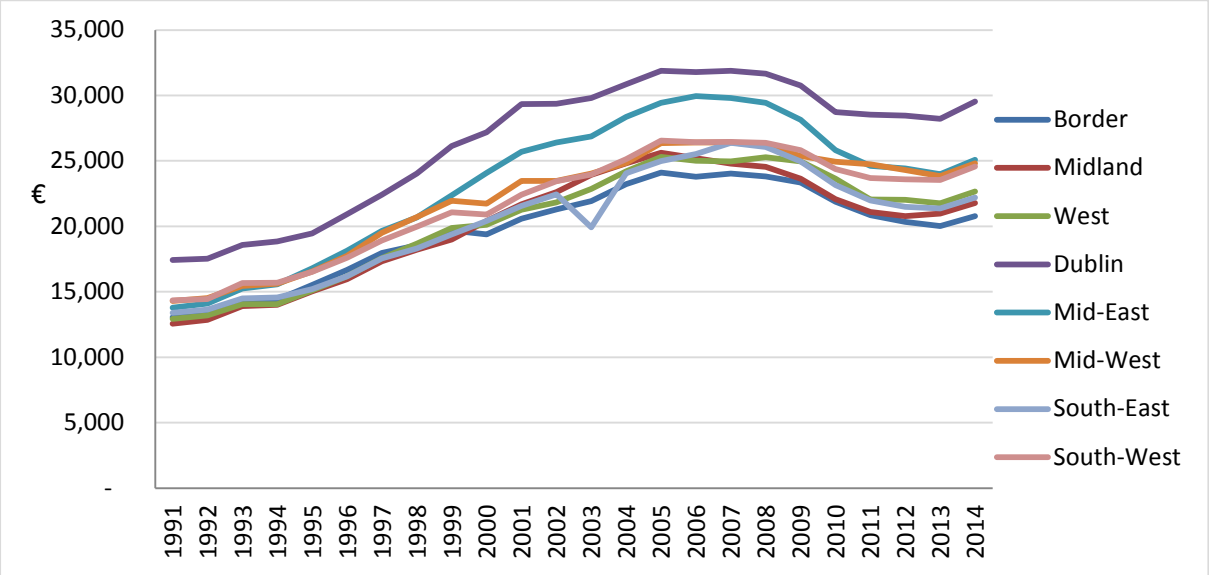
Source: Author's calculations using data from CSO County Incomes and Regional GVA and employment from the CSO Quarterly National Household Survey (QNHS).

3.2 INCOME

Personal or household income is not subject to the distortions highlighted above, except for the impact of the functioning of the tax and welfare measures at the regional level, where transfers benefit the poorer counties more, while taxes affect the richer counties more (see Morgenroth, 2010). Data on income are also available at the county level which is another significant advantage. Importantly, income is measured with respect to where persons earning income reside rather than where they earn their income, and is thus an imperfect indicator of local economic activity.

Figure 3.4 shows real total income per capita, which grew steadily in all regions up to the economic crisis. The graph shows the significant reduction in income and also the more recent growth in incomes, which had not been enough to catch up with the peak by 2014. Dublin has the highest per capita income throughout the period considered here, while the Border and Midland regions consistently have the lowest income. Closer analysis of the data shows that per capita incomes converged during the period up to 1998, then diverged strongly up to 2003, the distribution was quite stable for a period and thereafter has been subject to divergence since 2010.

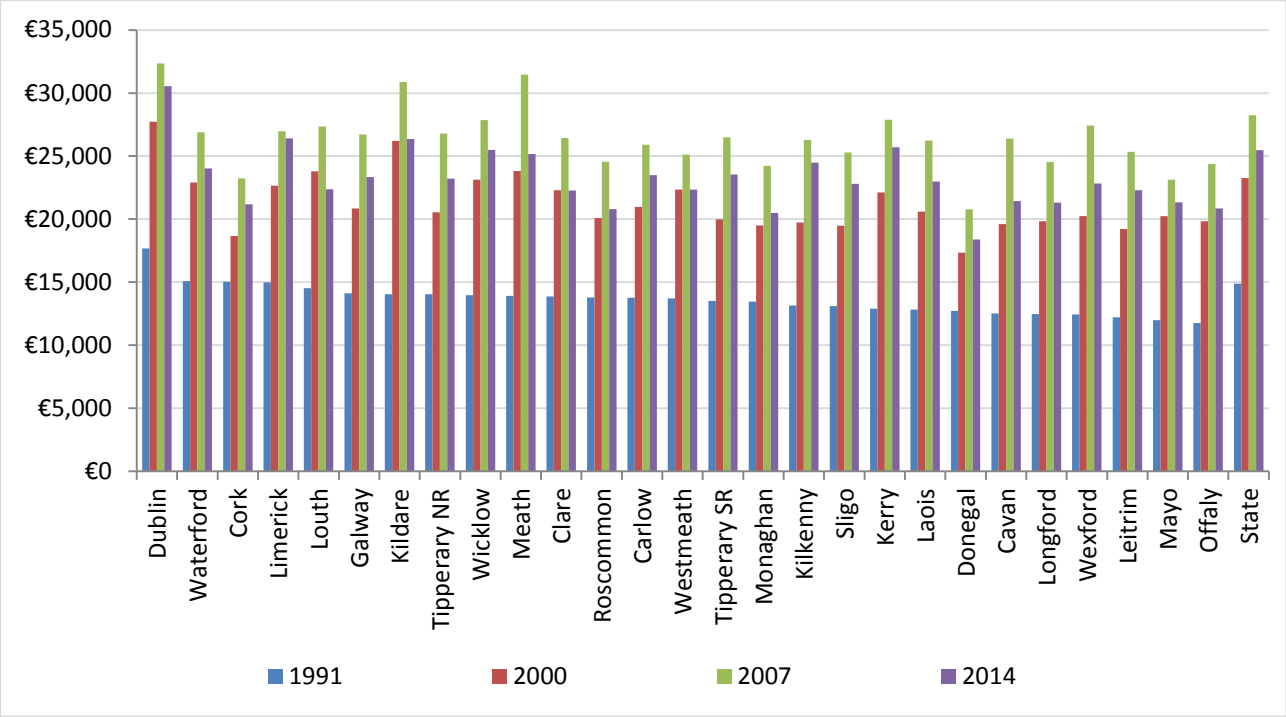
FIGURE 3.4 REAL TOTAL INCOME PER CAPITA BY REGION, 1991 - 2014



Source: Author's calculations using data from CSO County Incomes and Regional GVA and the CSO Consumer Price Index.

Given that income data are available at the county level it is also useful to consider trends across counties. Figure 3.5 shows that real per capita income increased significantly in all counties between 1991 and 2000. In the graph the counties are arranged by their per capita income in 1991, which was highest in Dublin and lowest in Offaly. Dublin maintained the highest per capita income over the entire 1991 to 2014 period, but other counties saw their relative position improve or deteriorate. For example, Waterford dropped from second highest to eighteenth between 1991 and 2014. In contrast, Wexford moved from twenty-fourth to tenth place. At the height of the boom in 2007 Kildare and Meath recorded incomes close to those in Dublin, but the recession affected income in those counties more, such that their real per capita income in 2014 was almost back to the level recorded in 2000. Considering the distribution of per capita county incomes over time, convergence is found over the period 1991 to 1997 and 2001 to 2010 but there was divergence in the period 1998 to 2001 and since 2011.

FIGURE 3.5 REAL TOTAL INCOME PER CAPITA BY COUNTY FOR SELECTED YEARS



Source: Author's calculations using data from CSO County Incomes and Regional GVA and the CSO Consumer Price Index.

3.3 POPULATION

Ireland has experienced considerable population growth over the recent decades. Since 1991 the population of Ireland grew by just over 1.2 million people, an increase of 35 per cent, which implies an annual average population growth rate of 1.4 per cent.

Of course population growth has not been evenly spread through time and across regions. Table 3.1 shows the population growth rates across regions and time periods. The table shows that the population grew in each period and region but there were significant differences. The Mid-East grew faster than the national average throughout the 1991 to 2016 period, while the Mid-West recorded lower than average population growth throughout the period. The other regions did not consistently grow faster or slower than the national average. For example Dublin grew faster than the national average in the 1991 to 1996 period and the 2011 to 2016 period, but grew slower than the national average in the other periods. The Midland region experienced the opposite pattern, growing faster than the national average over the period 1996 to 2011 but slower than the national average before and after that period.

The pattern of growth rates for the 2006 to 2011 period is more similar to that of the 1996 to 2002 period than the 2002 to 2006 period. Thus, the population growth trends are not stable over time which makes the construction of

population projections more difficult. In particular, the patterns seem to be driven by changes in internal migration patterns.

Over the entire 1991 to 2016 period, only the East and Midland regions experienced above average growth rates, and these two regions are the only regions to increase their population share over the period. The Mid-East accounted for 9.2 per cent of the population in 1991 but in 2016 accounted for 11.8 per cent. The Midland region increased its share in the national population from 5.8 per cent to 6.1 per cent over the same period.

TABLE 3.1 AVERAGE ANNUAL POPULATION GROWTH BY REGION AND PERIOD (%)

	1991-1996	1996-2002	2002-2006	2006-2011	2011-2016	1991-2016
Border	0.2	1.0	2.1	2.0	0.3	1.2
Midland	0.3	1.6	2.9	2.4	0.7	1.8
West	0.5	1.3	2.2	1.5	0.4	1.3
Dublin	0.6	1.0	1.4	1.4	1.1	1.2
Mid-East	1.4	3.1	3.8	2.3	1.1	2.9
Mid-West	0.4	1.2	1.6	1.0	0.3	1.0
South-East	0.4	1.4	2.2	1.6	0.5	1.3
South-West	0.5	1.0	1.8	1.4	0.8	1.2
State	0.6	1.3	2.1	1.6	0.7	1.4

Source: Author's calculations using CSO Census of Population data.

The pattern of population growth is even more heterogeneous across counties than those across regions, where some of the variability is reduced through aggregation. Table 3.2 shows the annual average population growth rates across counties. In the 1991 to 1996 period two counties, Longford and Leitrim, recorded a decline in the population, and during the most recent intercensal period Donegal and Mayo also experienced declining populations. In contrast, Kildare grew fastest during the 1991 to 1996 period, and Meath during the 1996 to 2006 period and again 2011 to 2016 periods. During the 2006 to 2011 period, Laois recorded the fastest growth rate. The lowest growth rates over the 1991 to 1996, 1996 to 2002, 2002 to 2006, 2006 to 2011 and 2011 to 2016 periods, were recorded for Leitrim, Monaghan, Sligo, Kerry and Donegal respectively. Over the full period, the fastest growth was achieved in Meath and the lowest in Mayo.

As a consequence of the different population growth rates the share of the population accounted for by the regions has changed. Figure 3.6 shows that the share of the population accounted for by Dublin is by far the largest. This share grew between 1991 and 1996 and again between 2011 and 2016 but over the full period declined from 29.1 per cent to 28.3 per cent. The population share accounted for by the Mid-East region has grown significantly from 9.2 per cent to

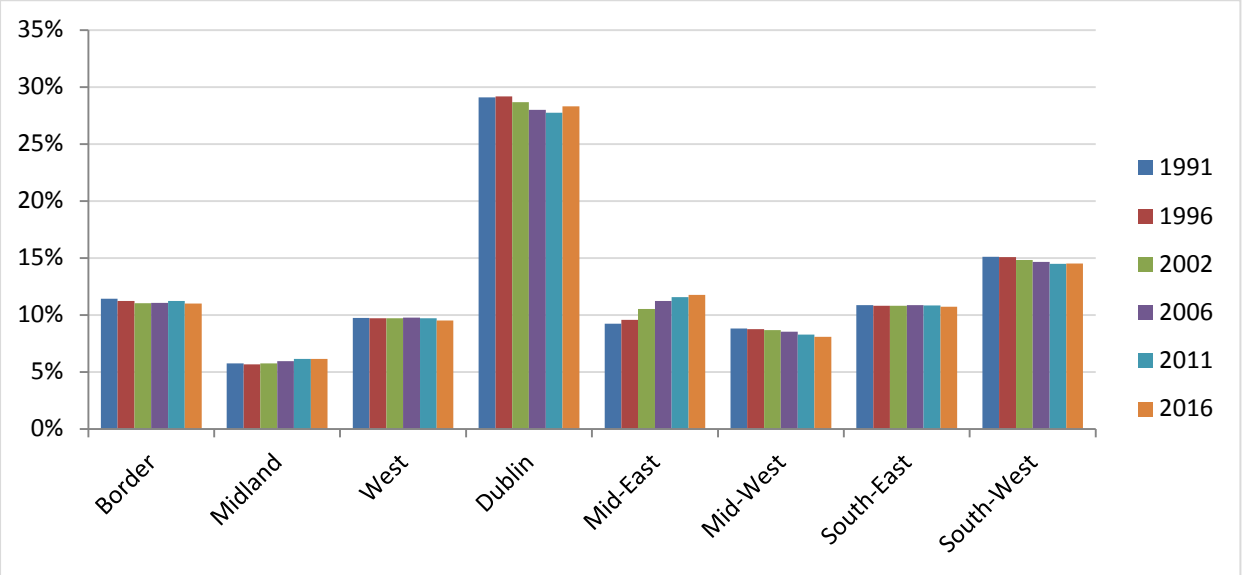
11.8 per cent. Thus the Greater Dublin Area (Dublin and the Mid-East) increased their share from 38.3 per cent to 40 per cent over the 1991 to 2016 period. The Midland also increased its share of the national population. Both are due to the significant expansion of the commuter belt around Dublin. The share accounted for by the South-East has been static over the period while that for all other regions has steadily declined. At the county level both Kildare and Meath increased their share in the national population from 3.5 per cent to 4.7 per cent and from 3 per cent to 4.1 per cent respectively. In contrast, the share accounted for by Limerick and Mayo has declined from 4.6 per cent to 4.1 per cent and 3.1 per cent to 2.7 per cent respectively.

TABLE 3.2 AVERAGE ANNUAL POPULATION GROWTH BY COUNTY AND PERIOD

	1991-1996	1996-2002	2002-2006	2006-2011	2011-2016	1991-2016
Carlow	0.3	1.8	2.4	1.7	0.8	1.6
Dublin	0.6	1.0	1.4	1.4	1.1	1.2
Kildare	2.0	3.6	3.4	2.6	1.1	3.2
Kilkenny	0.5	1.1	2.2	1.8	0.8	1.4
Laois	0.2	1.8	3.5	4.0	1.0	2.5
Longford	-0.1	0.5	2.7	2.7	0.9	1.4
Louth	0.3	1.7	2.3	2.1	0.9	1.7
Meath	0.8	3.7	5.4	2.6	1.2	3.4
Offaly	0.2	1.3	2.8	1.6	0.3	1.3
Westmeath	0.5	2.2	2.6	1.7	0.5	1.7
Wexford	0.5	2.0	3.2	2.1	0.6	1.9
Wicklow	1.1	1.9	2.5	1.7	0.8	1.9
Clare	0.7	1.6	1.9	1.1	0.2	1.2
Cork	0.5	1.1	1.9	1.6	0.9	1.3
Kerry	0.7	0.8	1.4	0.8	0.3	0.8
Limerick	0.4	1.0	1.2	0.8	0.4	0.8
Tipperary N.R.	0.1	0.9	2.1	1.3	0.3	0.9
Tipperary S.R.	0.2	0.8	1.3	1.3	0.1	0.8
Waterford	0.7	1.2	1.6	1.1	0.5	1.1
Galway	0.9	1.8	2.7	1.6	0.6	1.7
Leitrim	-0.2	0.5	3.1	2.0	0.1	1.1
Mayo	0.1	0.9	1.4	1.1	0.0	0.7
Roscommon	0.0	0.6	2.3	1.8	0.1	1.0
Sligo	0.4	0.7	1.2	1.5	0.0	0.8
Cavan	0.1	1.1	3.3	2.9	0.8	1.8
Donegal	0.3	1.0	1.8	1.9	-0.3	1.0
Monaghan	0.0	0.4	1.6	1.6	0.3	0.8
State	0.6	1.3	2.1	1.6	0.7	1.4

Source: Author's calculations using CSO Census of Population data.

FIGURE 3.6 POPULATION SHARES BY REGION, 1991 - 2016



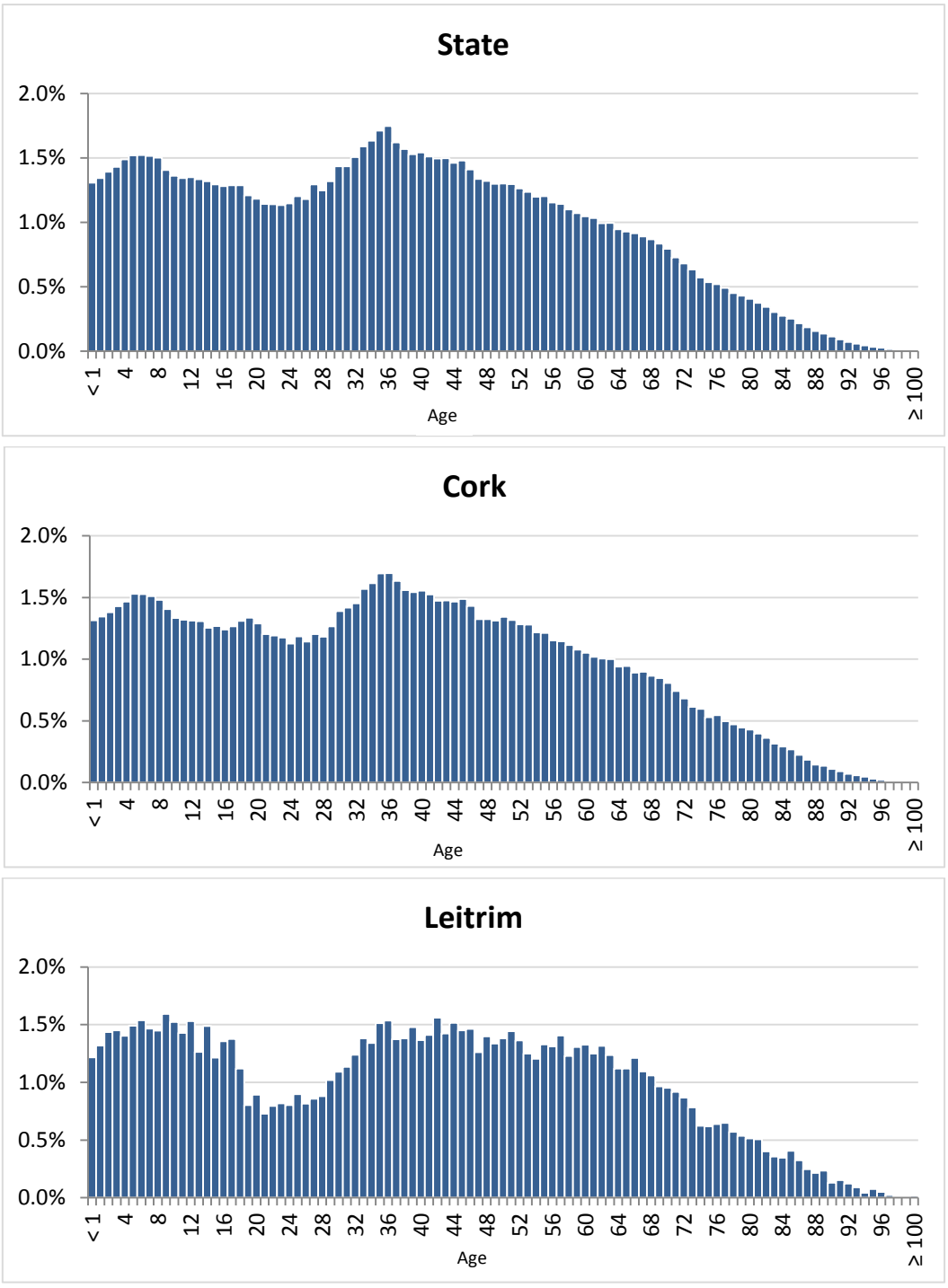
Source: Author's calculations using CSO Census of Population data.

Apart from differences in growth patterns across regions and counties, there are also significant differences in the population age structure. The differences in age structure have significant implications for the need for public services, impact on economic prospects and also impact significantly on the likely path of the population in the future.

Figure 3.7 shows the age structure of the population in 2016 for the State as well as Cork (City and County) and Leitrim. Nationally, the largest cohort was that aged 30 years of age. The cohorts decline steadily with increasing age. For the younger age groups the cohort aged 20 years of age is the smallest with larger numbers at younger and older ages recorded. The population structure for Cork is almost identical to that of the State and indeed it is the county that most closely mirrors the national population structure in 2011. In contrast the population structure in Leitrim is least like the national pattern. While Leitrim has a slightly larger share of persons aged under 15 (21.6 per cent) than the national average (21.3 per cent), the cohort aged 15 to 29 is significantly smaller in Leitrim (16.5 per cent) than the national average (20.5 per cent), and Leitrim also has a higher share of persons in the 65 and older age group (14.8 per cent) compared to the State (11.7 per cent).[8]

[8] Also noticeable for Leitrim is the fact that differences across individual age groups are more pronounced, which is due to the small size of the cohorts in Leitrim where the largest cohort (four-year-olds) accounts for just 522 persons. Thus relatively small absolute differences result in more substantial percentage differences than for counties with larger populations and hence larger individual cohorts.

FIGURE 3.7 POPULATION STRUCTURE MEASURES AS PERCENTAGE OF THE TOTAL POPULATION IN EACH SINGLE YEAR OF AGE, STATE, CORK AND LEITRIM, 2011



Source: Author's calculations using CSO Census of Population 2011 data.

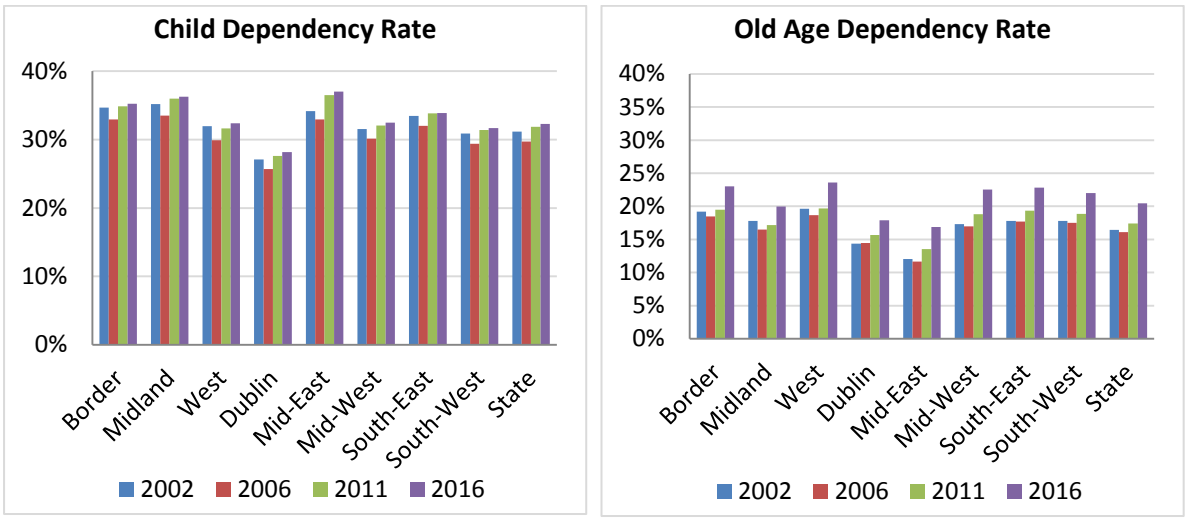
Trends in age structure are best described through age dependency rates. Here the old age dependency and the child dependency rates are considered separately as these have different implications from a planning and economic development perspective. The old age dependency rate is defined as the number of individuals aged 65 years and over as a percentage of the population aged 15 to 64 years. Similarly, the child dependency rate is expressed as the number of

persons aged under 15 years as a percentage of the population aged 15 to 64 years.

Figure 3.8 shows the two age dependency rates across regions for 2002 to 2016 and Table 3.3 shows the absolute numbers in respective age groups for the Census years. The graph for child dependency shows a high and increasing rate in the Mid-East and higher than average rates in both the Border and Midland regions. In contrast, Dublin has had a smaller than average child dependency rate although the estimates for 2016 suggest that this has increased. Comparing 2011 with 2002, all regions except the West and South-East increased their age dependency. The data for 2016 suggest that the West might have experienced an increase in the child age dependency rate recently.

Overall, the old age dependency rate is considerably smaller than the child age dependency rate, reflecting the relatively young population in Ireland. Nevertheless the old age dependency ratio is increasing faster than the child age dependency rate. The old age dependency rate has been increasing in all regions except the Midland for the period 2002 to 2011, and across all regions for the period 2002 to 2016. The average age in 2016 was 36.9 years.

FIGURE 3.8 CHILD DEPENDENCY (% AGED 14 AND LESS) AND OLD AGE DEPENDENCY RATE, 2002 - 2016



Source: Author's calculations using CSO Census of Population data.

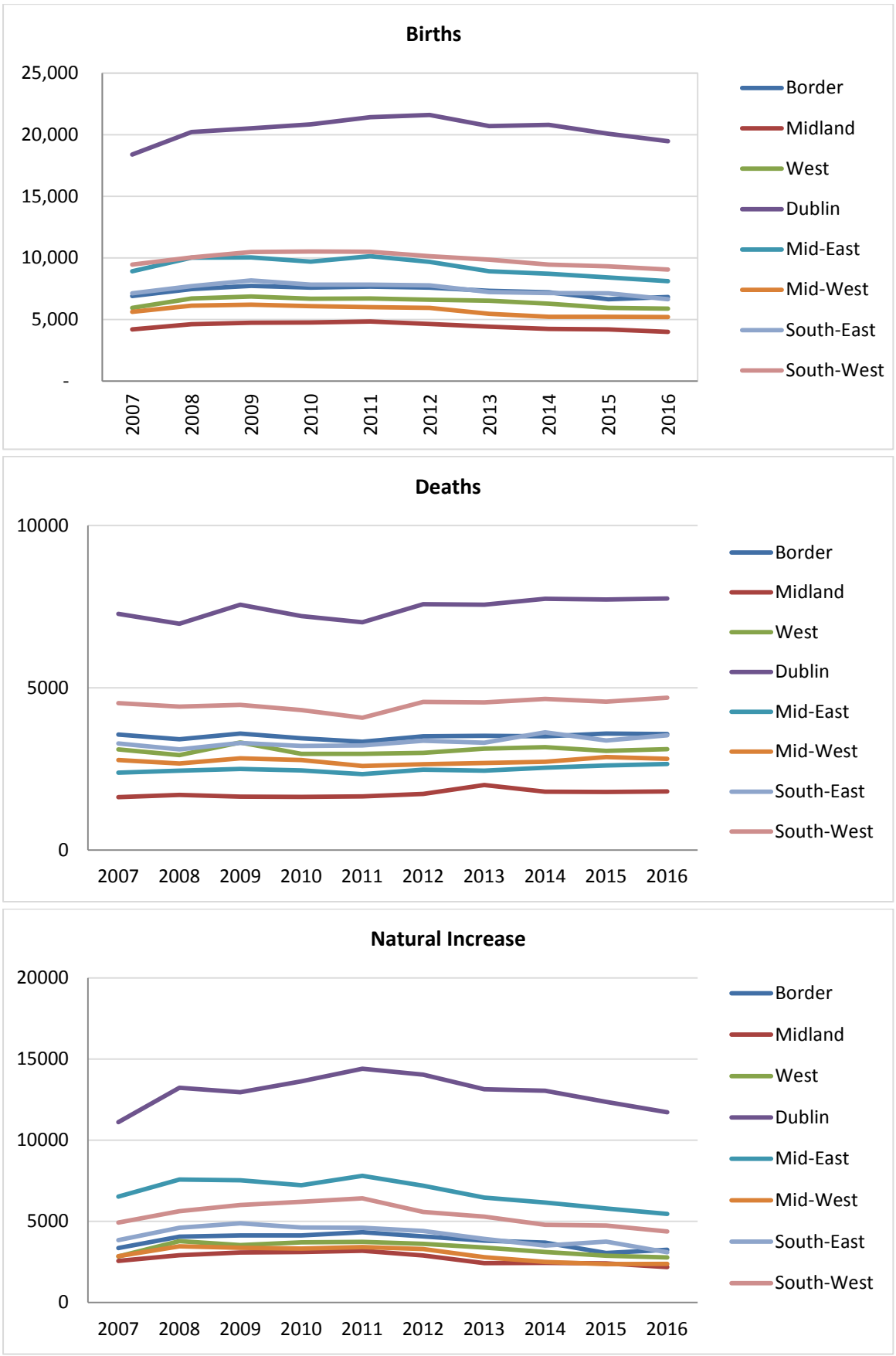
TABLE 3.3 TOTAL NUMBER OF PERSONS AGED UNDER 15 AND OVER 65 (%)

	Population aged under 15				Population aged over 65			
Border	97,506	101,935	116,321	117,611	53,937	57,191	65,023	75,678
Midland	51,874	56,235	66,353	69,101	26,201	27,663	31,688	37,407
West	80,176	83,432	93,079	98,236	49,222	52,085	57,984	67,970
Dublin	215,192	217,652	245,252	282,199	113,972	122,511	139,276	161,185
Mid-East	96,401	108,296	129,206	139,765	34,010	38,320	47,979	61,372
Mid-West	71,968	74,018	80,646	83,946	39,493	41,611	47,254	55,478
South-East	93,765	98,606	109,878	113,417	49,775	54,439	62,821	73,885
South-West	120,546	124,275	138,855	147,659	69,391	74,106	83,368	97,700
State	827,428	864,449	979,590	1,051,934	436,001	467,926	535,393	630,675

Source: CSO Census of Population.

Finally, a key driver of population growth is the natural increase of the population which is simply defined as the number of births minus the number of deaths. Obviously, if the number of births exceeds the number of deaths the population will grow unless there is net emigration. Figure 3.9 shows the total number of births and deaths across regions for the period 2007 to 2016. The graph shows that while births increased over the first half of that period they have been declining more recently, while deaths were largely unchanged in the first half of the period but have been increasing more recently. As a consequence, the natural increase while still positive has been decreasing since 2011, having increased prior to that. The natural increase peaked in 2011 in all regions except the Mid-West and South-East, where it peaked in 2008 and 2009 respectively. On average, the natural increase decreased by 25 per cent since peaking. The decline in the natural increase ranges across the regions from 19 per cent in Dublin to 37 per cent in the South-East. This implies that the average age across the population will increase more rapidly than has been the case and that unless immigration increases, overall population growth will slow.

FIGURE 3.9 BIRTHS, DEATHS AND NATURAL INCREASE, 2007 - 2016



Source: CSO Quarterly Vital Statistics.

3.4 EMPLOYMENT

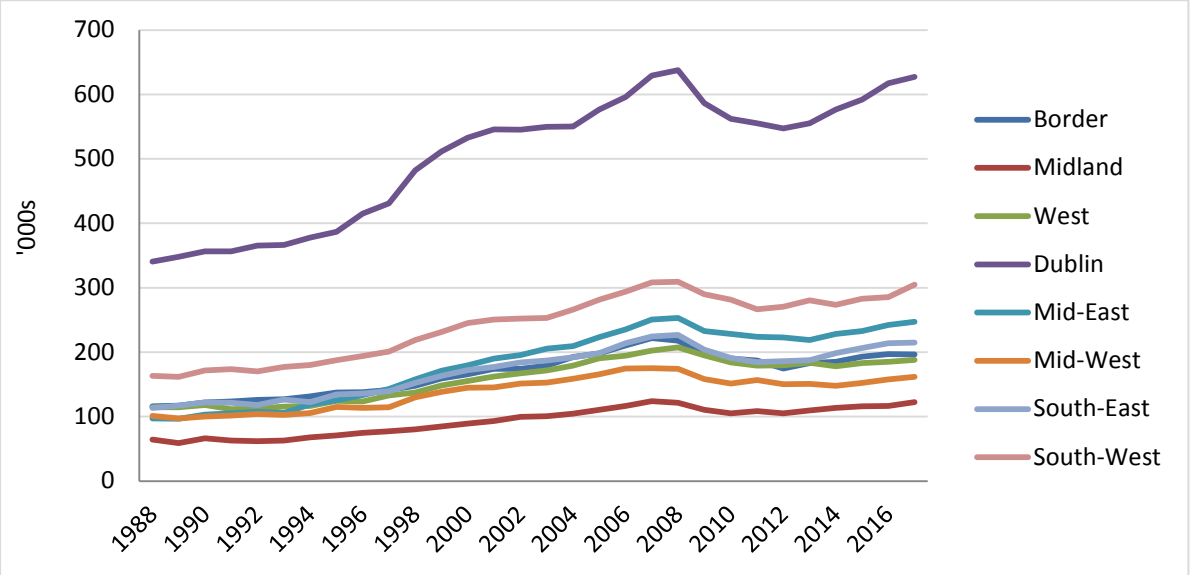
As indicated above, output measures for the Irish economy are subject to significant flaws, and these are amplified at the regional level. A better measure of real economic performance at the regional level is the labour market.

Employment at the sub-national level can be measured in two ways. Firstly, employment can be defined as the number of employed persons that are resident in an area. Secondly, it can be measured as the number of persons employed by businesses located in an area. The two are not necessarily the same, as individuals might not live in the area in which they work and commute between the two. To distinguish between the two concepts we refer to employment as the number of employed persons resident in a particular area. The number of persons employed by businesses located in an area is referred to as the number of jobs, which are discussed in the next section.

Figure 3.10 shows the evolution of employment over the period 1988 to 2016 across the eight regions.[9] The graph shows the significant differences in scale across the regions, with Dublin being clearly the largest in terms of employment, while the Midland region is the region with the smallest number of employees. Of course this reflects the underlying size of the regions. The graph also shows the continuous growth in the numbers employed, which peaked in either 2007 or 2008 in all regions, and the subsequent downturn and recovery. The graph shows that while the regions have experienced differences in employment growth, the rankings of the regions in terms of the number of persons employed have not changed much throughout the period. The overall pattern is one of convergence over the period 1988 to 2006, which implies that employment grew faster in the regions with lower employment than those with higher levels of employment. This is likely to be related to internal migration and reverse commuting particularly in the Mid-East and also the Midland and South-East regions (see Figure 3.10).

[9] Employment data for the eight NUTS 3 regions are available from the CSO Quarterly National Household Survey (QNHS), which also provides data on participation rates, unemployment and the working age population. This series starts in 1998, but data from 1988 to 1997 for total employment are available from the Annual Labour Force Survey, which had a similar coverage, but was conducted on an annual basis rather than a quarterly basis. For the purposes of analysing long-term trends, annual data are more suitable than quarterly data which follow seasonal trends as well as the longer-term trend. Therefore, the data from the QNHS that are utilised here refer to the observations for the second quarter of each year. The second quarter corresponds to the timing of the Census of Population which is usually held in April. Choosing data for this quarter therefore facilitates comparison with the Census results. There are important differences in the definitions of labour market status between the QNHS, which utilises the ILO definition, and the Census which contains results for the self reported labour market status. Under the ILO definition a person is employed if (s)he has worked even just one hour in the previous month. Persons who have only worked one hour are likely to describe themselves as unemployed. Data for employment by sector are only available from 1994 onwards.

FIGURE 3.10 EMPLOYMENT BY REGION, 1988 - 2016



Source: CSO Quarterly National Household Survey and CSO Labour Force Survey.
Note: Data refer to the second quarter of each year. The data are defined using the ILO definition. Employment relates to the resident population in employment.

There are significant differences in the length and severity of the downturn and subsequent recovery across the regions as shown in Table 3.4. This shows that there are differences across regions with respect to when employment hit its peak, and in particular when it hit its lowest level after the peak and during the economic crisis. For example while employment in the South-West started growing again after the crisis in 2011, the West only experienced an upturn in employment in 2014. The pattern of recovery from the recession also shows that those regions that experienced a greater decline in employment had a stronger recovery. For example while the smallest decline in employment was recorded in the South-West, it had the second smallest recovery. In contrast, the largest reduction in employment during the recession was recorded in the Border region, which experienced the second largest recovery in terms of employment growth. Significantly, no region has reached the employment levels seen at the peak. While Dublin and the Mid-East are now close to the previous employment peak, the Border region employment is still over 11 per cent below peak employment.

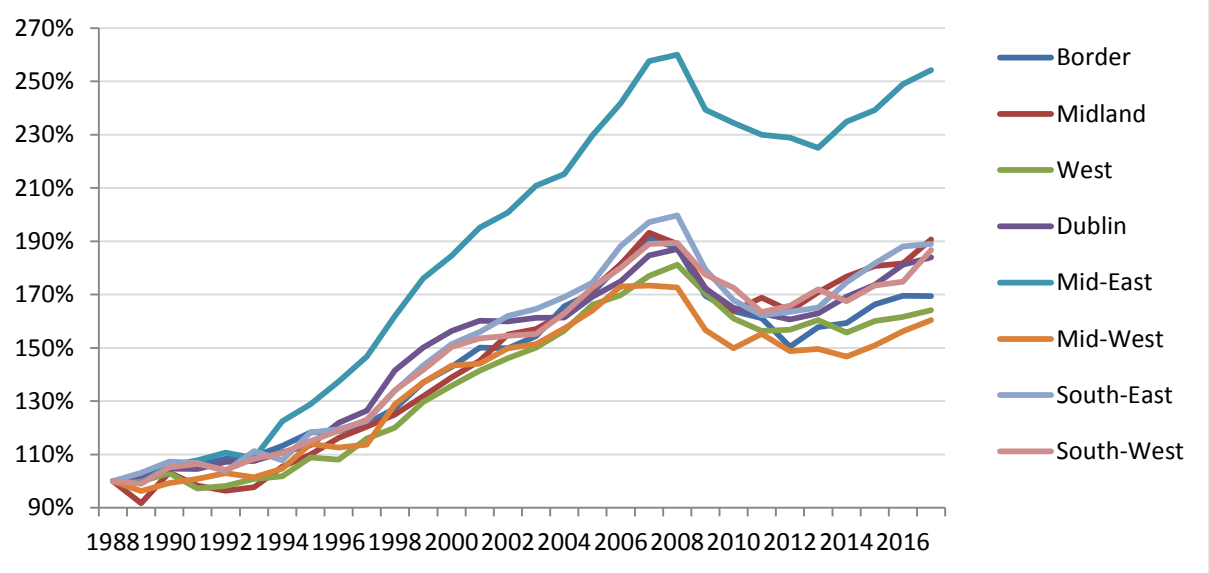
TABLE 3.4 EMPLOYMENT DURING THE CRISIS

	Peak		Trough		2016	Peak to Trough Decline	Recovery	2016 Relative to Peak
	Year	'000s	Year	'000s	'000s	% change	% change	%
Border	2007	221.8	2012	174.6	196.9	-21.3	12.8	88.8
Midland	2007	124.0	2012	105.2	116.6	-15.2	10.8	94.0
West	2008	207.4	2014	178.3	185.0	-14.0	3.1	91.3
Dublin	2008	637.7	2012	547.4	617.5	-14.2	12.8	98.1
Mid-East	2008	252.9	2013	219.0	242.2	-13.4	8.8	96.6
Mid-West	2007	175.0	2014	148.0	157.6	-15.4	5.0	90.1
South-East	2008	227.0	2011	184.5	213.8	-18.7	14.9	95.4
South-West	2008	309.1	2011	266.6	285.4	-13.7	5.4	92.5
State	2008	2,147.4	2012	1,836.2	2,015.0	-14.5	9.7	94.3

Source: Author's calculations using data from the CSO Quarterly National Household Survey.
Notes: Data refer to the second quarter of each year. The data are defined using the ILO definition. Employment relates to the resident population in employment.

The relative performance of the regions with respect to employment is more easily assessed when measured relative to a starting point. Figure 3.11 shows employment in each region relative to its 1988 level. This shows that the Mid-East has experienced the most significant growth in employment over the period from 1988. This is significantly driven by the expansion of the commuter belt around Dublin. In contrast, the Mid-West has not been performing well in terms of employment over this period since 2005.

FIGURE 3.11 EMPLOYMENT RELATIVE TO 1988



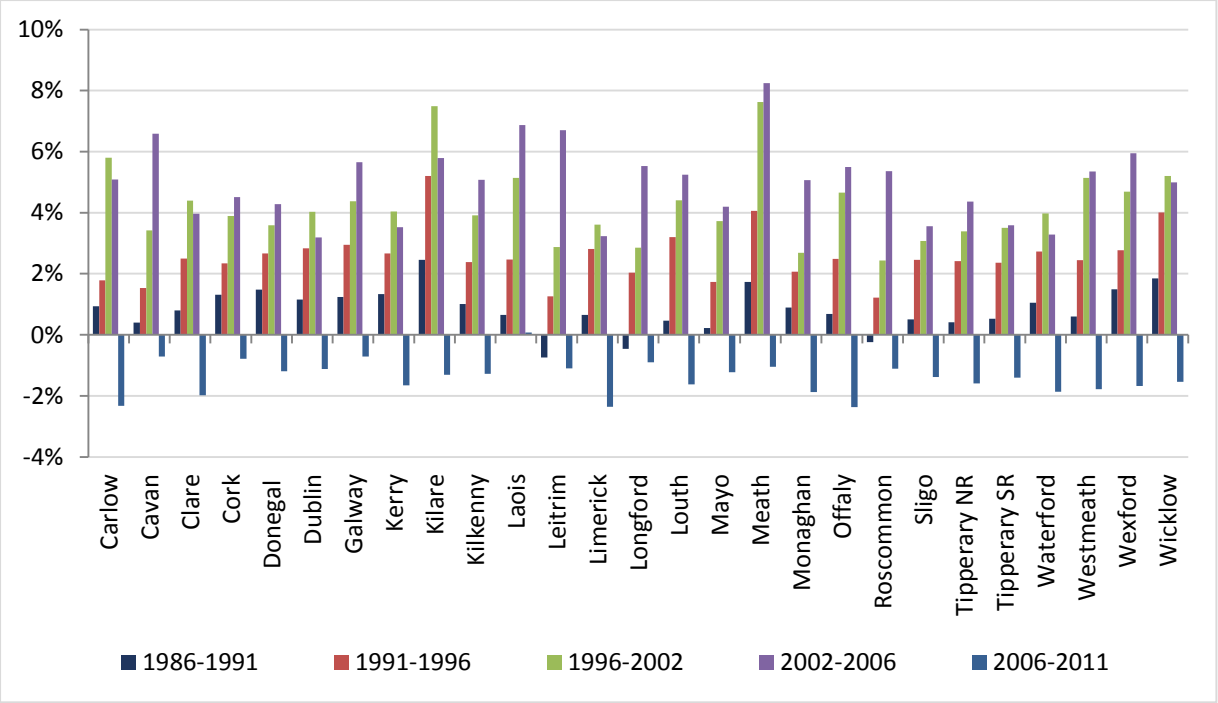
Source: Author's calculations based on CSO Quarterly National Household Survey and CSO Labour Force Survey data.
Notes: Data refer to the second quarter of each year. The data are defined using the ILO definition. Employment relates to the resident population in employment.

Employment change is not evenly spread across sectors and there are also differences in the path of sectoral employment across regions. For example, employment in all sectors except agriculture, forestry and fishing and industry is larger across all regions in 2016 than in 1998. But employment in agriculture, forestry and fishing grew in the Border region over that period, while it declined by 43 per cent in the West region. Industrial employment contracted in all regions between 1998 and 2016, but this decline ranged from just 4 per cent in the Mid-East region to a significant 35 per cent in the Border region. While construction employment is only modestly up from its 1998 level in 2016 for most regions, it is significantly larger for the Midland (45 per cent) and South-East (38 per cent) regions. The services sectors recorded the most significant growth in employment over the period, with human health and social work recording the highest increases ranging from 100 per cent (Dublin) to 198 per cent (Midland).

Of course the economic crisis affected sectors differently, and again the regions were differently affected. While employment in eight of the 12 sectors in the South-East is higher in 2016 than in 2008, just five sectors recorded higher employment in 2016 than 2008 in the South-West. The construction sector is smaller in 2016 across all regions than it was in 2008, but the contraction ranges from 37 per cent (South-West) to 50 per cent (Mid-East). Likewise, wholesale and retail employment declined in all regions, with the difference between 2008 and 2016 ranging from 4 per cent (South-East) to 23 per cent (Mid-West).

While the QNHS provides data at the regional level, data on employment at the county level are only available from the CSO Census of Population. As detailed data from Census 2016 are not available yet, coverage of employment over the recovery is incomplete. Figure 3.12 shows the annual average growth of employment between census years. This shows the significant heterogeneity in growth rates across counties in single periods but also across the periods. Employment growth was very modest during the 1986 to 1991 period particularly compared to the 1996 to 2002 and 2002 to 2006 periods. The graph shows that the Dublin commuter counties of Kildare and Meath experienced particularly strong employment growth. In contrast, Roscommon and Limerick recorded the smallest growth over the full 1986 to 2011 period. The correlation between the growth rates across the counties is positive between all periods indicating that counties with faster growth rates in one period also experience faster growth in subsequent periods.

FIGURE 3.12 ANNUAL AVERAGE EMPLOYMENT GROWTH FOR INTERCENSAL PERIODS BETWEEN 1986 AND 2011



Source: Author's calculations using CSO Census of Population data.
Note: Employment relates to the resident population in employment.

3.5 UNEMPLOYMENT

While the numbers employed identify one aspect of economic development, unemployment must be taken into account also. For example, the labour force may grow at a different rate than the numbers employed, which could result in either an increase or decrease in unemployment given a particular employment growth rate (see Morgenroth, 2012). Figure 3.13 shows the unemployment rate across regions for the period 1988 to 2017. This graph shows that the unemployment rate follows the economic cycle more closely than employment, as the graph shows the striking decline in the unemployment rate between 1988 and 2000, the low rates until 2007 and the rapid increase in the unemployment rate in the wake of the economic crisis, which was significantly faster than the decline during the 1990s. The graph also shows the significant reductions in the unemployment rate during the recovery.

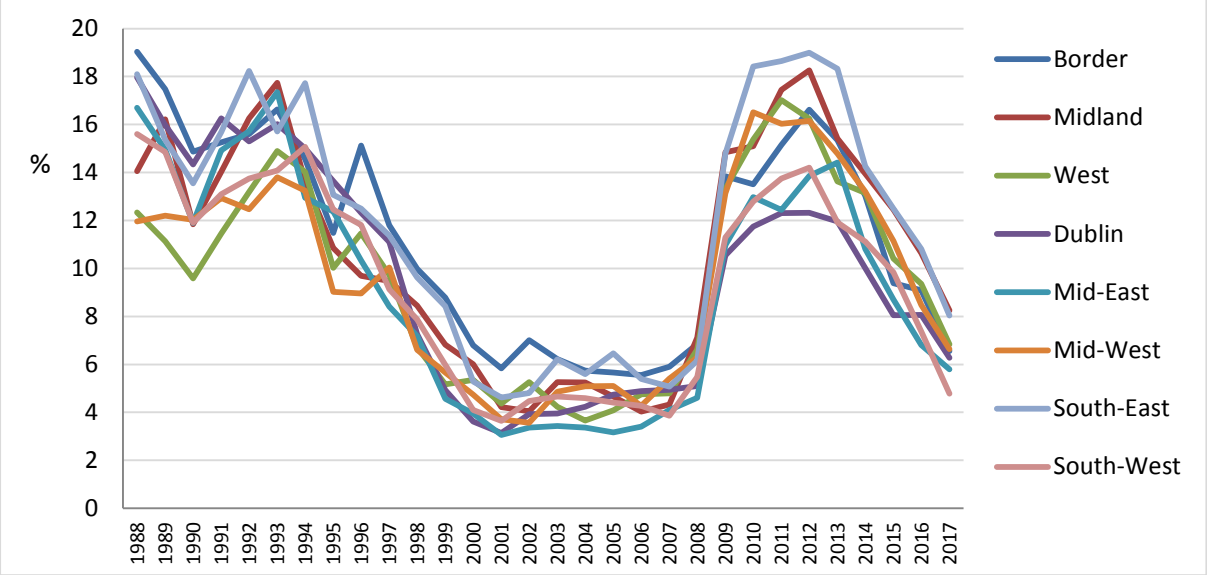
In absolute terms the total number of persons unemployed was 217,000 in 1988. This was reduced to just under 70,000 by 2001, which marked the lowest number of persons unemployed over the period for which consistent data are available. Over the period 2001 to 2007 the numbers unemployed rose gradually, but in 2009 the numbers had doubled over the previous year, reaching 275,000. The total number of unemployed persons peaked in 2012 at 323,000 and has declined

steadily to reach just under 190,000, a decline of almost 42 per cent over peak numbers.

While the unemployment rate across the regions follows a very similar time path, there are differences between the regions. On average, over the full period the highest unemployment rates were recorded in the Border, South-East and Midland regions. The lowest rates were recorded in the Mid-East, Mid-West and West. Interestingly, there was divergence with respect to the unemployment rate from the early 1990s until 2003 but unemployment rates have been converging between 2003 and 2009. In 2016 the lowest unemployment rate was 6.8 per cent in the Mid-East and the highest rate was 10.8 per cent in the South-East.

The largest annual increase in the numbers unemployed due to the economic crisis was recorded in the South-East and Mid-East where the numbers increased by 137 per cent and 135 per cent respectively between 2008 and 2009. Over the period 2007 to the respective peak levels of unemployment, total numbers of persons unemployed increased by between 138 per cent (Dublin) and 320 per cent (Midland). The recovery has reduced the numbers unemployed by between 30 per cent (Dublin) and 52 per cent (Mid-East).

FIGURE 3.13 UNEMPLOYMENT RATE, 1988 - 2017



Source: CSO Quarterly National Household Survey and CSO Labour Force Survey data.

3.6 JOBS

The coverage of the available data on jobs is less extensive in terms of time coverage but does encompass the county level. One source for such data is the CSO Business Demography data, which provides data for the period 2008 to 2014.

An alternative is to utilise a special tabulation of the travel to work data from the CSO Census, which is available down to the electoral district level to identify the location of jobs (see Morgenroth, 2009). One other source is data from the Department of Business, Enterprise and Innovation (DBEI) Annual Employment Survey (formerly Forfás Employment Survey), which covers a period starting in 1972, but is limited in coverage to firms that have had contact with the enterprise agencies, and thus excludes many sectors.[10] This survey asks all firms how many full-time and part-time employees they employ and, given that the survey is directed at firms, it collects data on what is called jobs in this paper. The lack of a comprehensive long time series for jobs makes it considerably more difficult to model these.

Table 3.5 shows the number of jobs by county for 2011 for both sources of data for comparison. This indicates that the Business Demography data undercount the number of jobs relative to that indicated by the Quarterly National Household Survey, while the Census data indicate a larger number of jobs than identified by the Quarterly National Household Survey. The under-count in the Business Demography may be due to missing micro-enterprises, but the source of the deviation between the Census data and the QNHS is less obvious. Given that the Census data are closer to the QNHS data and the fact that the sectoral breakdown also closely matches that of the QNHS for 2011, the Census data might provide the more accurate description of the geography of jobs. The latter also has the advantage that it is available at the electoral district level (ED) and thus is more easily disaggregated to smaller spatial units. However, the Census based data have the disadvantage of currently only being available for three cross-sections (2002, 2006 and 2011).[11] The period covered by the Business Demography data is also not ideal as it covers only the economic crisis and the subsequent recovery.[12] Neither data source provides an ideal basis to assess long-term trends as this would require a time series of at least 20 years.

[10] The Survey was conducted by Forfás for many years until Forfás was incorporated into the Department of Business, Enterprise and Innovation. The data have almost complete coverage of manufacturing and good coverage of internationally traded services but omit almost all firms in the construction, wholesale, retail and non-traded services sectors as well as agriculture, forestry and fishing.

[11] The data for Census 2016 were not available at the time of writing.

[12] One further drawback of the Business Demography data is that they do not disaggregate Tipperary into North and South, which makes aggregation to the former NUTS 3 planning regions difficult.

TABLE 3.5 TOTAL JOBS IN EACH COUNTY IN 2011

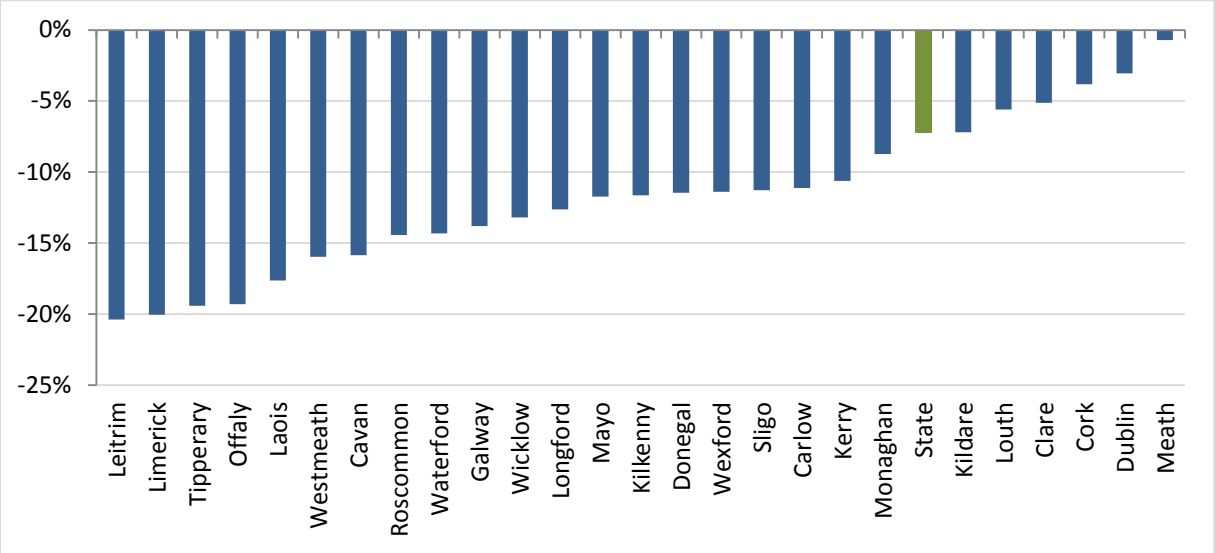
County	Business Demography	Census 2011	County	Business Demography	Census 2011
Carlow	11,363	19,046	Mayo	26,079	46,945
Cavan	14,762	24,796	Meath	30,464	54,148
Clare	25,137	41,942	Monaghan	13,724	21,566
Cork	126,021	210,515	Offaly	11,376	24,329
Donegal	27,323	47,954	Roscommon	9,459	19,372
Dublin	584,249	625,450	Sligo	15,000	25,831
Galway	54,471	99,792	Tipperary	29,329	58,089
Kerry	29,408	52,704	Waterford	26,502	44,267
Kildare	43,972	70,493	Westmeath	15,888	34,735
Kilkenny	16,938	34,746	Wexford	28,378	48,124
Laois	9,339	23,112	Wicklow	25,165	40,270
Leitrim	6,055	10,545	Unknown	10,197	
Limerick	39,686	76,511	All Counties	1,259,326	1,807,360
Longford	6,302	13,675	QNHS total	1,674,100	1,674,100
Louth	22,739	38,403	Difference	-414,774	133,260

Source: CSO Business Demography and author's calculations using a special tabulations from the CSO Census 2011 POWSCAR data.
Note: Jobs referred to the location where the economic activity takes place rather than where the person doing the job is resident.

Figure 3.14 shows the percentage change in jobs as identified in the CSO Business Demography data. It shows that the county that suffered the biggest loss of employment up to 2015 was Leitrim, where employment in 2015 was recorded to be just over 20 per cent lower than in 2008. Other counties where the number of jobs remained significantly below the 2008 level were Limerick, Tipperary, Offaly, Laois and Westmeath. According to these data, counties Clare, Meath, Cork, and Dublin were either least affected by the economic crisis or had recovered more by 2015 than the national average.[13]

[13] It is important to bear in mind that the national average is a weighted average.

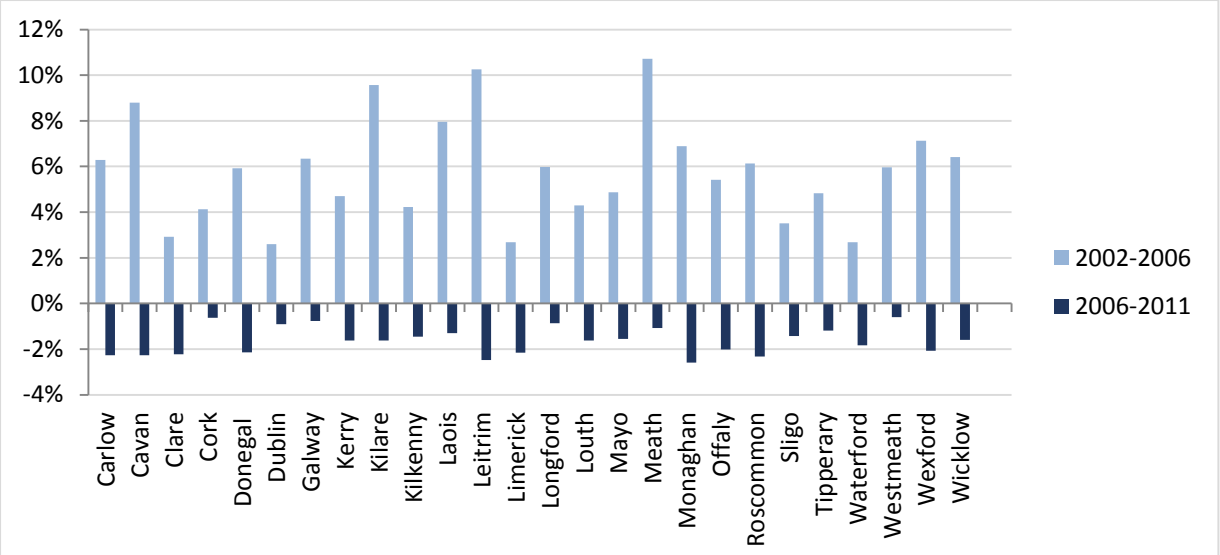
FIGURE 3.14 PERCENTAGE JOBS CHANGE BY COUNTY 2008 - 2015



Source: CSO Business Demography.
Note: Jobs referred to the location where the economic activity takes place rather than where the person doing the job is resident.

The data on jobs derived from the Census allow for an analysis of jobs growth over a longer period although they do not allow for an identification of growth patterns during the recovery. This shows that the annual average growth rates achieved in the 2002 to 2006 period exceeded 2 per cent in all counties and reached as high as 10.7 per cent, 10.3 per cent and 9.6 per cent in Meath, Leitrim and Kildare (Figure 3.15). An interesting finding is that the correlation between the growth rates in the two periods is negative (-0.14) which indicates that those counties which experienced the fastest growth in the first period also on average experience a greater decline in the second period.

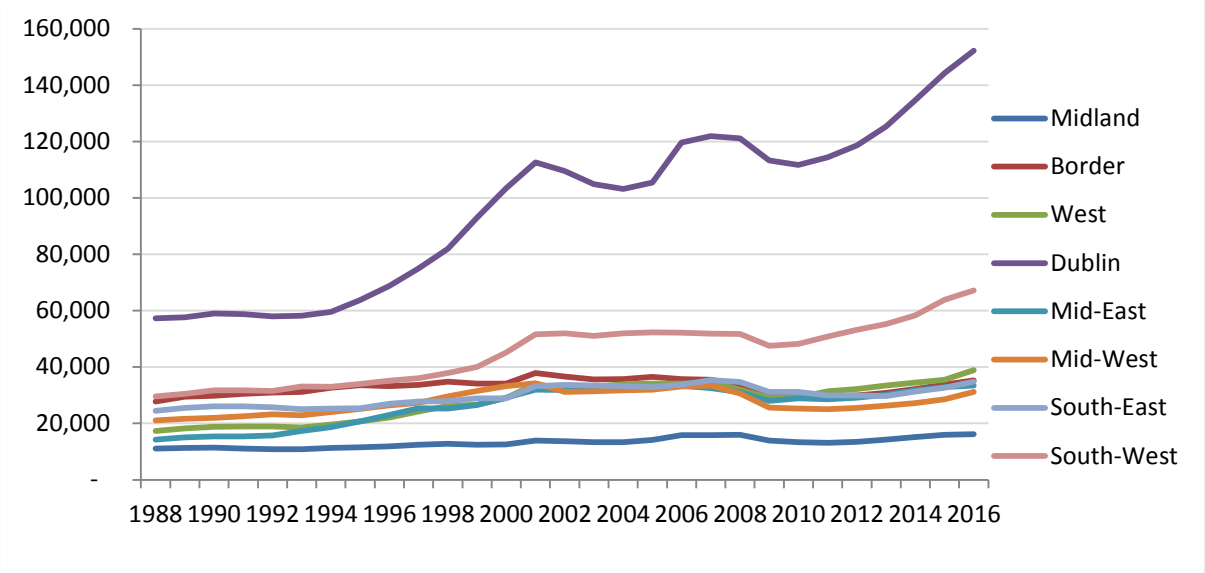
FIGURE 3.15 ANNUAL AVERAGE JOBS GROWTH BY COUNTY, 2002 - 2006 AND 2006 - 2011



Source: Special tabulations of the CSO Census of Population POWSCAR (2011), POWCAR (2006) and POWSAR (2002).
Note: Jobs referred to the location where the economic activity takes place rather than where the person doing the job is resident.

Jobs by region from the DEBI/Forfás Employment survey data are shown in Figure 3.16. The data appear to show a relatively small impact on jobs due to the recession.[14] However, this is due to the sectoral coverage of the data, which largely excludes construction and wholesale and retail businesses, which were hit most severely by the crisis. The sectoral coverage closely matches that of the (internationally) traded sector as defined in the ESRI Economic Outlook (Bergin et al., 2016a). Importantly these data show that the number of jobs is diverging since the early 1990s. This trend appears to have strengthened since 2010. Thus regions with a large number of employees covered under this survey appear to be growing the number of jobs faster than those with a smaller starting stock of jobs. Particularly important is the fact that the rate at which job numbers are diverging across regions is faster than employment numbers which implies that larger numbers of individuals are commuting across regional boundaries.

FIGURE 3.16 JOBS BY REGION FROM THE DJEI EMPLOYMENT SURVEY, 1988 - 2016



Source: DJEI/ Forfás Employment Survey various issues.
Note: Jobs referred to the location where the economic activity takes place rather than where the person doing the job is resident.

[14] Breathnach et al., 2015 using DEBI Employment Survey data found that the sector mix was the most significant driver of relative performance.

CHAPTER 4

Projections

The key task of this chapter is to set out projections for key variables, which requires the use of modelling techniques. In this chapter the techniques that are used and the related assumptions are set out, as are projections for the population employment and jobs. These provide an indication of the possible future development of the regions and counties on a 'current trends' basis where no policy interventions that might change these paths are assumed to be taken.

It is important to note that projecting any variable into the future is subject to significant uncertainty. This uncertainty is greater at the regional or county level compared to the national level as the effect of events or actions that are small in national terms can have very big local effects. A simple example illustrates how relatively small changes can have a big effect at the county level. The population of Leitrim in 2016 was just over 32,000. An increase in the population by just 500 constitutes an increase of 1.6 per cent. Such a change could easily arise if a new large employer were to locate in Leitrim, that attracted some of its workers from further afield such that they would relocate to Leitrim.

The projections are constructed under the assumption that the projected development patterns are accommodated through the development of housing and infrastructure, where required. The scenarios also ignore the potential negative impact of Brexit, particularly on the Border region. Assessing the likely impact of Brexit on the regions or counties is beyond the scope of this report. However, existing analysis suggests that rural parts of the country and especially those close to the border with Northern Ireland are either more connected economically to Northern Ireland or are more specialised in sectors that may be more affected by Brexit (see Lawless and Morgenroth, 2016).

The scenario presented in this chapter is a useful baseline to assess the desirability of the projected development patterns, and allows policymakers to consider appropriate measures to alter the development paths. As indicated above, the projections produced in this chapter and the next are consistent with the economic and demographic scenario produced as part of the ESRI Economic Outlook (see Bergin et al., 2016a). This national baseline constitutes a favourable economic development with GDP growth of 3 per cent or more per annum, and international migration patterns to match this positive economic environment. No other consistent economic and demographic scenario is available, so while higher or lower growth population scenarios could be constructed, corresponding

projections for employment and jobs are not available. Given the demographic structure of Ireland and fertility and mortality trends, faster population growth would require higher international net immigration into Ireland. This would only arise if Ireland were sufficiently attractive economically and if migrants could find accommodation at affordable prices. Increasing the number of immigrants would, holding all other factors constant, result in higher house prices, which would thus act to reduce immigration flows.

4.1 PROJECTING THE POPULATION

In order to plan for the efficient delivery of services, it is important to consider the likely evolution of the population. Ideally such projections should be produced for different age groups and gender, as for example, the need for schools is a function of the future size of the school going age population, while healthcare needs are significantly driven by the size of the older population, and the labour force is a function of the population of working age.

Alternative methodologies can be used to project the population at the national and sub-national level (see Morgenroth, 2001). A method that is widely used throughout the world is the so-called cohort component method, which is also the usual method applied in Ireland. For example, this is the method used by the CSO for the production of their national and regional projections, and by the ESRI for the national population projections used in medium-term projections of the Irish economy. Here the ESRI's **I**rish **C**ounty **PO**ulation **P**rojection model (IC-POP) is utilised to generate population projections (see Morgenroth, 2014a; Crawford et al., 2014). This model is also a cohort component model.

The cohort component method is based on the fundamental balancing equation of population change, which states that the population at some future date must equal the current population plus births, minus deaths (together termed natural increase) plus net migration. Thus, the methodology requires baseline population data along with projections of births, deaths and net migration. To provide an age breakdown, the usual approach is to use single year of age cohorts, and the starting data are available from Census 2016, which provides the base population.[15] Deaths can then be projected by applying mortality rates to individual age cohorts while births can be generated by applying age specific fertility rates to the cohorts of women of child bearing age. Thus, both births and

[15] The results of Census 2016 indicate that the population estimates produced by the CSO in 2016 underestimated the population by almost 90,000 persons. As labour market statistics were related to the population estimates these are not consistent with the Census results, which means that there is a mismatch between the demographic projections produced here and the jobs/employment projections. Thus, the labour market statistics based on the Quarterly National Household Survey, underestimate the total number of persons aged over 15, which implies that the total number of persons in each labour market status is also likely to be underestimated.

deaths are a function of the assumptions around age specific fertility rates and mortality rates.

Mortality

In order to generate the number of deaths for each individual age group and gender, mortality rates are required. The number of deaths is a function of age specific mortality rates and the size of individual age cohorts. Thus, two areas with the same age specific mortality rates will have different numbers of deaths if they have different sized age cohorts. As was shown above, counties and regions differ considerably in relation to the age distribution of their population.

There is also some evidence of differences in mortality rates across counties and between urban and rural areas. Pringle (1982; 2001) pointed to the regional differences in mortality in Ireland and recently the CSO published standardised death rates by type of area (CSO, 2010) which are shown in Table 4.1. This shows that rural areas have lower mortality rates than more urban areas, and that the highest mortality rates are found in Limerick City. Thus, while a greater share of the rural population is older, mortality rates in these counties are lower.

TABLE 4.1 STANDARDISED DEATH RATES BY SEX AND TYPE OF AREA, 2006/2007

	Both Sexes	Male	Female	Both Sexes	Male	Female
	Rate per 100,000 population			Rate relative to national		
Urban (incl. suburbs)	715	743	702	1.04	1.06	1.04
Greater Dublin Area	686	717	670	1.00	1.02	0.99
Cork City	777	785	778	1.13	1.12	1.15
Limerick City	785	752	832	1.14	1.07	1.23
Galway City	726	778	685	1.05	1.11	1.02
Waterford City	763	722	816	1.11	1.03	1.21
Towns 10,000 and over	696	729	677	1.01	1.04	1.00
Towns 1,500-9,999	759	795	739	1.10	1.13	1.10
Rural	655	660	636	0.95	0.94	0.94
State	689	703	674	1.00	1.00	1.00

Source: CSO 2010.

Walsh (2008) analysed trends in mortality rates and showed significant improvement in mortality rates over the 1990s, which he attributed to increased healthcare expenditure, improved lifestyles, improved environment and the improvement in the economy. He also analysed whether mortality rates across counties were converging or diverging and found no evidence of either. Layte and Nolan (2016) have shown that mortality rates have not fallen equally across all socio-economic groups, with managers and other professionals benefitting from the largest reductions in mortality rates, and that the mortality rates of farmers

and manual workers increased least, which implies a worsening of the relative mortality rates for these groups.

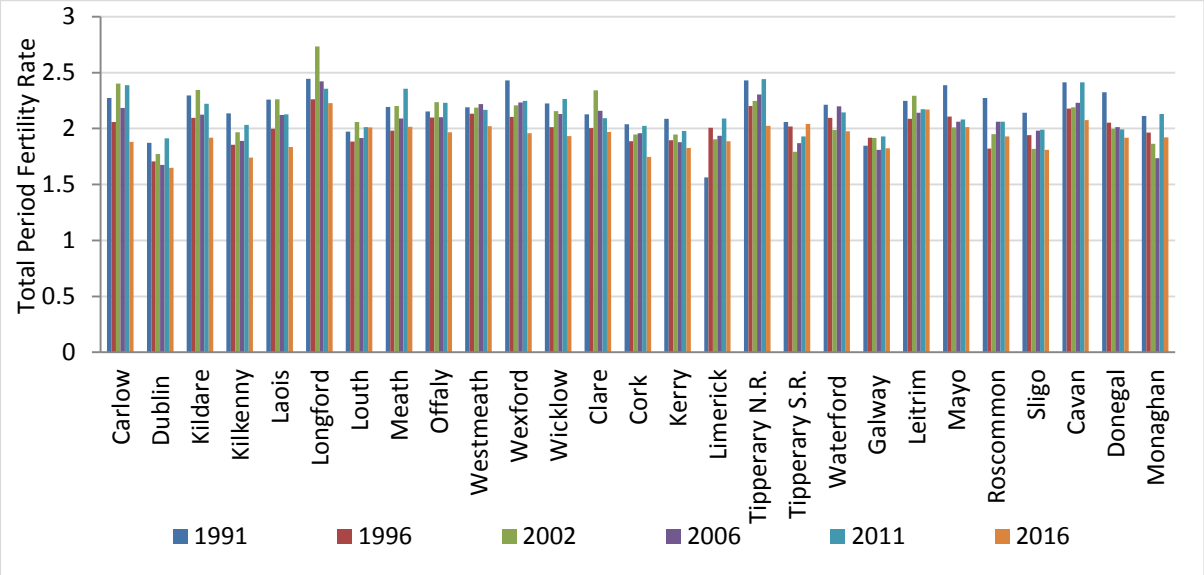
Unfortunately age specific mortality rates across counties, which would be required for the demographic model, have not been published. Furthermore, the lack of detailed research on trends in county mortality rates and underlying drivers means it is difficult to assess likely future trends. Therefore for the purposes of this report those used by the CSO for the production of their population and labour force projections. These are national mortality rates which therefore do not account for mortality rate differences across counties.

Fertility

In order to generate an estimate of the number of births, age specific fertility rates are required. Here fertility is assumed to remain constant at 2016 rates, which are calculated for this purpose using data on births by county and age of mother as well as estimates of the number of females in each age group and county.

Figure 4.1 shows the total fertility rates across counties over a longer period. This shows that while fertility rates fluctuate somewhat over time, the relative position of counties changes relatively little over time. This is confirmed by the fact that the rank correlation between 1991 and 2016 is 0.72. Thus, counties with higher fertility rates in 1991 also have higher fertility rates in 2016. However, there is also some evidence that fertility rates are converging at least over the period 2002 to 2016, although there is considerable volatility in fertility across counties from year to year. The CSO population projections where the initial fertility rate is held constant are usually referred to as F1 projections, and the approach here is to also keep the fertility rate at the 2016 level.

FIGURE 4.1 TOTAL FERTILITY RATES BY COUNTY, 1991, 1996, 2002, 2006, 2011 AND 2016



Source: Author's calculations using CSO Vital Statistics and own population estimates.

The literature on Irish fertility and particularly determinants of spatial fertility differences in Ireland is very limited. A number of papers noted the decline of Irish fertility rates over time.

O'Donoghue et al. (2011) highlight the decline of fertility overall and analyse the determinants of changes in age specific fertility rates in Ireland with a particular focus on delayed maternity. They show a relationship between educational attainment, career planning and fertility patterns across age cohorts. Unfortunately they did not consider spatial differences of fertility. However, the observed pattern of fertility across the country is consistent with their model, which suggests that fertility rates would be higher in areas with lower educational attainment and fewer economic opportunities. This is borne out by the negative correlation (-0.415 for 2011) between the percentage of females who hold a university degree and fertility rates across counties, while there is a positive correlation between the unemployment rate and fertility (0.24 for 2011).

In a study on urban-rural fertility differences in Finland, Kulu (2013) points to the fact that rural fertility tends to be higher than urban fertility. He further considers urban centres distinguished by size as well as rural areas and analyses factors driving the fertility differences across these types. In particular he considered not only socio-economic factors but also the possibility of simultaneity between fertility, housing and migration. He found that while socio-economic factors played a role, selective migration was not a factor in determining spatial fertility differences in Finland, but that housing was the largest factor explaining fertility differences.

Apart from pointing to the role of housing in fertility decisions these results which suggest that as the share of the population resident in urban areas increases, the average fertility rate would decline. Importantly, there is not necessarily a negative relationship between economic development and fertility. Luci-Greulich and Thevenon (2014) show that accounting for a range of factors such as birth postponement, and omitted variable bias, fertility increases above a threshold level of development but that the level of increase is dependent on institutional changes that allow women to combine labour market participation and family life. This suggests that the availability of affordable childcare is an important factor in determining fertility, and this could be an important regional factor.

To explore the determinants of fertility some regression analysis was conducted. This shows that for 2011, a 1 per cent increase in the percentage of women with a university qualification is associated with a reduction in fertility rate by 1.9 per cent. However, no statistically significant relationship between university qualifications and fertility is found for 2006. Interestingly, the analysis shows a positive relationship between fertility and female labour force participation. Of course this does not necessarily mean that higher labour force participation causes higher fertility. The causality may run in the opposite direction as the cost of childcare needs to be considered, where higher fertility might lead to higher labour force participation in order to pay for childcare. The analysis also finds a negative relationship between population density and fertility but surprisingly a positive relationship between house prices and fertility, although both are not statistically significant in all years.

The fact that there seems to be some decline in fertility rates and convergence across counties suggests that fertility rates are not constant. Indeed, initial regression analysis suggests that fertility rates are driven by different factors at different points in time and are quite variable. Given the uncertainty around the likely future path of fertility rates across counties, for the purposes of the projections the fertility rates are held at their 2016 level.

Migration

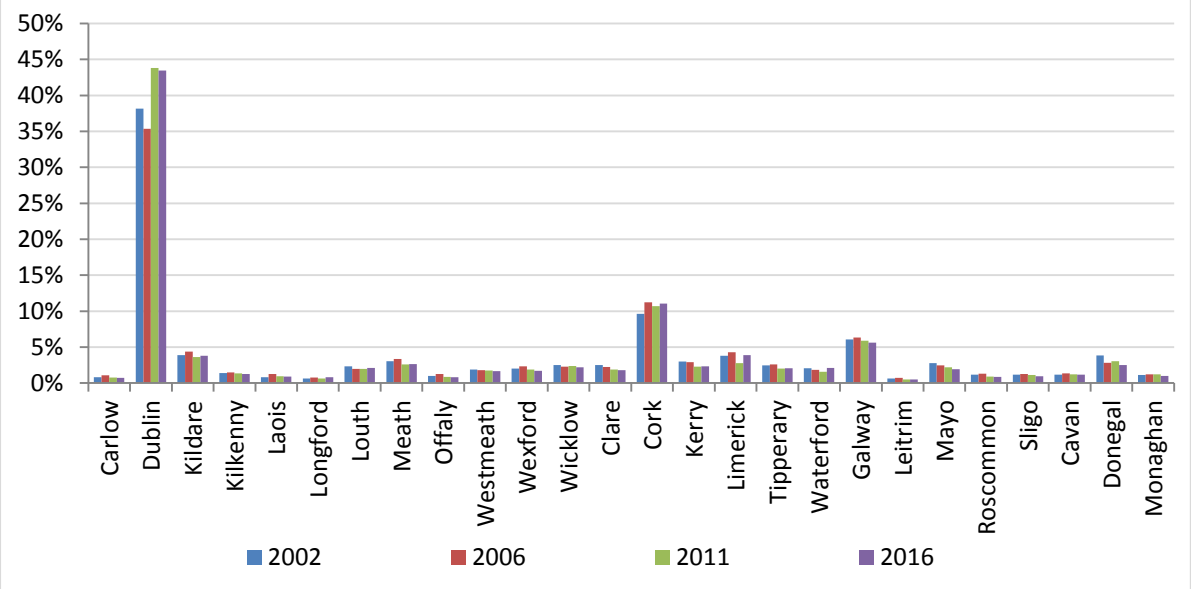
One of the key issues in generating regional or county population projections compared to the production of national population projections is that they require assumptions on or models of the spatial distribution of international migrants and internal migration patterns.

While the total number of international migrants has fluctuated significantly, the spatial pattern of international immigration has tended to be quite stable and is thus likely to remain similar to past patterns. Census data are available to analyse

the destination of international migrants, which is shown in Figure 4.2. Dublin is by far the most important destination for international migrants followed by Cork and Galway. Interestingly, neither Limerick nor Waterford attract a share of international migrants commensurate with their size. Nevertheless the correlation coefficient between the share of international immigrants and the population share across counties is almost perfect, with a correlation coefficient of 0.99.

On average, counties receive about one international immigrant for every 79 persons in the population in the years 2015/16, but this ranged from 116 in Offaly indicating that this county was less popular as a destination for international migrants to a low of one migrant for every 38 persons in the population in Dublin. A simple regression indicates that there is not just a direct relationship between the number of immigrants and the size of the population but also that there are scale effects where larger centres pick up a disproportionate share of the number of immigrants. Thus, if centres outside Dublin were to grow faster than Dublin then this would automatically help them attract disproportionate numbers of migrants. However, migrants are currently more likely to choose Dublin over other centres, which reduces the potential population growth in other parts of the country.

FIGURE 4.2 INTERNATIONAL MIGRATION DISTRIBUTION FOR RECENT CENSUS YEARS



Source: CSO Census of Population, various issues.

The preceding discussion highlights the need to understand the determinants of the location patterns of international migrants. While a lot of research has considered national trends in migration, its drivers and implications, little is known about the spatial patterns of international migration in Ireland. There is

some research on return migration in Ireland, but there appears to be no recent research considering spatial patterns of international immigration and emigration and their drivers for Ireland. An interesting paper on return migration shows a link between the location of multinational firms and return migration in Ireland (Jones, 2003). However multinational employment in Ireland is concentrated in the cities and particularly Dublin, and there is a trend for increasing concentration particularly in Dublin, which would imply increased concentration of return migration in Dublin. Jones (2003) further showed that return migrants that returned to Mayo, a county that does not rank highly in terms of multinational employment, were particularly motivated by family and quality of life issues to return to Ireland in 2002, but that an improving economy in Ireland allowed them to return. The Census data show that return migrants are less concentrated in Dublin and other counties with large cities than non-Irish immigrants. For all international immigrants, Dublin was the destination for 44 per cent in 2011. However, for Irish return migrants the share accounted for by Dublin was just over 33 per cent.

The international literature has produced a number of interesting insights. Research on location patterns of international immigrants in Australia shows significant differences between ethnic groups, with those coming from the UK choosing to locate in a much wider set of destinations in Australia, and that non-English speaking migrants in particular tend to be drawn to larger cities especially due to ethnic concentrations (Le, 2008). A similar pattern is also suggested by Irish data. In 2011 over 48 per cent of black and Asian people in Ireland were resident in Dublin, while just over 32 per cent of non-Irish white persons resided in Dublin.

A significant share of Irish immigration is of high skills individuals, whose migration motives and location choices might differ from those of other types of migrants. A study of destination choices of immigrant engineers in the US by Scott (2010) found that employment chances are the dominant factor in determining location choices, and that amenities had little effect. As larger centres tend to have better employment prospects especially for highly skilled persons, these are a natural destination for high skills migrants. A further benefit of greater scale is that high skilled migrant couples have substantially higher probability of finding two jobs in larger centres, and this has led to increased urbanisation of university graduates (Costa and Kahn, 2000). For Ireland, a trend of absolute divergence in third-level attainment rates of the population across counties has also been shown. The degree to which this is due to migration choices both of internal and international migrants has yet to be explored in detail.

Of course, while the large cities may be the first destination of international migrants, these need not be their permanent residence over the longer term, and the location choices in subsequent moves are also important. Using Spanish data, Silvestre and Reher (2014) show that the multiple movers tend not to reside in centres with high concentrations of ethnic groups. They also found that multiple movers tended to be younger and more educated but also more likely to be unemployed.

The distribution of the number of non-Irish nationals across Irish counties in 2016 was considerably more even than the international migration shares. This is particularly the case for European and North American migrants. This is evidence that in Ireland international migrants also move once they get established in the country. This suggests that there is scope to attract international migrants to areas other than Dublin provided there are employment opportunities in these areas, that they provide the right amenities and that the appropriate information is available to migrants to make an informed decision about their residential location.

For the purposes of the projections the total international migration post-2016 is taken from the recent ESRI Economic Outlook (Bergin et al., 2016b), which provides a set of demographic and population projections for the period to 2030 that is consistent with economic projections published in the Economic Outlook. Over the period 2017 to 2021 net-immigration is assumed to run at on average just over 8,000 per year and from 2021 onwards net migration is assumed to run at 12,500 per year.

In contrast to the spatial patterns of international migration internal migration patterns are quite unstable over time, reacting to relative push and pull factors. The spatial patterns of internal migration have fluctuated significantly over time as is shown in Figure 4.3, which shows the total net internal migrants for each county except Dublin which is shown separately in Figure 4.4. The graphs clearly show that for most counties internal migration is sometimes positive and sometimes negative. The only county for which net internal immigration is always positive is Meath, but even here there is significant variation in the size of the net-migration flows. Dublin, which is often regarded as the principal destination for internal migration in Ireland, experienced negative net internal migration in 2002 and 2006 (and again in 2015/2016), while relatively remote counties such as Donegal or Leitrim recorded positive net internal migration is some years. Table 4.2 shows the similarity/dissimilarity of internal migration patterns across the years. The table shows that the pattern of internal migration was quite stable for the period 1981 to 1996, but that the pattern has become very unstable since 1996. This shows that the pattern in 2002 is very similar to that in 2006 and 2016.

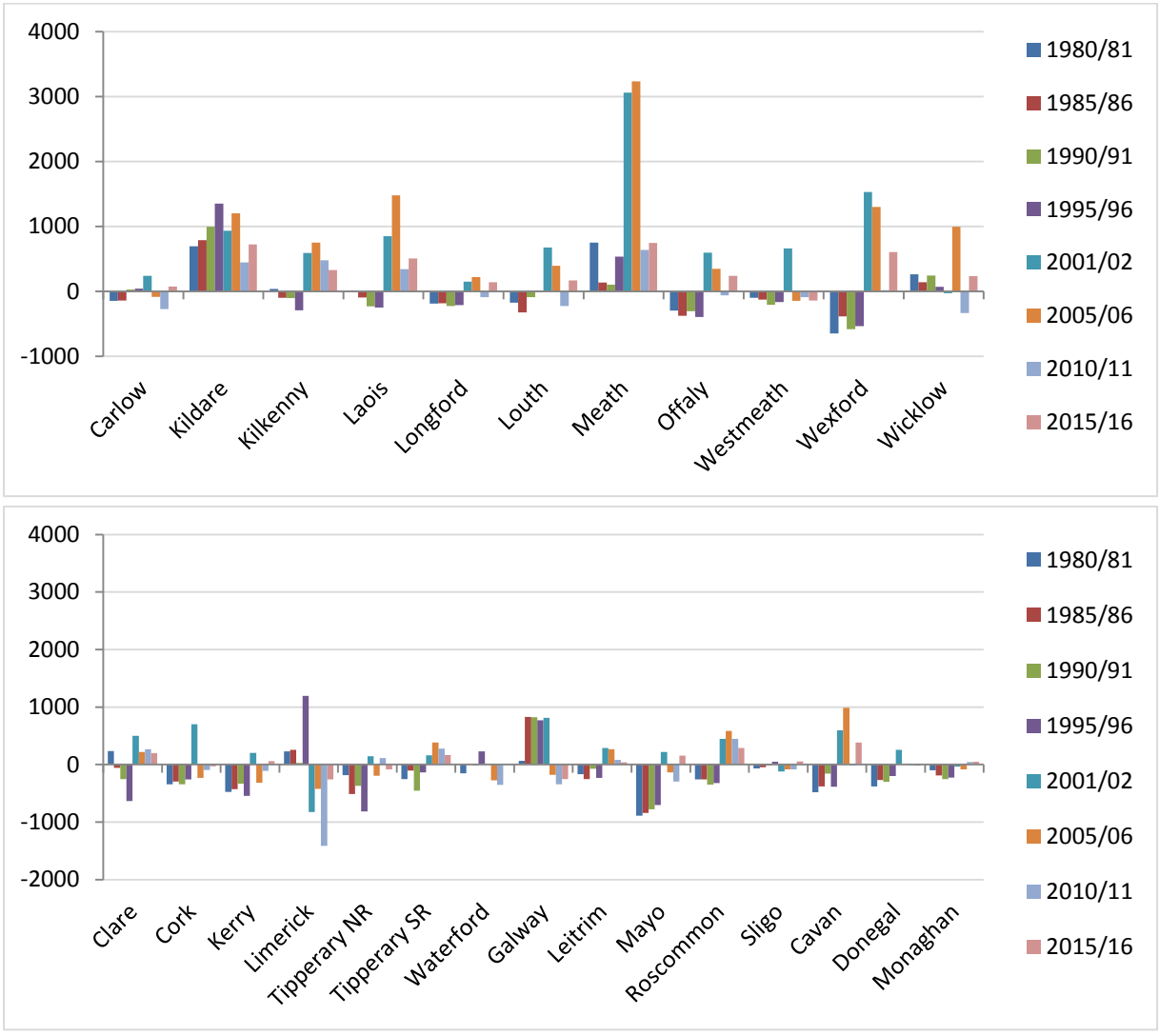
The pattern observed in 2011 is quite distinct from that observed in any recent year.

TABLE 4.2 CORRELATION BETWEEN INTERNAL NET-MIGRATION PATTERNS

	1980/81	1985/86	1990/91	1995/96	2001/02	2005/06	2010/11	2015/16
1980/81	1.00							
1985/86	0.95	1.00						
1990/91	0.93	0.98	1.00					
1995/96	0.81	0.87	0.86	1.00				
2001/02	-0.79	-0.83	-0.82	-0.59	1.00			
2005/06	-0.72	-0.79	-0.78	-0.53	0.98	1.00		
2010/11	0.36	0.25	0.25	-0.03	-0.15	-0.09	1.00	
2015/16	-0.79	-0.84	-0.82	-0.59	0.98	0.98	-0.12	1.00

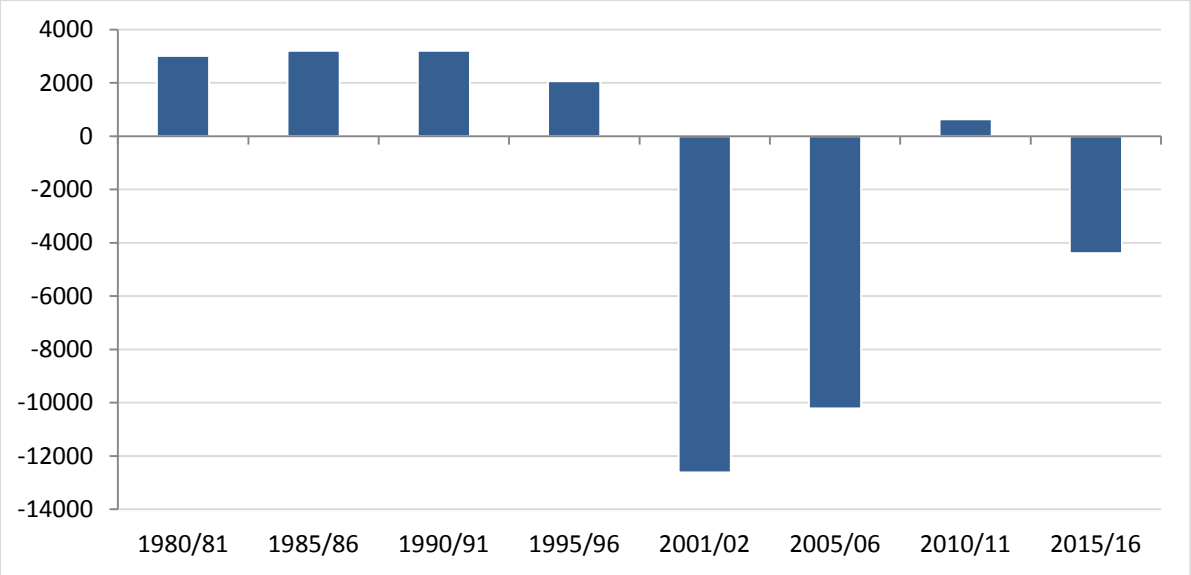
Source: Author's calculations using CSO Census of Population, various issues.

FIGURE 4.3 NET INTERNAL MIGRATION BY COUNTY FOR CENSUS YEARS FROM 1981 TO 2016



Source: CSO Census of Population, various issues.

FIGURE 4.4 NET INTERNAL MIGRATION TO/FROM DUBLIN FOR CENSUS YEARS FROM 1981 TO 2016



Source: CSO Census of Population, various issues.

The determinants of internal migration patterns have been analysed in the international literature, but for Ireland no such analysis has been undertaken. A variety of drivers of internal migration patterns have been considered in the literature. For example Sarra and del Signore (2011) show that better roads infrastructure, lower crime and more housing units per 1,000 inhabitants are factors that attract internal migrants. The importance of house prices, new house completions and deprivation was identified by Leishman and Bramley (2005) as important determinants of internal migration in the UK, with higher house prices or levels of deprivation leading to lower in-migration and large numbers of new house completions result in higher levels of immigration. Biagi et al. (2011) point to the fact that there may be different processes at work in short-distance internal migration compared to long-distance internal migration. In a paper using data for Austria, Kulu (2008) showed that there is a relationship between the arrival of the first child and residential location decisions, and that most moves are within the labour market area, and that there is a negative relationship between family size and longer distance migration. Saks and Wosniak (2011) find that long distance internal migration for the United States is pro-cyclical, particularly for younger workers and that this is due to labour market factors.

Garcia-Rodriguez and Morgenroth (2017) analyse Irish internal migration patterns. They estimate models of gross flows using a gravity type framework and a range of potential determinants of internal migration patterns, taking account of the fact that migrants may choose locations on the basis of their relative attractiveness. Furthermore their analysis allows for the fact that individuals might locate in neighbouring areas to their preferred one perhaps because of

housing costs and they also consider whether the factors driving internal migration decisions differ between moves to neighbouring counties and moves over a longer distance.

Their results, which are based on county level data rather than individual level data, show that for moves to contiguous counties, relative house prices, wages in neighbouring regions of the destination, the unemployment rate in neighbouring counties, proximity to an airport, border (negative effect) and the length of motorways in the destination region were particularly important. Non-linear effects are also allowed for by including squared terms of some variables. Factors that were only just statistically significant included distance, the unemployment rate in neighbouring regions to the origin county and whether the destination had a coast. These results are consistent with a model where moves are driven by house price differences and ease of commuting to neighbouring counties with higher wages, i.e. a pattern that generates sprawl rather than a type of pattern that is assumed under a city focused regional development pattern.

For migration between non-contiguous counties, house price differentials were not found to be statistically significant determinants but its squared difference was found to be significant, although the effect is smaller than that for house price differences. While the difference in house prices can be either positive or negative, the squared variable is always positive and thus is an indicator of differences between counties only. The finding of a negative coefficient on the squared house price differentials thus indicates that individuals are less likely to migrate to counties which have different house prices compared to their origin county. In addition to distance, the population age composition differences in the destination county, the wages in neighbouring counties to the destination, and the proximity to the coast and universities were found to be significant. This pattern is consistent with a model where longer distance internal migration is driven by life cycle factors, such as starting a third-level course. This type of migration is more likely to result in a more spatially concentrated growth pattern.

Overall, the results show that while there are significant fluctuations in the number and spatial pattern of internal migration, there exists an empirical relationship between internal migration and a number of determinants. These determinants are amenable to policy actions which would change internal migration patterns. For example, if policies changed the supply of housing such that the price of housing in some areas declined, then these areas can be expected to attract more internal migrants. Likewise, successful industrial policy can impact on local labour market conditions including wages. Finally, the analysis also points to the importance of amenities and infrastructure to attract migrants, and again amenities can be altered with policy.

For the purposes of the 'current trends' the pattern is assumed to remain similar to that identified in recent Census results and is assumed to apply over the projection horizon. The alternative scenarios presented in the next chapter are generated by altering the spatial patterns of both international and internal migration.

It should be noted that with the natural increase declining as a source of population growth, as shown above, the projections are more sensitive to variations in the migration assumptions. However, a larger population due to larger immigrant flows needs to be consistent with the underlying economic model. The baseline scenario of the ESRI Economic Outlook is a very benign scenario with growth rates that exceed those projected for most international economies. A more positive demographic scenario would need to be accompanied by an even more positive economic scenario.

Projection results

The regional population projections and their implied annual average population growth rates are shown in Table 4.4. Given the assumptions used, the population is set to increase by about one million persons over the period 2011 to 2040, with the population growth expected to be faster post-2016 than during the 2011 to 2016 period. Given the assumptions used, only the Mid-East and Dublin regions grow significantly above the national average rate of growth. This is consistent with a 'current trends' scenario where the growth is focused on the Greater Dublin region with significant sprawl from Dublin to the neighbouring counties. On the basis of the assumptions applied, the Border, Midland and South-East are projected to grow at below the national average rate while the West, Mid-West and South-West are expect to grow at similar rates to the national average. Given the assumptions, the population share accounted for by Dublin and the Mid-East is projected to grow from 40.1 per cent to 41.7 per cent, and all other regions except the West are projected to account for a smaller population share. Thus, Dublin and the Mid-East together are projected to increase their populations by about 440,000 between 2011 and 2040, and account for 50.5 per cent of the projected population increase.

TABLE 4.4 POPULATION PROJECTIONS AND ANNUAL AVERAGE POPULATION GROWTH RATES BY REGION

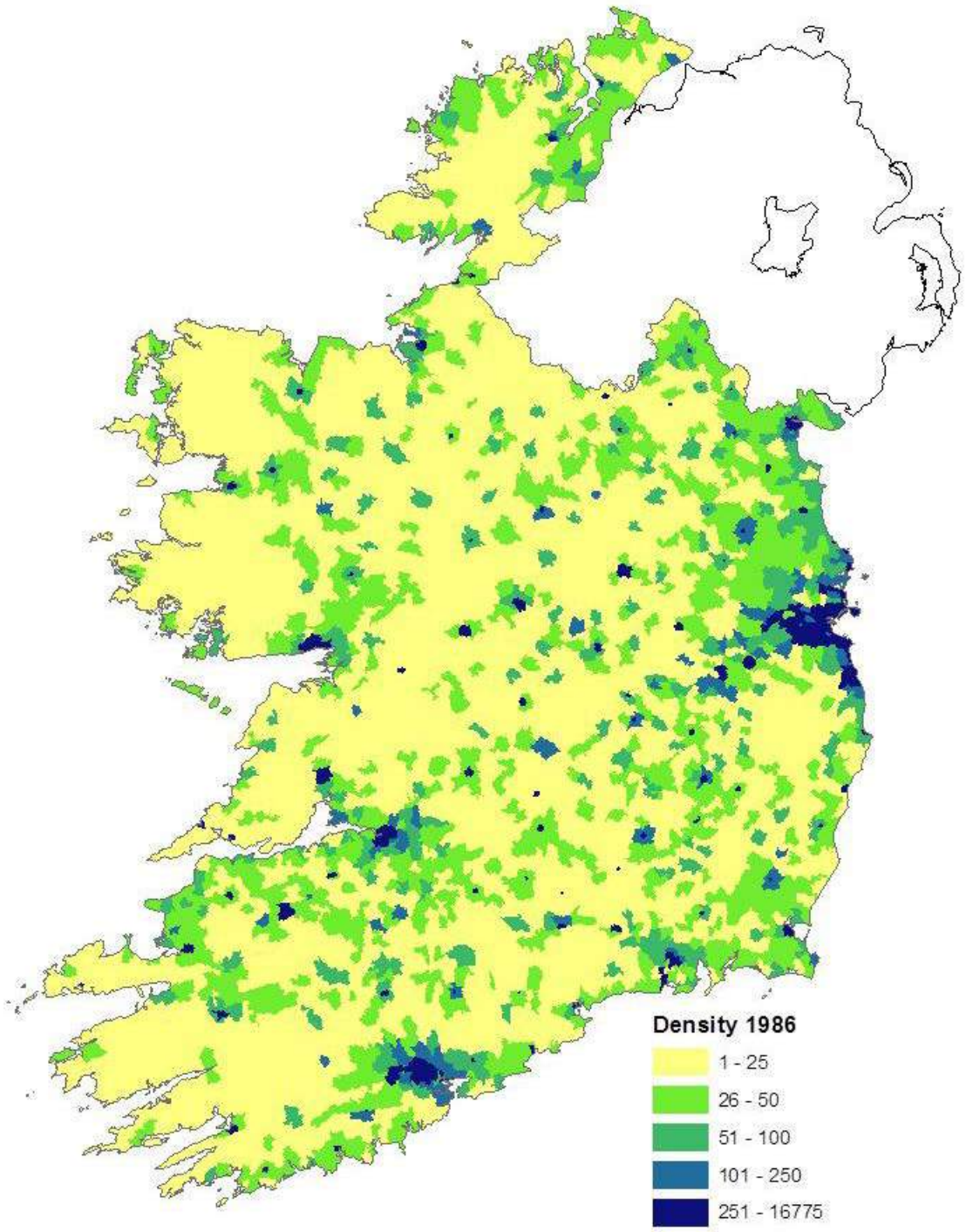
	Population ('000s)			Annual Average Growth		Population Share	
	2011	2016	2040	2011-2016 %	2016-2040 %	2016 %	2040 %
Border	514.9	523.2	589.0	0.3	0.5	11.0	10.5
Midland	282.4	292.3	330.5	0.7	0.5	6.1	5.9
West	445.4	453.1	534.1	0.3	0.7	9.5	9.5
Dublin	1,273.1	1,347.4	1,639.8	1.2	0.9	28.3	29.1
Mid-East	531.1	560.0	707.5	1.1	1.1	11.8	12.6
Mid-West	379.3	385.0	449.4	0.3	0.7	8.1	8.0
South-East	497.6	510.3	585.4	0.5	0.6	10.7	10.4
South-West	664.5	690.6	799.2	0.8	0.7	14.5	14.2
State	4,588.3	4,761.9	5,634.8	0.8	0.8	100.0	100.0
Northern and Western	837.4	847.4	961.6	0.2	0.6	17.8	17.1
Eastern and	2,209.5	2,328.5	2,839.2	1.1	0.9	48.9	50.4
Southern	1,541.4	1,585.9	1,833.9	0.6	0.7	33.3	32.5

Source: Author's calculations.

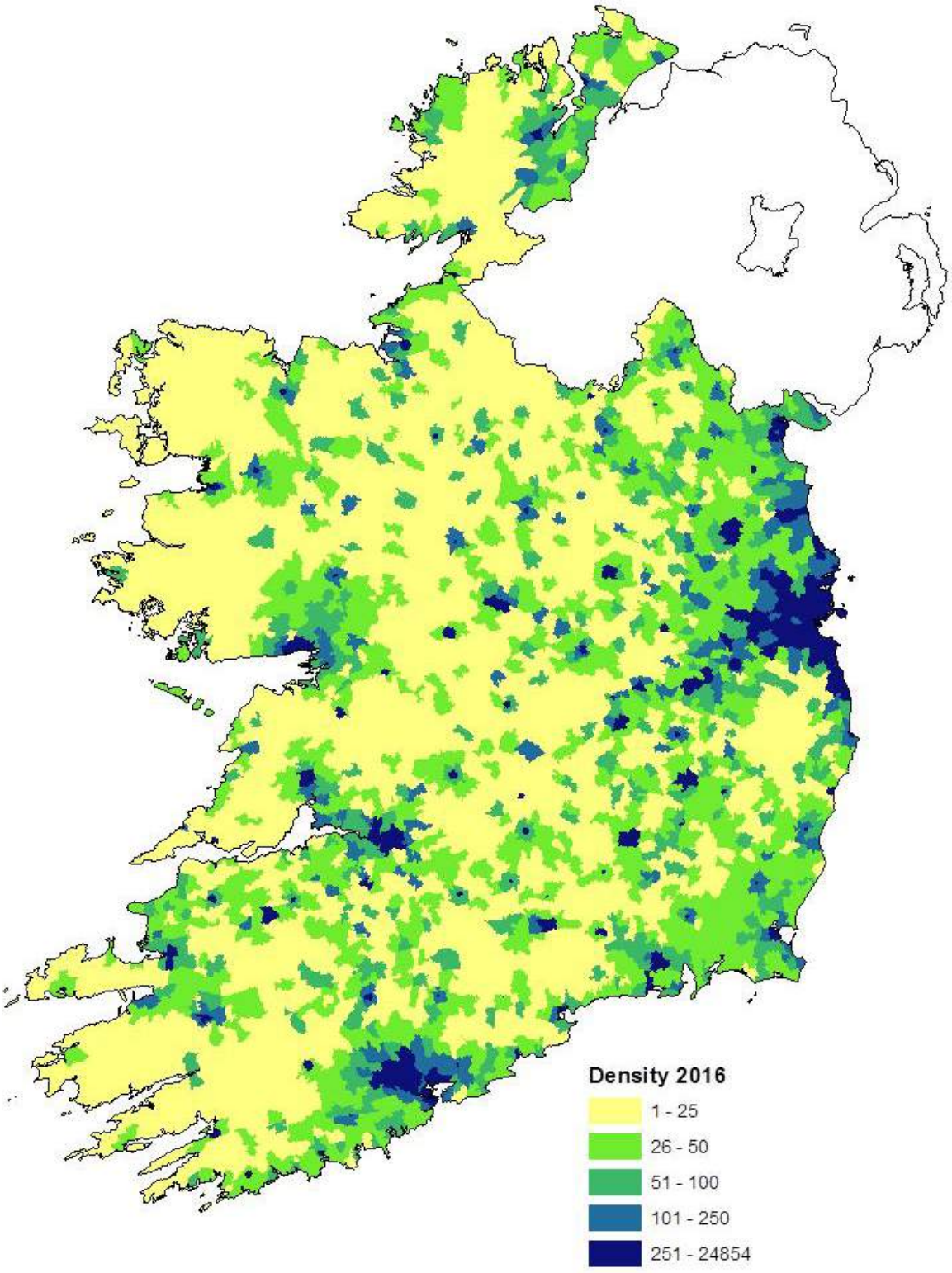
The projections are produced at county level and these can also be further downscaled to the Electoral District (ED) level using the model developed in Crawford et al. (2014). For the purposes of providing up to date projections this model was re-estimated using the preliminary Census data. The results of the downscaling exercise for 2041 are shown in Map 4.3,[16] which shows the population density across EDs. Maps 4.1 and 4.2 show the population density in 1986 and 2016 respectively for comparison. The projected pattern of population change is clearly focused in and around the big cities and in particular Dublin, and many rural parts of counties Kildare, Meath and Louth are projected to increase their population densities to more than 50 persons per square kilometre, while the eastern coastal corridor is projected to have essentially urban character.

[16] The ED model projects the population for census years only so that the estimates are produced for 2041 rather than 2040.

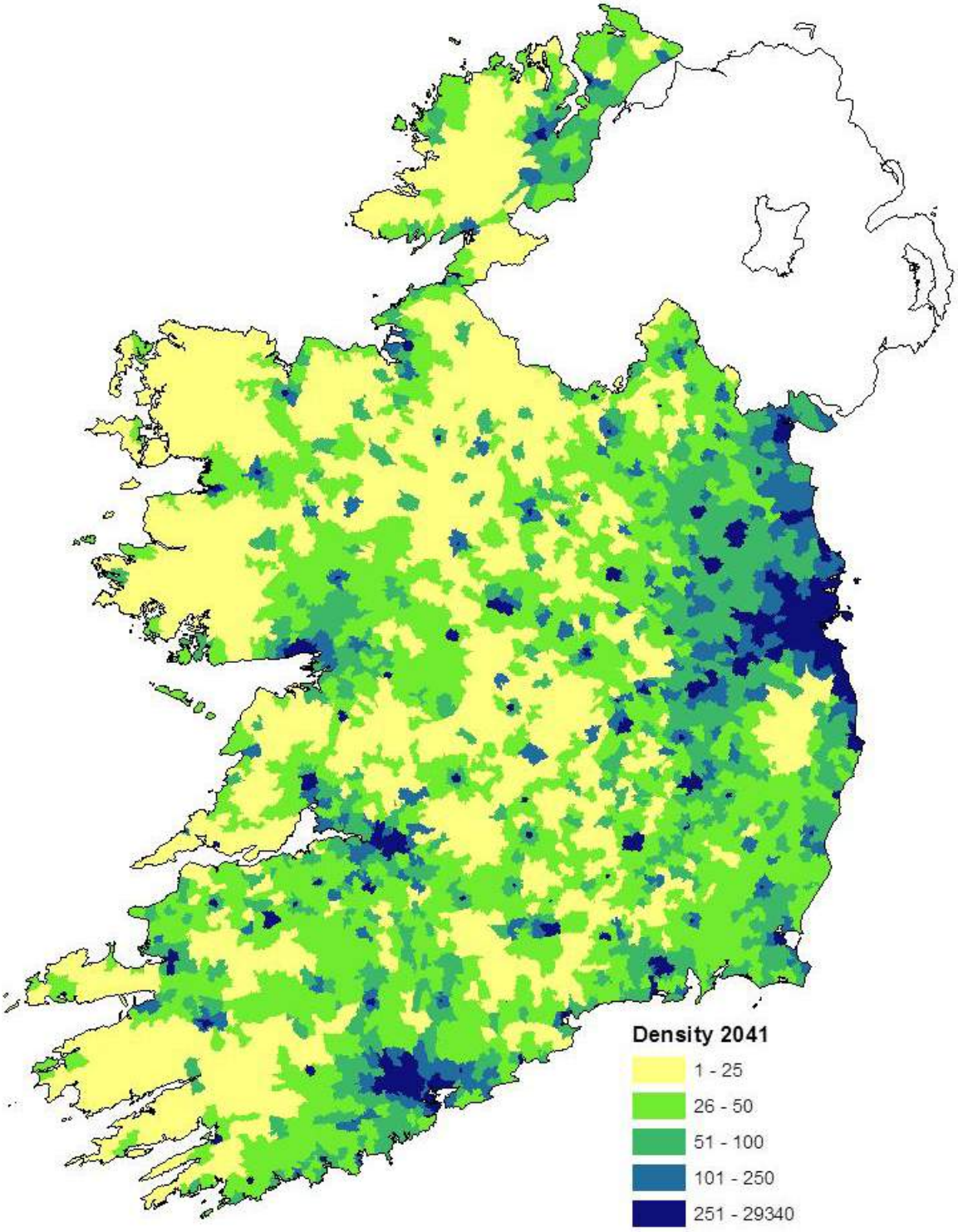
MAP 4.1 POPULATION DENSITY 1986



MAP 4.2 POPULATION DENSITY 2016



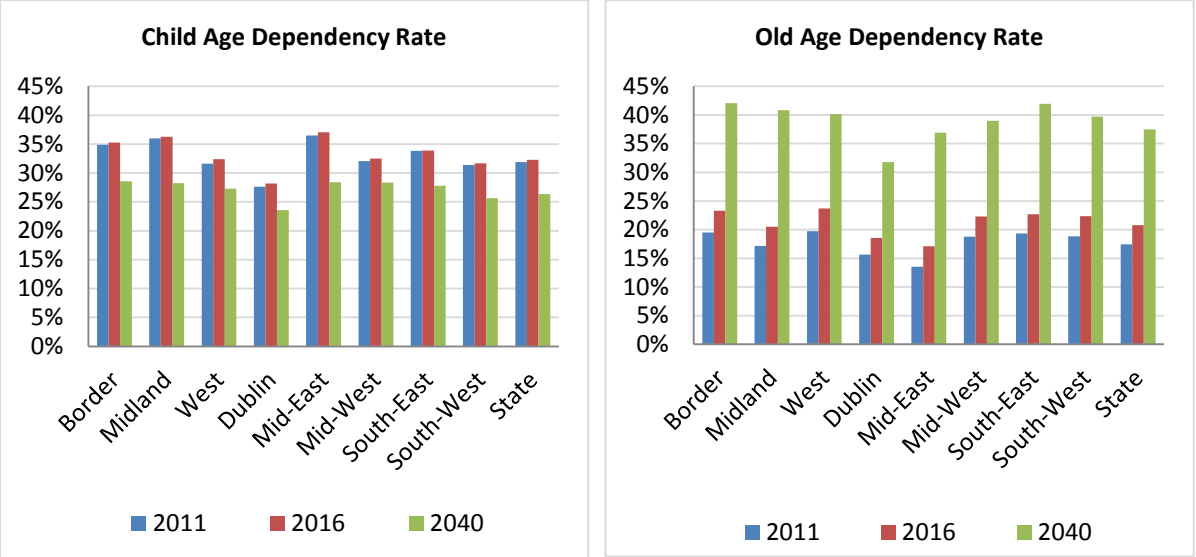
MAP 4.3 POPULATION DENSITY 2041



Finally, as noted above, the age distribution is an important determinant of the need for investment in public services. This is shown in Figure 4.5, which shows that by 2040 the child age dependency rate is projected to decline on average from 32 per cent in 2016 to 26 per cent in 2040, while the old age dependency is projected to increase significantly from 21 per cent to 37 per cent. Thus, the

overall dependency rate is also projected to grow significantly from 53 per cent to 64 per cent. In general the rankings remain constant across the regions but in relation to the old age dependency rate the Midland is projected to see a more significant increase than the West region. The average age is projected to increase from 36.9 years of age to 42.8 year of age.

FIGURE 4.5 DEPENDENCY RATES BY REGION, 2011, 2016 AND 2040



Source: Census 2011, 2016 and author's calculations.

4.2 EMPLOYMENT PROJECTIONS

The aim of this section is to provide projections for employment at the regional and county level, for which a model is now available. Given the aim of providing 'current trends' projections, the key to developing a simple model to accomplish this task is to find a way to extract the trends from the time series of employment data. Another requirement is to ensure that the resulting regional projections add up the national projections from the ESRI Economic Outlook. Furthermore, the results have to be consistent with the projections of the working age population which are an output of the population projections model. Thus, the model needs to generate a set of results for employment – the labour force and unemployment along with the projections of the working age population – that is consistent with the national projections from the ESRI Economic Outlook.

Given that there is considerable heterogeneity with respect to sectoral employment growth patterns across the regions, the aim is to provide some sectoral disaggregation. These sectoral patterns are important from an economic perspective as sectors differ in their growth prospects, the type of employment they create and wage levels. For example, average income in agriculture, forestry

and fishing is relatively low while wages in professional, scientific and technical activities are relatively high on average.[17]

The new ESRI macroeconomic model, COSMO, distinguishes three sectors: the (internationally) traded sector, the non-traded sector and the government sector. These three sectors capture important distinctions. For example, the traded sector activity is significantly driven by competitiveness and world demand, while non-traded sector activity is determined by domestic demand. The government sector is significantly determined by policy, and should thus be treated differently. The projections from the ESRI Economic Outlook over the period to 2030 and for this paper are extrapolated to 2040.

The trends in employment in these sectors are shown in the three left hand graphs of Figure 4.3. They show the significant growth of employment across the sectors over the period up to 2007 and the decline during the economic crisis. Government sector employment declined only very slightly during the crisis, while the other two sectors were more affected, which reflects the fact that they are market sectors. Non-traded sector employment which includes construction declined by over 24 per cent reflecting the very considerable contraction of the domestic economy, while traded sector employment declined by 14 per cent.

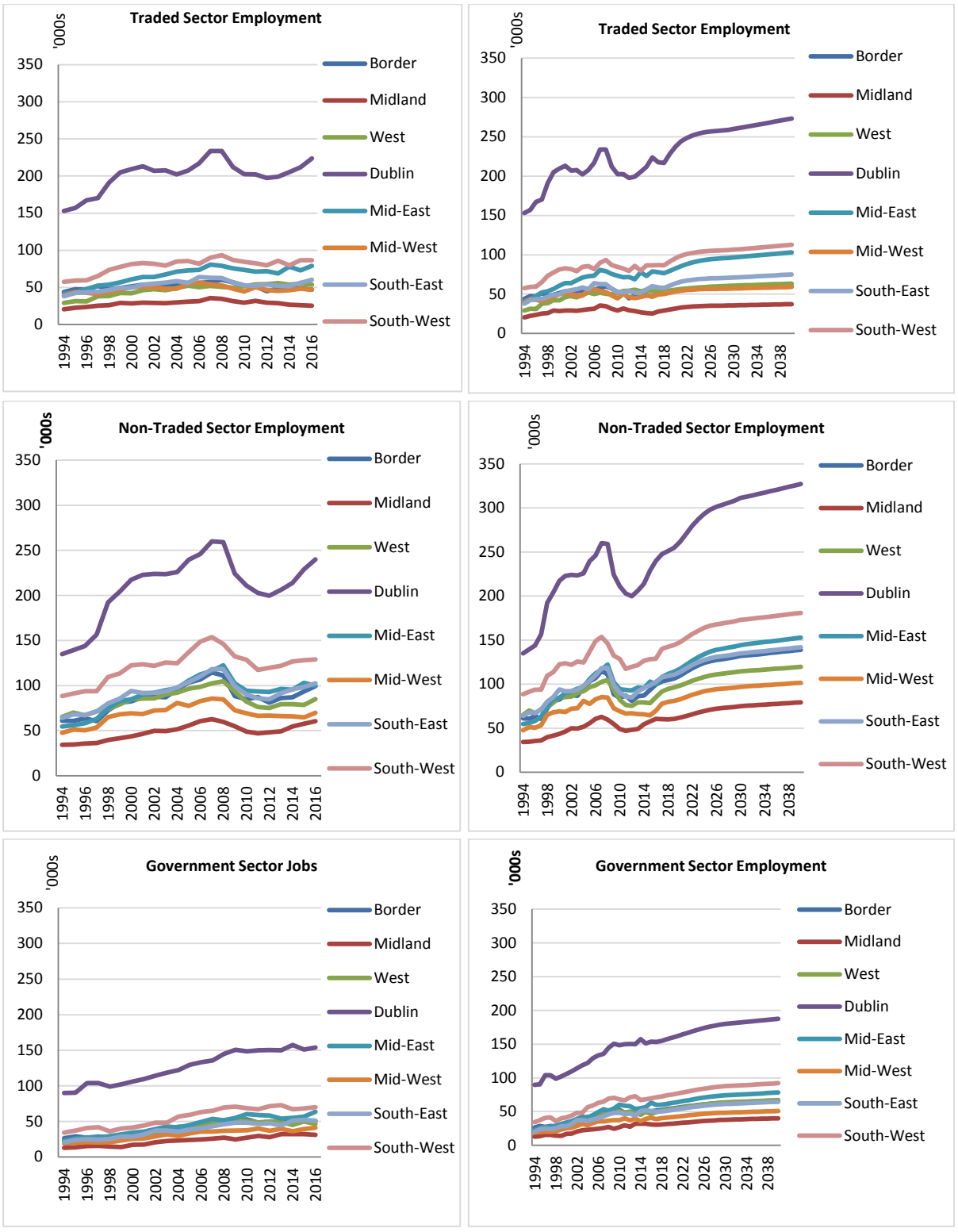
A large range of econometric models was tested to achieve the objective of generating a consistent set of projections for the labour market, with the final specification being chosen on the basis that it provides stable and plausible results. The chosen specification involves estimating the relationship between sectoral employment of each region as a function of national employment in that sector and lagged regional sector employment using data for the period 1994 to 2016. This corresponds with a simple top-down model and allows for the sharing out across the regions of the national projections provided by the ESRI Economic Outlook (see Bergin et al., 2016a). The projections are then generated using the parameters from the econometric analysis and the projection of national employment for each sector from the ESRI Economic Outlook, where the sum of employment across the regions is constrained to equal the ESRI Economic Outlook figure.

Projections for employment in the three sectors are provided on the right hand side of Figure 4.6. The projections imply different rates of growth across the regions and sectors (Table 4.5 and Table 4.6). Using these simple 'current trends'

[17] According to CSO annual average earnings data, hourly wages in the accommodation and food and wholesale and retail sectors are over 50 per cent and 20 per cent respectively lower than the national average, while wages in finance and insurance and information and communication are around 30 per cent higher than the national average.

projections, total employment is projected to grow by 38 per cent between 2016 and 2040 in the Mid-East while employment in Dublin is projected to grow by 28 per cent. In relation to the traded sector, the Midland region would grow most while the West would record the lowest growth. For the non-traded sector the Mid-East is projected to increase by most and Dublin by least, while for the government sector the West is set to grow most and Dublin least. Of course it is important to remember that employment refers to the number of persons resident in an area that are in employment and this therefore does not necessarily indicate growth in the number of jobs located in that region which is explored further below.

FIGURE 4.6 ACTUAL AND PROJECTED EMPLOYMENT BY REGION



Source: CSO Quarterly National Household Survey and author's calculations.
Note: Employment relates to the resident population in employment.

TABLE 4.5 ANNUAL AVERAGE PROJECTED GROWTH RATE IN EMPLOYMENT BY REGION AND SECTOR OVER THE PERIOD 2016 - 2040 (%)

Sector	Border	Midland	West	Dublin	Mid-East	Mid-West	South-East	South-West	State
Traded Sector	1.1	2.0	0.8	0.9	1.3	1.1	1.0	1.3	1.1
Non-traded Sector	1.7	1.3	1.7	1.5	2.2	1.9	1.6	1.7	1.7
Government	1.3	1.3	1.9	0.9	1.0	1.0	1.1	1.3	1.2
Total	1.4	1.4	1.5	1.2	1.6	1.4	1.3	1.5	1.4

	Northern and Western	Eastern and Midland	Southern
Traded Sector	0.9	1.1	1.1
Non-traded Sector	1.7	1.7	1.7
Government	1.6	1.0	1.2
Total	1.4	1.3	1.4

Source: Author's calculations.
Note: Employment relates to the resident population in employment.

TABLE 4.6A EMPLOYMENT AND PROJECTED EMPLOYMENT BY SECTOR AND REGION, 2016 AND 2040 ('000S)

Sector		Border	Midland	West	Dublin	Mid-East	Mid-West	South-East	South-West	State
Traded Sector	2016	46.9	25.2	53.6	223.8	78.9	46.9	60.3	86.6	622.2
	2040	59.7	37.3	63.4	273.2	103.1	59.2	75.1	112.7	783.6
Non-Traded sector	2016	99.4	60.5	85.0	240.0	99.8	69.8	102.6	129.0	886.1
	2040	139.1	79.3	119.5	327.3	152.9	101.6	141.9	180.9	1,242.4
Government sector	2016	50.6	30.9	46.4	153.7	63.5	40.9	50.9	69.8	506.7
	2040	66.5	40.2	67.2	187.5	78.4	51.0	64.6	92.2	647.6
Total	2016	196.9	116.6	185	623.7	242.2	157.6	213.8	285.4	2,015.0
	2040	265.2	156.7	250.1	795.9	334.4	211.8	281.6	385.8	2,673.7
Labour Force	2016	217.4	128.0	201.0	671.5	262.4	171.2	237.0	309.8	2,198.2
	2040	292.2	171.5	271.1	855.1	361.4	229.6	311.1	417.9	2,910.0

Source: Author's calculations.
Note: Employment relates to the resident population in employment.

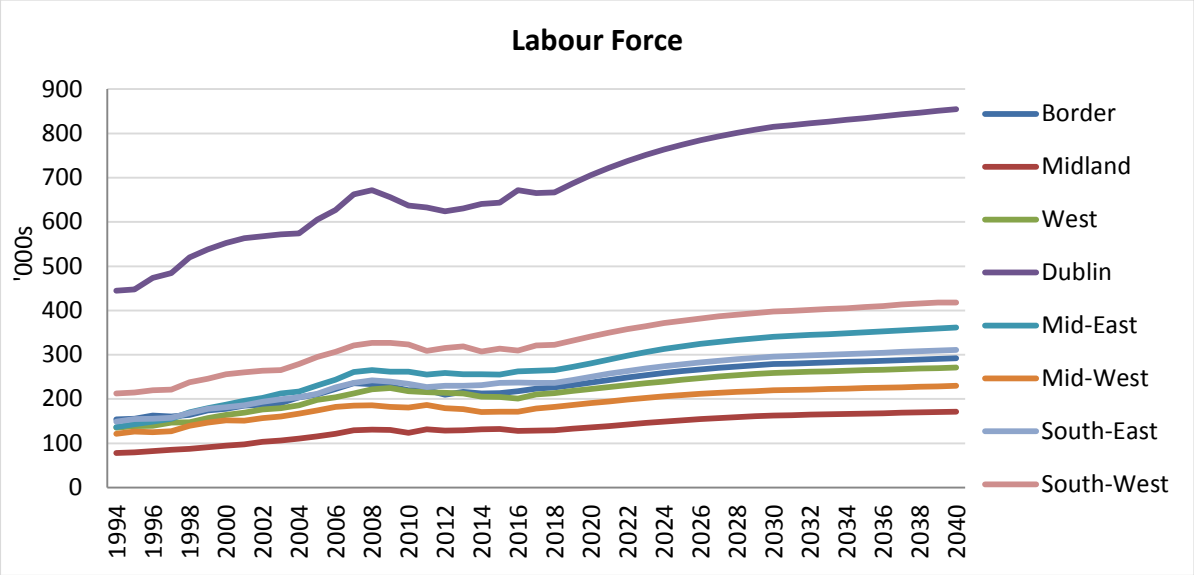
TABLE 4.6B EMPLOYMENT AND PROJECTED EMPLOYMENT BY SECTOR AND REGIONAL ASSEMBLY, 2016 AND 2040 ('000S)

Sector		Northern and Western	Eastern and Midland	Southern	State
Traded Sector	2016	89.8	338.6	193.8	622.2
	2040	108.8	427.9	247.0	783.6
Non-Traded Sector	2016	158.9	425.8	301.4	886.1
	2040	223.2	594.9	424.3	1,242.4
Government Sector	2016	85.7	259.4	161.6	506.7
	2040	118.4	321.4	207.8	647.6
Total	2016	334.4	1023.8	656.8	2,015.0
	2040	450.3	1344.2	879.1	2,673.7
Labour Force	2016	363.9	1116.4	718.0	2,198.2
	2040	482.4	1468.9	958.7	2,910.0

Source: Author's calculations.
Note: Employment relates to the resident population in employment.

The labour force projections arising out of the model are shown in Figure 4.7 and Table 4.6. These indicate a growing labour force, but that growth slows after 2030. The population projections imply a stronger surge in the labour force in Dublin than in other regions initially, but this levels off gradually. Over the full projection horizon the labour force participation rates behind the projection are expected to converge.

FIGURE 4.7 ACTUAL AND PROJECTED LABOUR FORCE BY REGION, 1994 - 2040



Source: CSO Quarterly National Household Survey and author's calculations.

4.3 JOBS PROJECTIONS

The challenge in modelling jobs is the lack of time series data rather than the complexity of having to achieve consistency between the employment, labour force and working age population. As was highlighted above, apart from the DEBI/Forfás employment survey, the other existing data do not cover a long time period, which means that the series relate largely to the economic crisis period or are limited to a number of cross-sections.

A further complication is the desire to model jobs for the three sectors described above separately. However, as the DEBI/Forfás data closely matched the traded sector as defined in the ESRI Economic Outlook, these data can be used to model the traded sector. To do so the data are reweighted to match the total number of jobs in the economy, which is equal to the total number of employees. The approach taken here is to utilise a similar econometric approach to that used in modelling employment. Thus, traded sector jobs are modelled as a function of total jobs and a regional time lag of jobs. As the data are available for both counties and regions, the modelling can be done at the county level and the results can be readily aggregated.[18] As before for employment, the estimated parameters are used in conjunction with the total number of jobs projected by the ESRI Economic Outlook, which at the national level needs to be the same as the numbers employed, to generate the number of jobs in each region.

This approach cannot be used to model either the non-traded or government sectors, due to lack of a sufficiently long time series. For the government sector it is assumed that jobs are related to size of the population. The economic outlook projects an increase in the ratio of employment in the government sector to the population, which is consistent with increasing dependency rates. Applying this trend to the ratios at the regional level allows us to project the jobs in the government sector for each region, where the sum of regional jobs is constrained to be equal to the total projected in the ESRI Economic Outlook.

For the non-traded sector only two cross-sections are available from the 2006 and 2011 Census. These are used to estimate the relationship between the county share in non-traded sector jobs as a function of the lagged share and the population. This reflects the fact that the non-traded sector, such as wholesale and retail or construction, serves the local population. The predicted shares are then used to generate the non-traded sector jobs for each county, where a constraint is applied that they sum to the total number of non-traded sector jobs projected in the ESRI Economic Outlook.

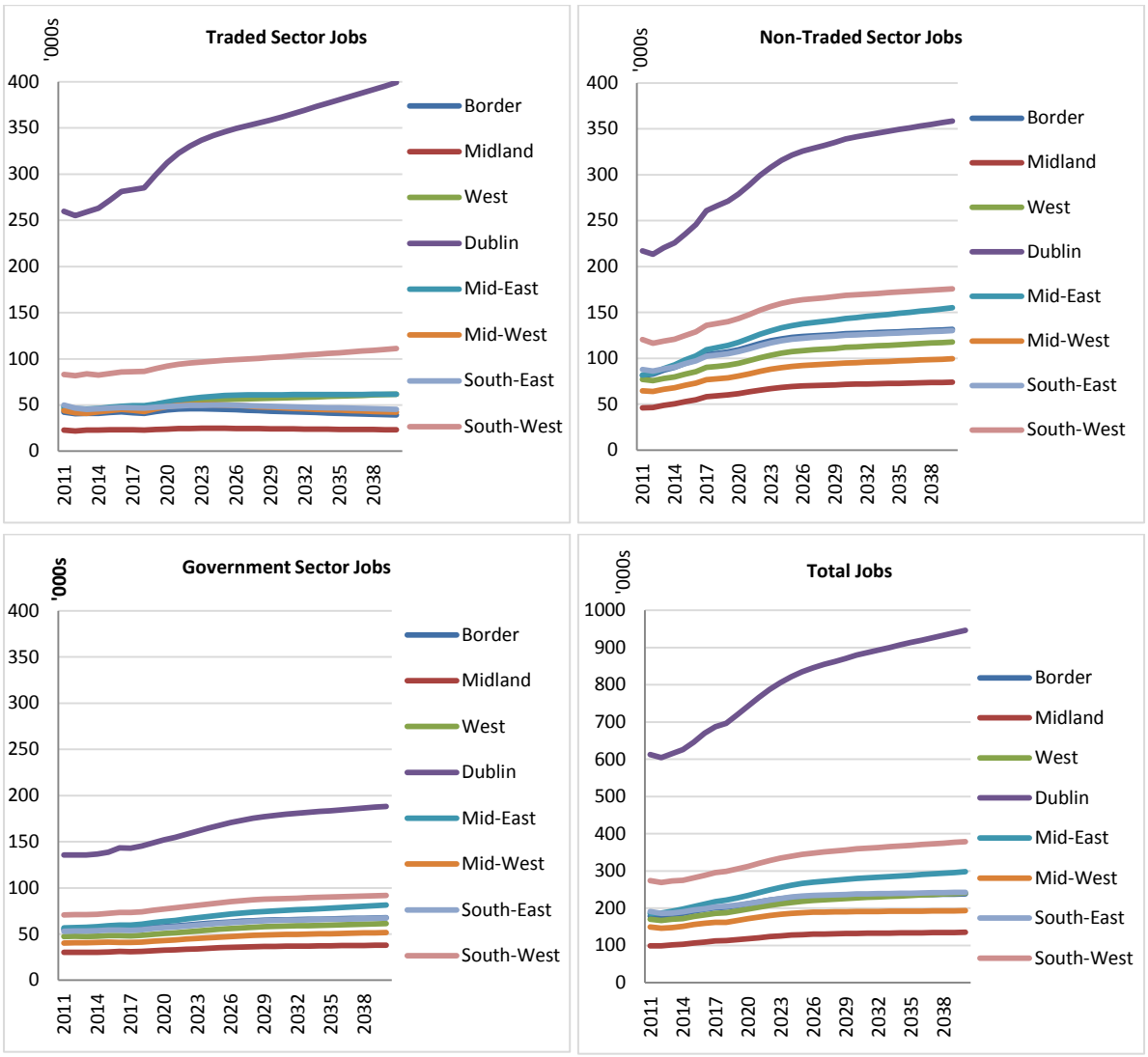
[18] It was verified that modelling the regions separately yielded almost identical results.

Given the difficulties in estimating robust relationships, the results from this exercise, particularly for the counties, need to be treated with caution, and should be taken as indicative of potential trends. Again it needs to be noted that jobs refer to where the activity takes place while employment refers to where employed persons live. It should also be noted that the approach is based on the implicit assumption in the analysis in this report that there is no commuting to or from other countries including Northern Ireland. In practice there is some commuting across the border with Northern Ireland, but Census 2011 results show that this is limited to just under 15,000 persons for commuting in both directions for both work and study, with a net outflow from the Republic of Ireland of 1,800 (CSO, 2014). The 2016 Census found that just 7,073 workers commuted from Ireland to Northern Ireland (CSO, 2017).

The results are shown in Figure 4.8, Table 4.7 and 4.8. These show that total jobs are projected to grow in all regions, but that Dublin and the Mid-East are projected to have above average jobs growth. For Dublin, all sectors are projected to grow faster than the average, while for the Mid-East both the traded and government sectors are projected to grow at the average rate while the non-traded sector is projected to grow by more than the national average. For the Border and the South-East the model projects traded sector jobs to decline slightly. The range of growth rates varies less for the non-traded and government sectors than the traded sector. This is likely to be due to both the differences in the methodology used and the fact that the spatial distribution of traded sector jobs has been changing more than that of the other sectors.

Overall the projections imply economic divergence across the regions, with Dublin in particular growing significantly faster. The model projects the Mid-West, Border and South-East regions to grow slowest. The jobs growth in the South-West and West is projected to be just under the national average, which is largely due to the influence of Cork and Galway.

FIGURE 4.8 ACTUAL AND PROJECTED JOBS BY REGION, 1994 - 2040



Source: Author's calculations using DJEI/Forfás Employment Survey and CSO Census data.
Note: Jobs referred to the location where the economic activity takes place rather than where the person doing the job is resident.

TABLE 4.7A ANNUAL AVERAGE PROJECTED GROWTH RATES IN JOBS BY REGION AND SECTOR OVER THE PERIOD 2016 - 2040 (%)

Sector	Border	Midland	West	Dublin	Mid-East	Mid-West	South-East	South-West	State
Traded Sector	-0.3	0.0	1.2	1.8	1.1	-0.3	-0.2	1.2	1.1
Non-traded Sector	1.4	1.5	1.6	1.9	2.1	1.5	1.4	1.5	1.7
Government	0.9	0.9	1.1	1.3	1.5	1.1	1.0	1.0	1.2
Total	0.9	1.0	1.4	1.7	1.7	0.9	0.9	1.3	1.4

Source: Author's calculations using DJEI/Forfás Employment Survey and CSO Census data.
Note: Jobs referred to the location where the economic activity takes place rather than where the person doing the job is resident.

TABLE 4.7B ANNUAL AVERAGE PROJECTED GROWTH RATES IN JOBS BY REGION AND SECTOR OVER THE PERIOD 2016 - 2040 (%)

Sector	Northern and Western	Eastern and Midland	Southern	State
Traded Sector	0.6	1.5	0.5	1.1
Non-traded Sector	1.4	1.9	1.5	1.7
Government	0.9	1.3	1.0	1.2
Total	1.1	1.6	1.1	1.4

Source: Author's calculations.
Note: Jobs referred to the location where the economic activity takes place rather than where the person doing the job is resident.

TABLE 4.8A JOBS AND PROJECTED JOBS BY SECTOR AND REGION, 2016 AND 2040 ('000S)

Sector		Border	Midland	West	Dublin	Mid-East	Mid-West	South-East	South-West	State
Traded	2016	42.7	23.3	48.1	281.1	48.8	45.2	47.2	85.8	622.2
	2040	39.2	23.3	61.7	399.2	61.7	42.1	45.3	111.1	783.6
Non-Traded	2016	98.2	54.9	85.5	245.6	102.7	73.0	97.1	129.0	886.1
	2040	131.4	74.1	117.9	358.6	155.0	99.5	130.2	175.7	1242.4
Government	2016	55.7	31.1	48.2	143.3	59.6	41.0	54.3	73.5	506.7
	2040	67.7	38.0	61.4	188.3	81.3	51.7	67.3	91.9	647.6
Total	2016	196.6	109.3	181.9	670.0	211.1	159.2	198.6	288.3	2015.0
	2040	238.4	135.3	241.0	946.2	298.0	193.3	242.8	378.7	2673.7

Source: Author's calculations.
Note: Jobs referred to the location where the economic activity takes place rather than where the person doing the job is resident.

TABLE 4.8B JOBS AND PROJECTED JOBS BY SECTOR AND REGION, 2016 AND 2040 ('000S)

Sector		Northern and Western	Eastern and Midland	Southern	State
Trade	2016	81.7	362.4	178.2	622.2
	2040	92.8	492.3	198.6	783.6
Non-Traded	2016	160.2	426.7	299.2	886.1
	2040	213.8	623.2	405.4	1,242.4
Government	2016	90.0	247.9	168.8	506.7
	2040	110.2	326.5	210.8	647.6
Total	2016	331.8	1,037.0	646.1	2,015.0
	2040	416.8	1,442.0	814.8	2,673.7

Source: Author's calculations.
Note: Jobs referred to the location where the economic activity takes place rather than where the person doing the job is resident.

CHAPTER 5

Alternative scenarios

It is possible to put forward an almost infinite number of alternative scenarios for the spatial patterns of demographic and economic development, but only a small set of scenarios is likely to be feasible. The aim in this chapter is to consider a small number of scenarios that reflect some of the discussion about regional development in Ireland. Alternative views about the desired spatial development paths for Ireland are regularly expressed in public debates. For example, some argue that the growth of Dublin, even if this has a negative impact on other parts of Ireland, should be facilitated as Dublin is the only city of international scale on the island of Ireland. In contrast, others argue that policy should favour the growth of the second tier cities such as Cork or Limerick, while others argue for a more even distribution of growth or faster growth in the more rural areas.

Here five alternative demographic scenarios to the current trends scenario are presented, which address these alternative views. In particular, one scenario considers a situation where the East and Midland region grows more than under the current trends scenario. Such a scenario implies that the greater Dublin area will be even more dominant that it currently is. Other scenarios are developed in this paper where population growth is equally shared between the East and Midland region and the rest of the country and where the growth is concentrated outside the East and Midland region. For the latter, a more compact city orientated growth pattern and one where growth is more even are also considered.

Lacking appropriate empirical results that show the potential for policy to affect the spatial patterns of fertility and mortality,[19] the assumption in the alternative demographic scenarios is to hold fertility rates constant at their 2016 county estimates[20] and that mortality rates improve slowly, but are the same across counties. Thus, the scenarios are generated by changing the spatial patterns of internal migration and international migration only. It is assumed that roughly half of the change in each scenario is due to changes in internal migration patterns and half due to changes to international migration patterns.

[19] For example fertility rates might differ if there are regional differences in childcare provision, while mortality rates might differ due to local environmental factors.

[20] The fertility rates were estimated using the age cohorts from the 2016 Census of Populations along with births that were recorded in the year up to the Census.

The OECD (2009) noted that regional policy does not just affect regional growth but also national growth. The Dublin and Mid-East regions accounted for 45 per cent of population growth between 1991 and 2016. If the other regions had all grown at the average national rate over that period, the total national population would have been 82,000 higher in 2016 than was recorded in the Census. Population growth is significantly influenced by both internal and international migration. If regions were more attractive to international migrants and attractive enough to retain their resident population rather than lose them through internal or international emigration, they would record higher population growth.

Research also shows that spatial patterns matter to economic performance. A robust relationship between density of economic activity and productivity has been found (see Ciccone and Hall, 1996; Ciccone, 2002; Melo et al., 2009). This implies that for two economies that only differ with respect to size of agglomerations, the economy with the larger agglomerations will have a higher GDP simply due to agglomeration economies. However, excessive concentration of economic activity in one agglomeration can result in congestion in that agglomeration and underutilisation of resources elsewhere, thus reducing output (see Henderson, 2003).

The above evidence suggests that alternative spatial patterns would have an effect on the total national development in Ireland. However, in order to focus on the differences of the alternative scenarios to the current trends scenario, the alternative scenarios are constructed for an essentially fixed population.[21] This ensures consistency with the underlying economic scenario (see Bergin et al., 2016a).

5.1 APPROACH

As the total population is held constant the total number of international migrants is not changed from that used in the baseline scenario, but the spatial pattern of international migration is altered. Likewise the pattern of internal migration is changed to generate the scenarios. The resulting projections can then be compared to the current trends scenario and assessed regarding their feasibility and desirability.

The continued trends scenario projected that 58.5 per cent of population growth over the period 2016 to 2040 could be accounted for by the East and Midland

[21] Small deviations in the total population under the alternative scenarios compared to the current trends scenario are due to the approach to fertility rates adopted where immigrants (internal or international) are assumed to take on the fertility rate of the area they move into.

region. As was indicated above, there is some debate about the appropriate spatial development paths for Ireland. Here the scenarios are constructed to reflect these views. In particular the following scenarios are put forward:

1. Where 68 per cent of the increase in the population is accounted for by the East and Midland region, and where the population growth in the other regions is scaled down proportionately. Here the relatively sprawled pattern of population growth that is a feature of the current trends scenario is also maintained. This scenario is referred to in short as 'EMR=68%'. This scenario would see the spatial development pattern dominated even more by Dublin than under the current trends scenario;
2. A scenario where the population increase is roughly equally split between the East and Midland region and the rest of the country, which is referred to as the '50:50' scenario. This scenario would see some rebalancing of growth but would still let Dublin grow significantly;
3. A scenario where the East and Midland region is assumed to account for less than 50 per cent of the absolute population increase over the period 2016 to 2040, which is termed 'EMR<50%'. Under this scenario the growth of Dublin is curtailed.

Apart from the distribution of growth between regions, the distribution within regions is very important, as that same total population in a region could be distributed quite evenly or could be more concentrated in a few places. From an efficiency perspective large agglomerations which imply more concentration are better. Therefore, additional scenarios are calculated for the '50:50' and 'EMR<50%' scenarios using an alternative inter-regional distribution to the current trends scenario which continues the spatially more distributed pattern (termed 'NSS' here). This alternative internal distribution is one where growth is focused on the major cities within each region, which is termed 'City'. Here the migration patterns are altered so that counties with larger centres attract larger net inflows than under the current trends scenario. This is not restricted to Cork, Limerick, Galway and Waterford but other counties with larger centres (e.g. Sligo) also receive higher inflows under this scenario. The increases for each county are roughly proportional to the size of their largest urban centre.

5.2 ALTERNATIVE POPULATION SCENARIO RESULTS

The results are summarised in Table 5.1 where the scenarios are labelled as indicated above. The current trends scenario is labelled 'CT'. The difference in the national total between the scenarios is due to the fact that fertility rates across counties differ significantly and immigrants are assumed to take on the fertility of their new county of residence, which implies that the national average fertility rate is altered by migration. An alternative assumption would maintain the fertility rates of migrants at the origin levels, which would alter the county

fertility rates but would be very complicated as individuals might migrate more than once over the projection horizon.

The population of the East and Midland region increases by almost 82,000 under the 'EMR=68%' scenario compared to the current trends scenario. Under this scenario the share of the population accounted for by Dublin increases to 29.6 per cent compared to the 29.1 per cent under the current trends scenario and that of the Dublin and Mid-East combined reaches 49.4 per cent, up from 40 per cent in 2016. For the East and Midland region as a whole the share goes up from 48.9 per cent in 2016 to 51.8 per cent, implying considerable sprawl. In contrast, population growth in the North and West and Southern regions is considerably reduced relative to the current trends scenario. Thus this scenario would leave Ireland's development largely determined by the greater Dublin area.

The implication of this scenario is that while Dublin would gain in scale, the significant sprawl into the wider East and Midland region would increase congestion and costs. In contrast the scenario would yield only very marginal increases in the scale of second tier centres. Under the current trends scenario the number of commuters into Dublin could increase by 100,000. Under this scenario commuting would increase even more. Furthermore, the scenario leaves some counties with little or no growth, undermining their economic viability.

The table shows that under the '50:50' scenario, the change relative to the continued trends baseline scenario are relatively modest, with the East and Midland population reduced by between 29,000 and 78,000 by 2040 relative to the baseline. The scenario implies a more even spread of growth across the country. While the 'NSS' internal distribution would minimise the differences in growth rates across counties, the 'City' distribution would channel the growth into the second tier cities.

In contrast the scenarios where the population growth is concentrated outside the East and Midland region results in a very significant reduction in the projected population in the East and Midland region of between 312,000 and 370,000. This scenario would result in a reduced population in the Midland region compared to 2016 and considerably reduced growth in the Mid-East and Dublin regions. This reflects the implicit assumption that population growth in the Midland region is largely a spillover from the Greater Dublin region.

Under the 'City' scenarios the regions with the larger cities and towns are projected to have greater population growth. The absence of large cities in both the Border and the Midland regions and to some extent in the South-East region

limits their potential population growth under these scenarios while a more dispersed 'NSS' pattern results in more 'even' growth outside the East and Midland region.[22]

[22] The implications of the lack of large centres is more apparent at the county level.

TABLE 5.1 POPULATION PROJECTIONS UNDER ALTERNATIVE SCENARIOS FOR 2040

	Population ('000s)							
			CT	EMR=68% NSS	50:50 NSS	50:50 City	EMR<50% NSS	EMR<50% City
	2011	2016		2040				
Border	514.9	523.2	589.0	587.6	597.3	592.0	625.1	602.8
Midland	282.4	292.3	330.5	353.1	321.2	321.2	287.7	258.6
West	445.4	453.1	534.1	524.2	554.1	556.6	595.3	610.4
Dublin	1,273.1	1,347.4	1,639.8	1,667.9	1,592.1	1,596.3	1,485.0	1,481.2
Mid-East	531.1	560.0	707.5	732.8	685.7	685.7	609.4	597.8
Mid-West	379.3	385.0	449.4	429.9	464.2	475.3	514.2	548.7
South-East	497.6	510.3	585.4	562.4	601.4	560.9	659.3	613.8
South-West	664.5	690.6	799.2	777.2	822.1	851.8	870.0	931.3
State	4,588.3	4,761.9	5,634.8	5,635.1	5638.1	5,639.8	5,646.1	5,644.6
Northern and Western	837.4	847.4	961.6	944.5	993.7	990.8	1,076.0	1,082.4
Eastern and Midland	2209.5	2,328.5	2,839.2	2,921.1	2756.8	2,760.9	2,526.6	2,468.4
Southern	1541.4	1,585.9	1,833.9	1,769.5	1887.7	1,888.0	2,043.6	2,093.8

Source: Author's calculations.

Note: 'CT' refers to current trends, 'EMR=68%' refers to a scenario where 68 per cent of growth is accounted for the by the East and Midland region, '50:50' refers to a scenario where growth is equally shared between East and Midland region and the rest of the country, 'EMR<50%' refers to a scenario where more than half the absolute increase in the population is accounted for by the Northern and Western and Southern regions. 'NSS' refers to a more distributed growth pattern while City refers to a more compact growth scenario focused on major cities.

A key question is whether such changes are feasible, which requires an understanding as to what drives internal migration patterns in Ireland and what changes could would generate outcomes like the scenarios. For the purposes of the scenarios, it is useful to consider the change in migration which is required to achieve the scenarios.

The changes to the baseline 'current trends' scenario required to achieve the alternative scenarios is smallest for the '50:50 NSS' scenario and greatest for the 'EMR<50% City' scenario. For example the '50:50 NSS' scenario implies a reduction in net internal migration to Dublin by a total of just over 13,000 while under the two 'EMR<50%' scenarios the reduction in net internal migration in Dublin needs to be more than 80,000 over the period 2016 to 2040. In contrast the 'EMR68%' scenario would require Dublin to attract a further 17,000 internal migrants compared to the current trends scenario over the period. This implies that the annual change required under the '50:50 City' scenarios, is for Dublin to receive about 450 fewer net migrants per year while under the 'EMR<50% City' scenario Dublin would need to have about 2,700 fewer net internal migrants per year.

It is possible to assess the feasibility of these changes using the results of the internal migration model by Garcia-Rodriguez and Morgenroth (2017). In their model internal migration is a function of a number of variables including house prices, and in particular house price differences across counties. This shows that a 1 per cent increase in Dublin house prices would change both the house price difference between counties and the squared house price difference. Taking one set of estimates from the work of Garcia-Rodriguez and Morgenroth (2017) to assess the impact of such a change in house prices shows that this would reduce the gross flows into Dublin by 276 persons, with almost two-thirds of this change due to reductions in migrant numbers from contiguous counties and the remainder accounted for by the rest of the country. Thus a house price increase of around 1.5 per cent would achieve the reduction in internal immigration assumed under the '50:50 City' scenario and a reduction such as that assumed under the 'EMR<50% City' scenario would require a 10 per cent increase in Dublin house prices while all other house prices stay fixed. While the required change in net internal immigrants to Dublin to achieve the 'EMR68%' scenario is feasible, the substantial increase in net immigration across the entire East and Midland region that would be needed to achieve such an outcome is unlikely to be met.

Of course house prices across the country do move together to some extent, and demographic changes impact on house prices. For Irish counties, estimates by Morgenroth (2014) suggest that a 1 per cent increase in household numbers increases prices by 4 per cent. Thus it is unlikely that the type of change assumed under the 'EMR<50%' scenarios could be achieved with respect to internal

migration but that the type of change assumed under the '50:50' scenarios can realistically be achieved. The 'EMR=68%' scenario also looks unrealistic as it implies falling relative house prices across the East and Midland region while household numbers are increasing significantly.

The analysis suggests that the '50:50' scenario is feasible, which leaves a choice in terms of desirability between the 'NSS' and 'City' internal growth patterns. While arguments can be brought forward that would favour the more distributed 'NSS' pattern, the results of academic literature suggest that the city focused pattern is likely to yield more benefits over the long run, as this pattern would enhance the scale of the second tier cities, enabling them to benefit from agglomeration economies that smaller centres cannot gain. The size of the second tier cities is currently relatively small which means that these play a more limited role for their hinterland than larger centres could, thus reinforcing the role of Dublin. This has a negative effect on their wider hinterland including rural areas.

5.3 ALTERNATIVE JOBS SCENARIOS

The baseline current trends economic scenario was based on simple econometric models which estimated the trend and used this to project forward. However, both the models for non-trade sector jobs and government sector jobs also incorporate the importance of the local population, reflecting the fact that non-internationally traded activities such as retail are significantly driven by the location of the population. Likewise, public services provision is a function of the location of the population. Thus, the alternative demographic scenarios also imply alternative economic scenarios, which can be generated by incorporating the alternative population scenarios into the jobs models.

Table 5.2 shows the results of the alternative scenarios for jobs. The most notable finding from this analysis is that the number is only slightly changed under the alternative scenarios compared to the current trends scenario. This reflects the nature of the models used to generate the jobs projections, where the projected jobs are primarily driven by the long-run trend. Otherwise the projections reflect the nature of the demographic scenarios, as a higher population implies increased demand for services such as retail and public services. Thus, under a scenario where the East and Midland region population grows more than under the current trends scenario, job growth is also increased. Likewise the scenarios where population growth is higher in the other regions, jobs are higher in those regions and correspondingly lower in the East and Midland region.

TABLE 5.2 JOBS PROJECTIONS UNDER ALTERNATIVE SCENARIOS

	Total Jobs ('000s)							
			CT	EMR=68% NSS	50:50 NSS	50:50 City	EMR<50 % NSS	EMR<50 % City
	2011	2016		2040				
Border	178.6	196.0	238.4	237.9	239.3	238.8	250.0	242.3
Midland	99.3	109.4	135.4	143.3	133.6	132.4	121.1	110.5
West	170.1	182.2	241.7	237.7	243.3	247.8	261.1	266.7
Dublin	612.5	667.6	932.8	951.6	936.7	928.4	890.8	887.6
Mid-East	186.4	212.2	302.6	308.5	296.3	292.6	266.6	261.7
Mid-West	149.2	160.2	196.9	187.7	196.5	202.7	215.4	228.1
South-East	190.8	199.8	246.4	236.0	246.4	234.8	267.9	253.0
South-West	274.3	287.5	379.3	371.1	381.4	396.1	400.9	423.7
State	1,861.2	2,015.0	2,673.7	2,673.7	2,673.7	2,673.7	2,673.7	2,673.7
Northern and Western	310.6	332.9	420.7	412.2	422.2	426.4	455.2	457.6
Eastern and Midland	931.7	1,029.9	1,429.8	1,461.8	1,437.4	1,409.6	1,328.3	1,305.8
Southern	618.9	652.2	823.3	799.6	827.4	837.7	890.2	910.3

Source: Author's calculations.

CHAPTER 6

Drivers and implications of spatial development patterns

The analysis presented in this report considered a scenario where current spatial development trends were maintained, and a number of alternative scenarios where the spatial development patterns are altered. While the analysis yields some important implications of alternative spatial development patterns, such as the increased long distance commuting under the current trends scenario compared to the present situation, the broader implications of different scenarios were not discussed in detail.

A criticism of the National Spatial Strategy (NSS) was that it did not adequately consider the implications of market interaction and the wider economic impact of spatial development patterns, which contributed to the modest impact of the NSS (see Morgenroth, 2013). It will therefore be important for the National Planning Framework to reflect the key insights from the relevant research.

This chapter considers both the determinants of spatial patterns and their impact at different spatial scales with reference to the international and, where available, national literature. In doing so the chapter aims to identify key market mechanisms that operate in modern economies and implications for spatial planning.

The uneven distribution of economic activity has long been observed internationally and in Ireland. Research has shown that this distribution is neither random nor are geographic factors responsible for much of the observed spatial patterns. Physical geography (such as topography, location by the sea or along a river) only accounts for about 20 per cent of the variation of spatial distribution of GDP per capita with the remainder being due either to man-made agglomeration economies or to the interaction between man-made agglomeration economies and geography (see Chasco et al., 2012).

The international literature has investigated the effects of alternative spatial development scenarios on a number of dimensions. For example, the literature has considered the relationship between firm performance and agglomeration.[23] The nature of agglomeration economies and their physical extent has also been

[23] Agglomeration refers to places which are both large in scale and have relatively high densities.

investigated. The implications of the findings of this literature also relate to the urban hierarchy. The literature has also considered the location determinants of enterprise start-ups as well as the determinants of location choices of multinational enterprises. The results from this research suggest that the nature of the spatial development pattern has an impact on the aggregate economic performance of countries. The analysis has also considered issues relating to workers and households, including wage rates, housing costs and migration patterns. While much less is known about the economic determinants of spatial patterns in Ireland and their effect on overall national economic performance, it is possible to consider some of the findings of the international literature in the context of analysis of Irish data.

Importantly, the literature shows that the mechanisms that generate agglomerations may not necessarily generate outcomes that are economically and socially optimal. This points to the important role of policy to address market failures. This is particularly important in the context of the finding that these spatial patterns tend to be self-reinforcing. Furthermore, as the research has shown that certain patterns of agglomeration and interaction lead to better economic performances, the research findings have had significant influence on policy.

6.1 AGGLOMERATION, DENSITY AND SPECIALISATION

A key aspect of the spatial patterns of both the distribution of the population and of economic activity is that of agglomeration. The fact that agglomerations emerge and persist over long periods suggests that there are benefits to agglomeration. Exploring these benefits has been a central concern of economic geographers, regional scientists and economists.

The spatial patterns of economic activity in Ireland are also characterised by an uneven distribution, with a small number of agglomerations. Economic activity in Ireland is also more spatially concentrated than the distribution of the population (see Morgenroth, 2009). This analysis showed that most of the fast growing sectors are more heavily concentrated in urban areas in 2006. Repeating the analysis with 2011 data shows that the urban focus of sectors is almost unchanged (correlation coefficient of 0.95).[24] Comparing the spatial patterns of economic activity at the Electoral District (ED) level in 2006 with that of 2011, reveals that economic activity is slightly more concentrated in 2011 than it was in 2006.[25] The degree of spatial concentration in sectors, that is the degree to which individual sectors are spatially concentrated, remained almost unchanged

[24] At the time of writing the data for 2016 were not available.

[25] The Herfindahl Index in 2011 is 0.9 per cent larger than that for 2006 (see Morgenroth, 2009 for definitions).

(correlation coefficient of 0.997), while the degree to which individual EDs are specialised has changed somewhat but is still quite similar to that in 2006 (correlation coefficient of 0.76). This highlights one important fact about spatial patterns, which is that they change only very slowly. This slow change in spatial patterns suggests that policy measures will also take some time to change spatial patterns significantly.[26]

A range of explanations of how agglomerations emerge have been put forward going back to the early pioneers of economics. For example Adam Smith highlighted in 1776 that agglomerations are related to the degree of specialisation and that some activities require a large enough local market to be profitable.

> *There are some sort of industries, even of the lowest kind, which can be carried on nowhere but in a great town. A porter, for example, can find employment and subsistence in no other place. A village is by much too narrow a sphere for him; even an ordinary market town is scarce large enough to afford him constant occupation.* (Adam Smith, 1776).

He also argued that scale offers consumers the benefits of greater variety and lower cost.

> *Abundance, therefore, renders provision cheap, and encourages a great number of workmen to settle in the neighbourhood, who find that their industry can there procure them more of the necessaries and conveniences of life than in other places.* (Adam Smith, 1776).

Just over 100 years after Adam Smith, Alfred Marshall wrote about the emergence of industrial districts (Marshall, 1890). These were argued to have emerged by the existence of external (to the enterprise) economies such as a local pool of specialised labour, presence of subsidiary trades and services and the fact that the new machines that were being invented in the course of the industrial revolution could be utilised more fully in larger markets. Importantly, two types of external economies can be identified, namely; *localisation economies* that are benefits generated by the proximity of enterprises producing similar goods that have led to approaches based on specialisation, and *urbanisation economies* – advantages associated with the overall level of economic activity, that have led to further research focusing on scale, density and diversity. Marshall also noted that the agglomerations tended to persist for long periods, which has led to further research on embeddedness and also laid the foundation for subsequent theories that identified self-reinforcing tendencies

[26] One explanation for the slow change in spatial patterns is that only a small percentage of either the population or jobs move in any period leaving the bulk essentially fixed in a location.

(cumulative causation) of agglomeration (see Myrdal, 1957). Marshall's ideas significantly shaped spatial economic analysis.

Another explanation of the development of agglomeration is the central place theory of Christaller (1933), which is based on a hierarchical relationship between different economic activities and a relationship between a place and its hinterland. In this theoretical framework, places (towns/cities) that contain higher order functions also have lower order functions, which implies that they are bigger and that they serve a larger hinterland. The distribution of the different functions is a function of a minimum size threshold and the size of the market is determined by the maximum distance that individuals are willing to travel to purchase goods or services. This framework is particularly relevant in explaining urban hierarchies.

More recently, the so-called 'New Economic Geography' literature which emerged in the 1990s suggests that agglomerations emerge as a result of the co-location of firms and consumers to exploit increasing returns to scale and that the degree and distribution of agglomeration is a function of transport costs (see Fujita et al., 1999). These models highlight the importance of the local market in driving agglomeration economies, which implies that once agglomerations are large they tend to keep their advantage. This in turn explains the persistence of cities over very long periods.

It is sometimes argued that remote working, facilitated by the roll-out of quality broadband infrastructure, will reduce the importance of agglomerations and will offer an avenue for rural economic development. However, there is also evidence that some firms that might be expected to be leaders in remote working given their involvement in the IT sector are no longer enthusiastic about remote working. For example IBM has stopped remote working for its staff earlier this year. Firms have reservations about teleworking due to worries about IT security, a lack of control of staff, limited scope for team work and lack of informal interaction among staff. Data from a special tabulation of the Census travel to work data show that in 2011 just under 16,000 of workers in Financial Services, Real Estate, Computer Services and Business Services worked from home accounting for just 5.3 per cent of jobs in those sectors.[27] Almost 10,000 of these live and work in urban areas i.e. less than 6,000 are in rural areas and of these many are close to the larger urban centres. This evidence suggests that teleworking is unlikely to change the nature of spatial economic patterns at least in the medium term.

[27] The data also show that almost 50 per cent of those who work mainly from home, and for which their sector is known, work in agriculture. Data from the 2016 Census were not available yet at the time of writing.

While specialisation might have been an important driver of agglomeration economies and productivity growth in the 19th and early 20th centuries, there is evidence that over the last number of decades, specialisation has been associated with lower growth. A comprehensive study of the relationship between specialisation and regional development for a large number of European countries found that regions with lower specialisation tend to grow faster (Krieger-Boden et al., 2008). This result is due to the fact that specialised regions tend to be specialised in declining sectors and that growing sectors tend to be co-located with other sectors such that the areas they are located in have a relatively diverse industrial structure. For Ireland, a negative impact of specialisation on output of Irish regions was found (Morgenroth, 2008).

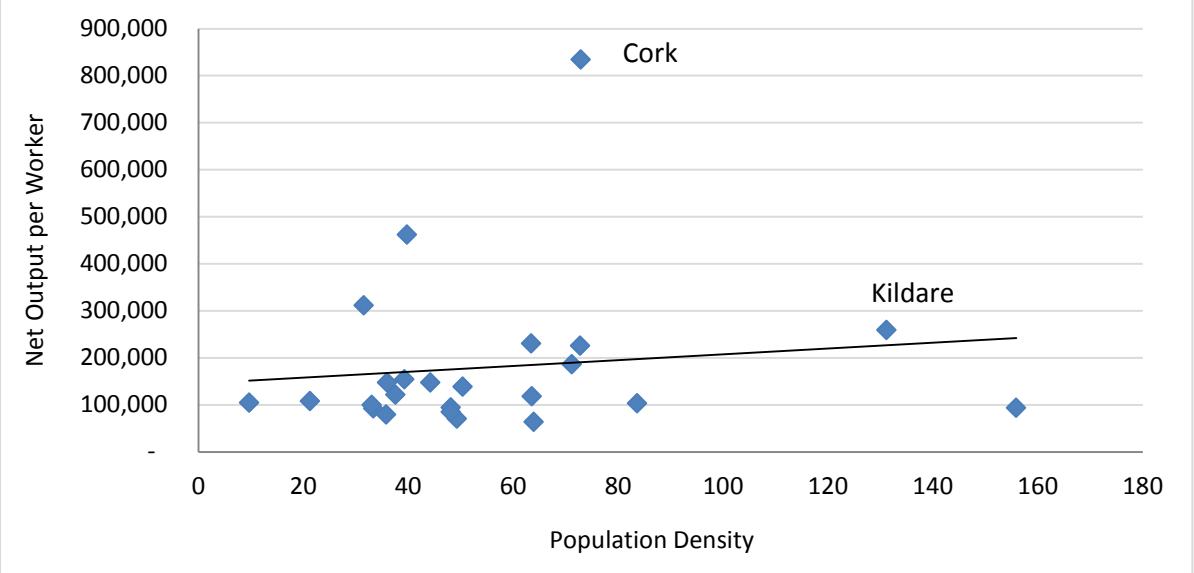
In contrast, variety (diversity) as opposed to specialisation can be a source of innovation as ideas 'jump across' to other sectors and technology can also be diffused in this way, which increases the impact of the innovation or technology. For such spillovers to happen, enterprises need to share some common features, which in the literature has been termed related variety. The literature on related variety emphasises the importance of linkages of enterprises both within regions but also out of the region. These external linkages coupled with related variety within the region allow for the absorption of external innovations among a wider group of enterprises.

Agglomeration implies that economic activity in a particular sector is denser, measured by the number of workers per square kilometre, in the areas where the agglomerations locate. A number of papers have investigated the relationship between density and productivity which provides a natural estimate of the benefits of agglomerations (Ciccone and Hall, 1996; Ciccone, 2002). The initial results by Ciccone and Hall (1996) found that a doubling of the employment density increases average labour productivity by 6 per cent and approximately half of the variance in productivity is explained by density. The later analysis by Ciccone (2002) found slightly lower estimates of agglomeration benefits for Europe. A meta-analysis of the existing studies found that on average a doubling of density would increase productivity by 4.7 per cent, and that the impact differs across sectors and countries (Melo et al., 2009).

Unfortunately, estimates of agglomeration benefits for Ireland are not available. Figure 6.1 shows a scatter plot of net output per industrial worker against population density at the county level in 2011. As Dublin has a significantly larger population density than any other county this is omitted in the graph. Overall the graph shows a positive relationship between population density and labour productivity. Cork has a considerably higher net output per worker, which is due

to the importance of foreign owned firms particularly in the pharmaceutical industry, largely located in or near Cork City, while the population density is measured for the city and county area. Thus, the point for Cork which shows the highest level of net output per worker has artificially been shifted to the left and the true value of labour productivity might also be biased upwards. A more thorough analysis should be based on firm level data and should reflect the density at a smaller spatial scale than counties.

FIGURE 6.1 SCATTER PLOT OF INDUSTRIAL OUTPUT PER WORKER AGAINST POPULATION DENSITY



Source: Author's calculations using CSO Census of Industrial Production data.

Agglomeration in urban regions also generates higher incomes, and employment rate growth and clustering – even within cities – has been found to have a positive impact (Spencer et al., 2010). Overall, this evidence suggests that urbanisation economies are more important than localisation economies. Combes et al. (2008) show that high skills individuals agglomerate in the larger, denser and more skilled labour markets and up to half of the differences in wage rates across local labour markets can be attributed to differences in human capital.

In addition to wage rates and the probability of finding a suitable job, high skills individuals choose their residential location on the basis of other quality of life characteristics. Glaeser et al. (2001) have shown that cities with better consumer amenities such as shops and restaurants have faster growth. Here again a process of cumulative causation applies, whereby a larger centre can maintain a higher level of consumer amenities and thereby attract additional population. This also points to an important policy tool namely the improvement of the quality of life to attract high skills individuals.

An important question is how far agglomeration economies extend. If for example, agglomerations benefit a wider hinterland around themselves, then a smaller number of agglomeration would provide a benefit for a larger part of a country. A number of papers have attempted to estimate the extent of agglomeration economies. Rosenthal and Strange (2008) found that agglomerations extend as far as 40 to 80 kilometres. In contrast Ahlfeldt et al., (2015) found that the extent is limited to a few kilometres. In a recent paper Verstraten et al. (2017) argue that the wide range found in the literature is due to scale and number of spatial units analysed. They estimate a model for the Netherlands using data for small spatial units and find that the benefits of agglomerations run out between 40 and 80 kilometres. Importantly, they find that the agglomeration economies do not spill across the border from the Netherlands to Belgium or Germany, despite the fact that the border is invisible and there is considerable cross border commuting. This is an important finding for Ireland as it suggests that the potential for cross border spillovers from agglomeration economies for example along the Dublin-Belfast corridor or for Derry-Letterkenny may be more limited.

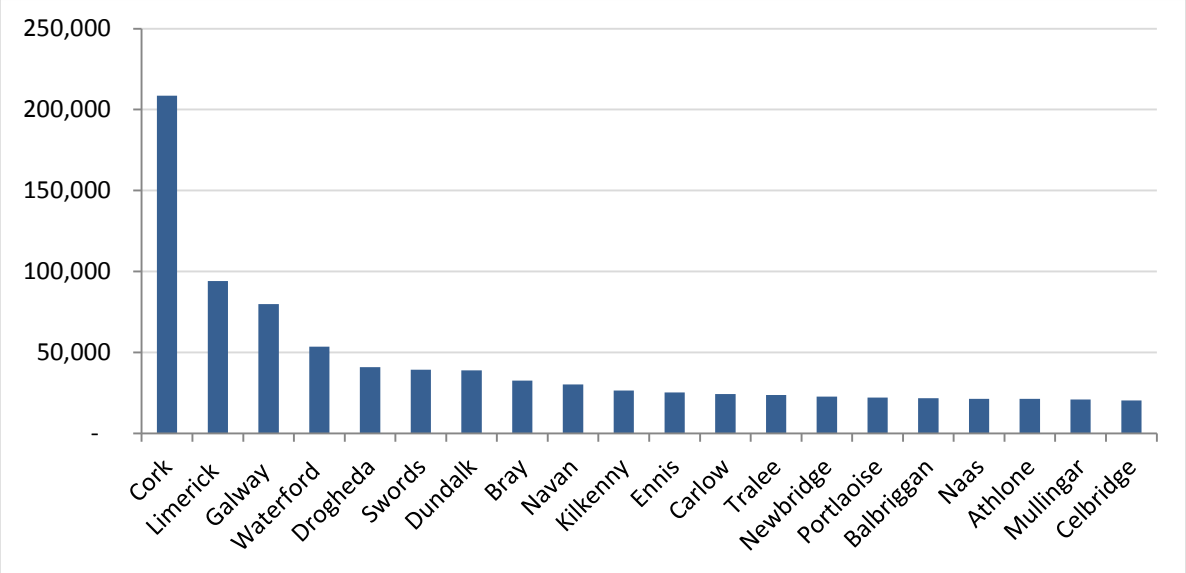
While the bulk of the academic literature highlights the benefits of agglomerations, a smaller literature shows that excessive concentration of the population in one centre, which is known as primacy, can have a significant negative effect on national economic performance. For example quality of life has been shown to be badly affected by excessive primacy (Henderson, 2002). Excessive primacy also increases house prices and transport costs (Richardson, 1987). Henderson (2003) shows that excessive primacy reduces national productivity, and that the optimal level of primacy depends on the size of the country and state of development. The optimal level of primacy is higher for small countries but declines with economic development. The findings on the negative impact of primacy has important policy implications as it shows that concentrating growth in just one centre will harm national economic performance.

6.2 URBAN HIERARCHY

Closely related to the development and effect of agglomerations is the concept of urban hierarchies, which was proposed by Christaller (1933). A key feature of this concept is that larger urban centres fulfil a larger range of functions and more high value functions than smaller centres, which implies that the location and size of urban centres is important in regional and national economic development. The small number of large centres and their lack of scale of Irish urban centres has been pointed to in the literature.

Figure 6.2 shows the size of the 20 largest urban centres after Dublin City.[28] Other than Cork, Limerick, Galway and Waterford, no centre has a population in excess of 50,000 and a number of these second tier centres such as Swords, Bray, Balbriggan and Celbridge are almost contiguous to Dublin, while Dundalk, Drogheda, Navan, Naas, Newbridge and Mullingar are in the Dublin commuter belt. Likewise Ennis is close to Limerick.[29] The nine centres together have combined population of less than 600,000 which is the size of the second largest centre one would expect to see in most countries, given the size of Dublin (Limerick and Ennis are counted together). While Dublin accounts for a large share of the population (24.6 per cent), taking the 20 largest centres together they account for 42.4 per cent of the population. In contrast the Belfast metropolitan area accounts for 15.1 per cent, but the top 20 urban centres in Northern Ireland account for over 50 per cent of the population. Overall the urban structure of Northern Ireland is closer to that of other developed countries than that of Ireland.

FIGURE 6.2 POPULATION OF THE 20 LARGEST URBAN CENTRES EXCLUDING DUBLIN, 2016.



Source: CSO Census of Population, 2016

In order to show the relatively small size of Irish urban centres it is useful to compare the Irish urban hierarchy with that in other countries. Figure 6.3 compares the size of Irish urban centres with their counterpart in Denmark.[30] In the figure, rank indicates the rank in the urban hierarchy with 1 indicating the largest city which for both Ireland and Denmark is the capital city. The graph

28 Here the legally defined towns and cities are used, while the report otherwise focuses on local authorities and regions.

29 Thus 11 of the 20 centres are part of larger conurbations which leaves nine centres.

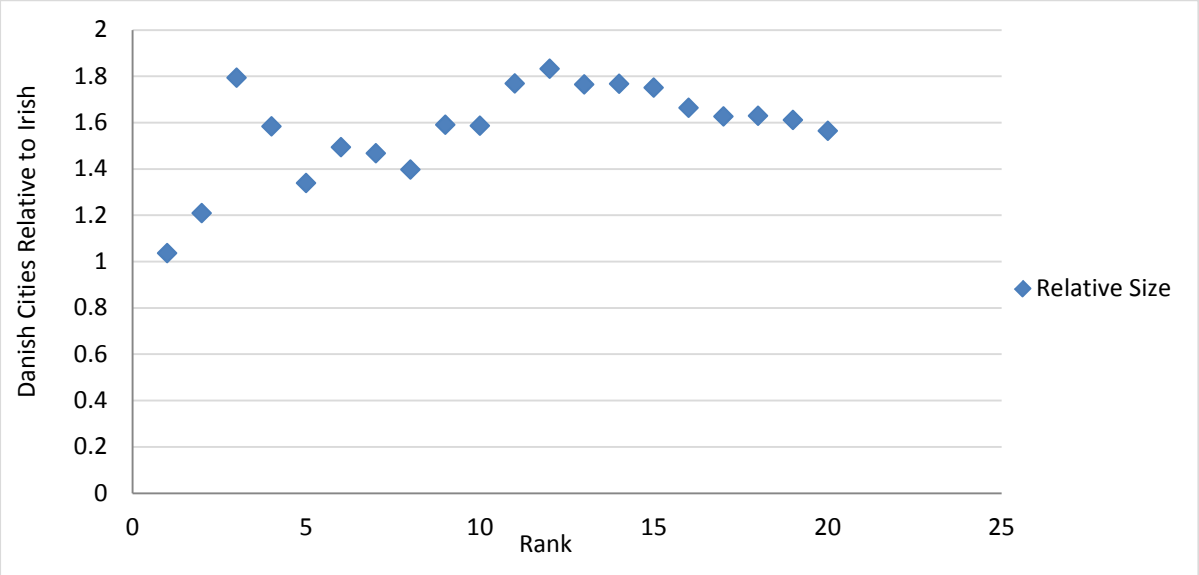
30 Denmark is considered here as an example of country of similar population and level of development to Ireland but that is often considered to have a more effective spatial planning system.

shows that Copenhagen is only marginally bigger than Dublin but that the second largest Danish city is 20 per cent larger than Cork and the third largest city is 80 per cent larger than Limerick. For the other cities the Danish cities are between 40 per cent and 80 per cent larger than their Irish counterparts. A comparison of the urban hierarchy with that in a number of European countries is provided in Figure 6.4, which again shows that particularly the second tier cities such as Cork, Limerick and Galway are smaller than their international counterparts. The implication of the relatively small size of the second tier cities in the context of central place theory is that these centres fulfil less high value functions than larger centres would and as such their role in driving the development of their hinterland is more limited. This also implies that Dublin plays a more important role nationally than would be the case if the second tier cities provided more functions, thus reinforcing the primacy of Dublin.

Apart from the lack of larger second tier centres, the geographic location of centres leave significant parts of Ireland remote from larger centres as is shown in Map 6.1. This shows that there are no urban centres with a population of more than 30,000 people in Ireland north of a line between Galway and Dundalk. With a population of just over 83,000 Derry is the only larger centre in the North-West of the island of Ireland, but Brexit threatens spillovers from Derry into Donegal, and as outlined above, research has suggested that the spillovers of agglomerations across borders is at best limited. This leaves the North-West at a significant disadvantage, especially if Brexit impacts on the ease of travel and transport across the border.

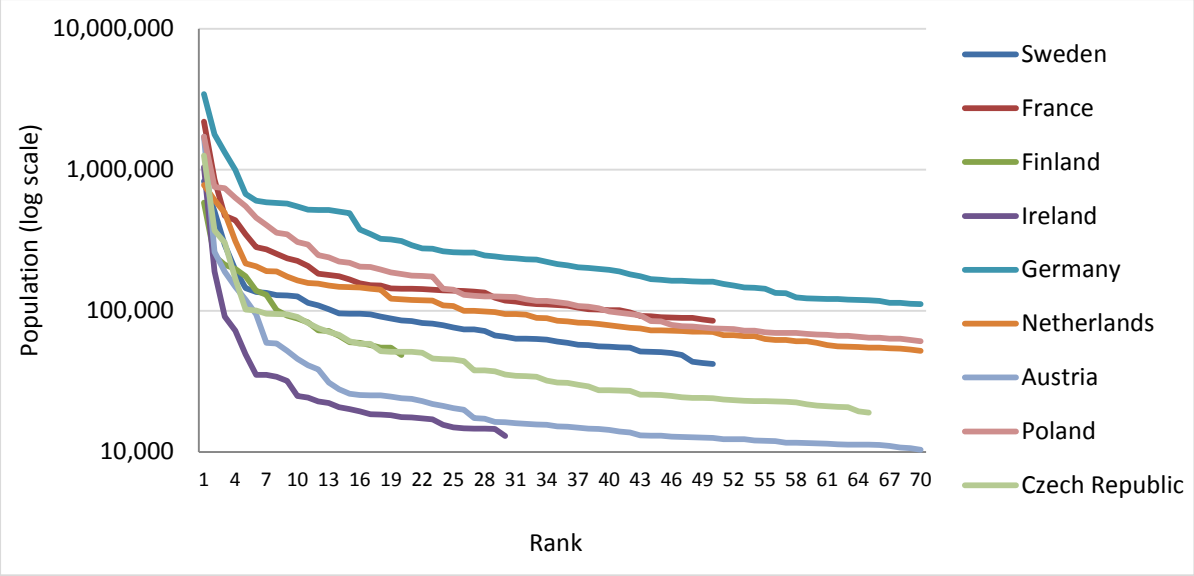
The map also shows the lack of centres of scale in the Midland region and even Galway and Limerick are of relatively small scale, with a population of less than 100,000. Importantly, given the fact that the key benefit of agglomeration is due to density this implies that simply redrawing the urban boundaries to include sub-urban and peri-urban areas with relatively low population densities is of little benefit. This also suggests that designating multi-centre gateways as was done in the NSS is likely to be ineffective, as that would not result in centres with a sufficient size and contiguous density.

FIGURE 6.3 SIZE OF DANISH CITIES RELATIVE TO IRISH CITIES OF EQUAL RANK



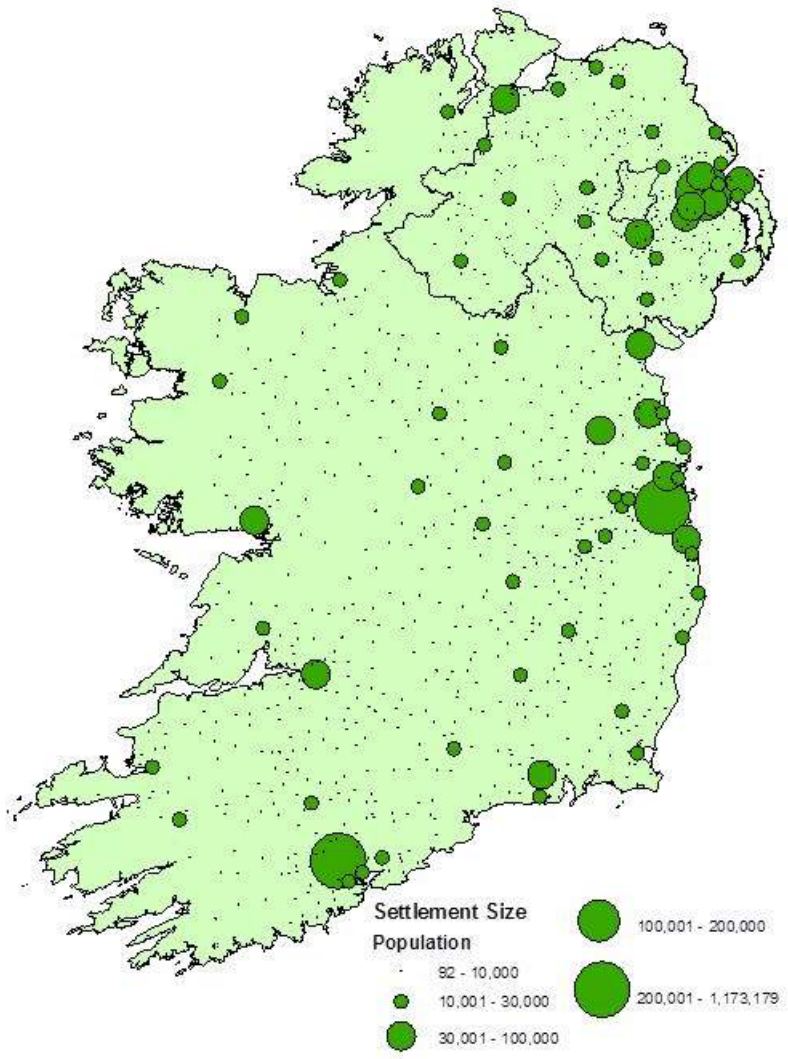
Source: CSO Census of Population, 2016 and Danishnet.com.

FIGURE 6.4 RANK-SIZE RELATIONSHIP FOR URBAN CENTRES IN SELECTED EUROPEAN COUNTRIES



Source: The data were obtained from the respective Offices of National Statistics for each country.

MAP 6.1 GEOGRAPHIC DISTRIBUTION OF URBAN CENTRES BY SIZE



Source: Data for Ireland are from the CSO Census of Population, 2016 and the data for Northern Ireland are from the NISRA NINIPS website and are for 2015.

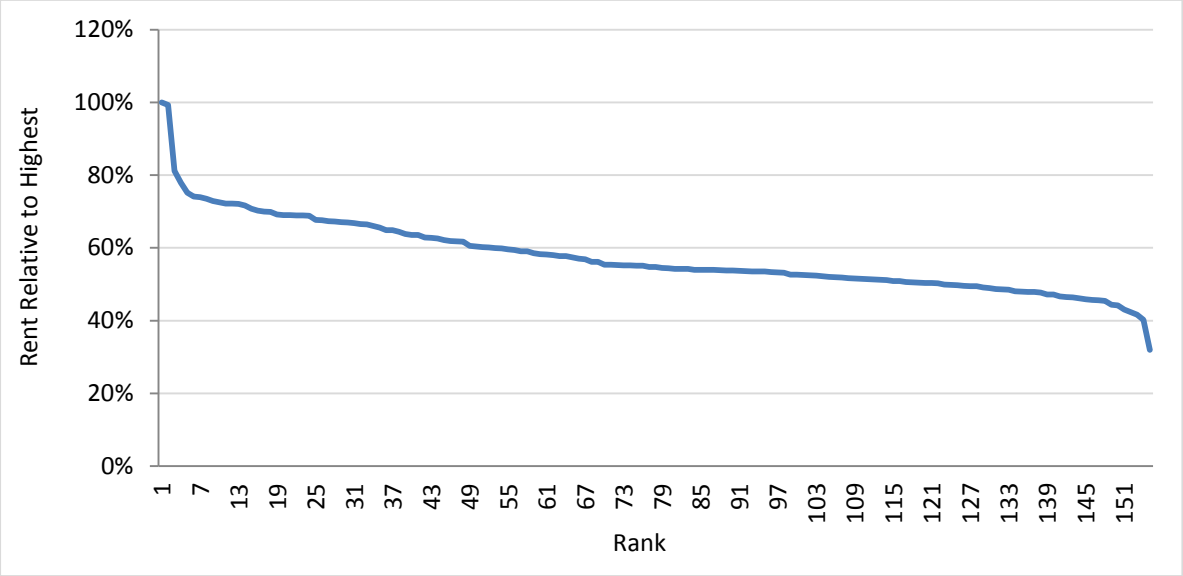
6.3 HOUSING MARKET AND RESIDENTIAL LOCATION

A key implication of agglomerations is that land values and rents differ across regions, the so-called bid rent gradient, which arises due to the different levels of demand in different areas. The most agglomerated central places tend to have the highest productivity as was pointed out above, which drives up property values and rents in these areas. This concept is also closely related to urban hierarchy models as differences in productivity are at least to some degree driven by the types of function that are performed in different centres. A higher population also implies greater demand for accommodation, which leads to higher prices in and around larger centres. As rents and land values for commercial development impact on rents and property values for residential development, they have a significant effect on the housing market, residential location decisions and thus commuting. However, as the requirements of

enterprises are not identical to those of individuals there are some differences in the geography of rent gradients for these different types of activities. Specifically, individuals are drawn to amenities in the widest sense including commuting distance/time/cost) and also choose property types given their household characteristics while enterprises are sensitive to different types of transaction costs and firm/sector specific requirements.[31]

To illustrate this it is instructive to consider residential rents in Dublin. In Dublin, the areas with the highest residential rent in 2016 were Grand Canal Square and Grand Canal Dock. Figure 6.5 shows the average rents paid in 2016 in different parts of Dublin relative to the highest rent. This shows that almost 70 per cent of areas in Dublin have a rental rate of less than 60 per cent of the top and for almost 20 per cent (29 out of 155 areas) of areas the rental rate is less than half the top rate. This clearly shows the significant differences in rental rates.

FIGURE 6.5 AVERAGE RENTS IN DUBLIN AREAS RELATIVE TO THOSE IN THE AREA WITH THE HIGHEST RENT



Source: Residential Tenancies Board, Average Rents by Area.

Hwang and Quigley (2006) show that local and national economic factors impact significantly on local house prices and they also show that the level of vacancies plays and important role in price determination. For Ireland, Morgenroth (2014) estimates the effect of economic fundamentals on county level house prices, supply and vacancy rates using a standard framework. These estimates suggest that house prices are more responsive to demographic change than to changes in income. They show that a 1 per cent increase in the growth rate of households is

[31] Determinants of firm location are discussed in more detail in section 6.4 below.

expected to raise house price inflation by 4 per cent, which at least in part is due to the slow supply response in the Irish and particularly Dublin housing market. This has important implications for residential location patterns as an increase in the population will increase prices significantly, which will act to reduce in-migration to that area.

Recent research by Garcia-Rodriguez and Morgenroth (2017) confirms the role of house prices in internal migration decisions in Ireland and they also show that this leads to spillovers and sprawl. This arises as high prices are not affordable for some individuals in their preferred location or they would have to trade-off desired housing characteristics to afford to live in their first choice location such that they choose second choice locations which are typically further from the centre.[32] This in turn puts upward pressure on house prices in these areas, pushing some individuals further out. Empirically, this type of house price ripple effect has been identified in a number of studies (e.g. Holly et al., 2011; Brady, 2014).

This points to the importance of housing supply in developing scale economies which in turn depends on zoning, the availability of local infrastructure, the incentives to develop brown field sites and other development incentives such as tax incentives. The potential competition between commercial and residential property also needs to be borne in mind. In a scenario where commercial activity is able to pay a higher price (per unit) for property in central locations than households, then most (new) households will locate further from the centre thus inducing higher commuting distance (Fan et al., 2000). Research has also shown that imbalances between supply and demand due to macroeconomic fundamentals, specific local housing related factors, and sluggish supply responses can result in substantial oscillations and result in asset bubbles (Wheaton, 1999).

Larger agglomerations and higher densities are attractive to higher skills individuals. Up to half of the differences in wage rates across local labour markets are being attributed to differences in human capital (Combes et al., 2008). This reflects the fact that more specialised advanced activities tend to require a larger market, which means that those seeking employment in those type of activities will more readily find employment in those larger centres. This point is amplified for two-earner high skills families where the probability of both finding a job commensurate with their skills is considerably higher in large conurbations (see Costa and Kahn, 2000). However, research has also found that high skilled workers may be more footloose and willing to tolerate longer commutes but that

[32] This is another example of diseconomies that arise particularly in excessively large agglomerations.

they choose their residential location on the basis of amenities and the quality of housing (van Oort et al., 2003).

In addition to simple labour market factors, individuals also choose their residential location on the basis of amenities including consumer amenities such as shops and restaurants and that the range of such amenities has an influence of population growth (Glaeser et al., 2001). Numerous studies have also shown that other amenities such as parks and access to public transport or disamenities such as high crime rates also influence residential location decisions. Senior et al. (2004) show that households that were moving location in Cardiff (Wales) chose less dense locations, which suggests that density is a type of disamenity to individuals while it is an amenity to firms. This may be due to the type of housing and other amenities/disamenities available in the more densely populated areas.

A number of papers have considered the effect of urban centres on their wider hinterland. In particular the literature considers what they term 'spread' and 'backwash' from urban growth. Spread measures the positive effect of urban growth on the hinterland, while backwash refers to flows of capital or labour into the centres due to growth. A paper by Partridge et al. (2007a) considers the relationship of rural population growth in Canada with that in cities accounting for the negative impact of being further away from a city. They found that areas that are further away from cities experienced lower population growth than if they had been located closer to a city, but that rural areas adjacent to cities capture one-third of the population growth rate of the city. They also find that small rural communities need to improve factors determining quality of life to be able to benefit from urban spillovers. In a related paper, Partridge et al. (2007b) show that large Canadian cities are engines for growth. In a more recent paper Lavesson (2017) finds that rural to urban commuting in Sweden has a positive effect on rural employment. This is due to the fact that the money earned in urban areas by commuters stimulates demand in the rural areas for services and retail. This implies that for areas that are within reasonable commuting distance urban growth has a positive effect.

6.4 LOCATION OF INDIGENOUS START-UPS AND MULTINATIONAL CORPORATIONS (MNCS)

Economically, regions grow through the emergence of new firms either as start-ups or firm relocations including foreign direct investment (FDI), the growth of existing firms, increased employment in existing firms and productivity growth. The literature shows that employment numbers tend to be more significantly increased by new firms than the expansion of existing firms. For the US Haltiwanger et al. (2013) found that while new firms account for just 3 per cent of employment they account for 20 per cent of employment growth.

For Ireland, Morgenroth and O'Malley (2003) show that over the period 1979 to 1999 there was no systematic difference in employment growth by firm sizes and that the entrance of new firms made a particularly significant contribution to regional employment growth. Lawless (2014) confirmed this result and showed that firm entry was the most significant source of employment growth, accounting for 38 per cent of employment growth, and that young firms accounted for another 26 per cent of employment growth. This means that factors that drive the rate of firm entry, either through start-ups or the location of new FDI, are particularly important in driving regional economic performance. Thus, a crucial issue is where firms start and what determines start-up (and survival) rates.

Armington and Acs (2002) found that the number of establishments in a given industry in a region has a strong positive effect on enterprise birth rates, which suggests that clustering increases enterprise birth rates. Enterprise birth rates in one location are also correlated with enterprise birth rates in neighbouring locations. However, the enterprise start-up rate has been found to be declining in regions with a high initial number of establishments, but clustering nevertheless increases the start-up rate (De Silva and McComb, 2012). A higher density in close proximity to enterprises in the same industry reduces enterprise survival, presumably due to competition, while a high concentration over a larger area increases survival rates.

High enterprise birth rates only have a lasting positive effect if they are accompanied by at least average survival rates. It is thus important to consider enterprise survival and closure along with enterprise birth, which collectively are referred to as enterprise demography. However, a negative relationship between birth rates and survival has been found in many studies (e.g. Love, 1996), which arises out of the inherent risks involved in starting a business and competing with incumbent enterprises. Therefore the key to converting start-ups into economic growth is not necessarily to maximise the number of start-ups, but to ensure that start-ups grow and create employment which many start-ups fail to achieve (Shane, 2009). This suggests that the focus of public policy should be on high potential start-ups rather than on maximising the number of start-ups.

For many decades the economic strategy of Ireland has involved efforts to attract multinational enterprises. The determinants of their location choices, while related to those of indigenous start-ups, differ in that their choice typically involves choosing between countries first and then a choice between locations within a country, while the location of indigenous start-ups has at least a random element.

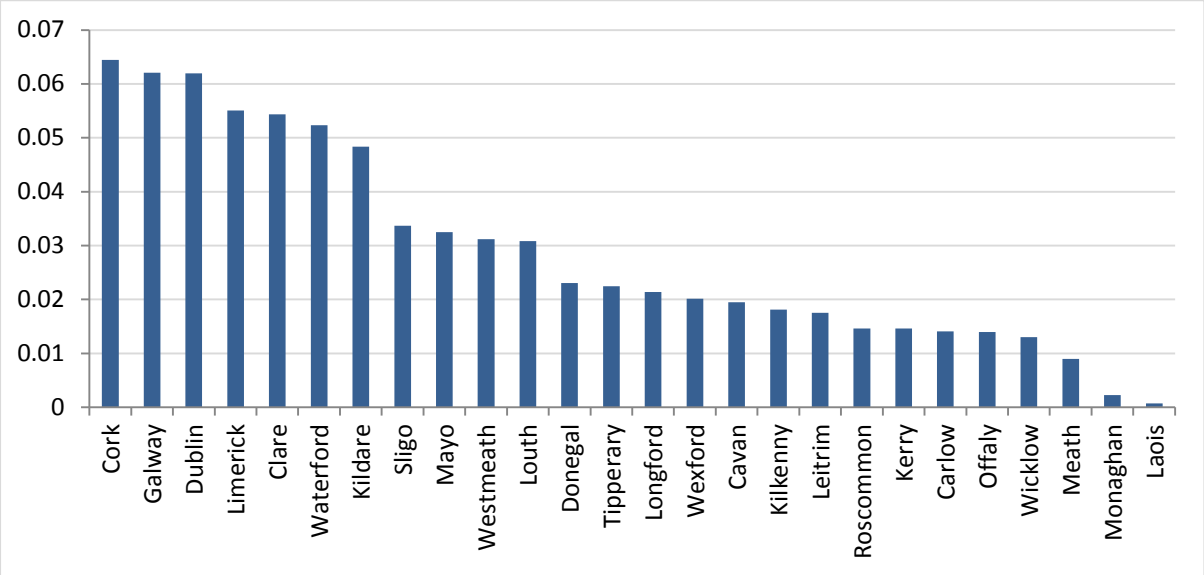
Recent research has shown that corporation tax rates are the most important factor for the location decisions of MNCs that choose to locate a new facility in Europe (Lawless et al., 2014). Other factors that help attract FDI include EU Structural and Cohesion policy (Basile et al., 2008). A related finding is that a better infrastructure has been shown to increase the probability of attracting FDI. Similarly, the availability of sites or premises is an important factor. The latter is a constraint in locations that are growing rapidly. The empirical literature has shown that higher labour costs deter MNCs while a higher unemployment rate attracts such companies, presumably due to the availability of workers (Coughlin et al., 1991), but that high wages do not deter MNCs if labour productivity in an area is high (Bellak et al., 2008). Given the relationship between productivity and education and skills this suggests that higher human capital levels are important in attracting FDI. This is a factor that has often been cited as a key to attracting FDI to Ireland.

Given the importance of MNCs in the Irish economy, their location choice has more pronounced regional development effects than in most other EU countries. The Department of Business, Enterprise and Innovation Employment Survey shows that in 2016, 40.6 per cent of all enterprise agency supported jobs in foreign owned firms were located in Dublin, up from 38.3 per cent in 2011. In contrast, Dublin accounted for 28.3 per cent of the population in 2016 up from 27.7 per cent in 2011. Figure 6.6 shows the number of jobs in foreign owned firms per capita in 2016 for all counties.[33] This shows that while Dublin accounts for the largest share of total foreign jobs, on a per capita basis, Cork and Galway benefit most from foreign jobs. In contrast Laois and Monaghan have the lowest number of foreign jobs per capita. Overall, the graph shows that jobs in foreign owned firms are more concentrated in the counties with larger urban centres and those in the immediate vicinity.

In part, this reflects the fact that more foreign direct investment into Ireland now involves service activities which tend to have a particular preference for larger conurbations. Multinationals appear to have a positive impact on enterprise entry in manufacturing (Görg and Strobl, 2002) and enterprise survival rate (Görg and Strobl, 2003), which suggests that these location patterns are reinforcing the overall spatial pattern of economic activity.

[33] The data are scaled by population to account for the size difference between counties.

FIGURE 6.6 JOBS IN FOREIGN OWNED FIRMS PER CAPITA, 2016



Source: Author's calculations using Department of Business, Enterprise and Innovation Annual Employment Survey, 2016 and CSO Census of Population.

One way to analyse the relationship between foreign jobs and the size of agglomerations is to estimate a regression of the density of foreign owned jobs measured as foreign owned jobs per square kilometre of area in each county as a function of the county population. The results are shown in Table 6.1. As both variables are in logarithms the coefficient measures the percentage change of the dependent variable to a 1 per cent change in the explanatory variable. Thus the analysis shows that for a 1 per cent increase in the population, the foreign owned jobs density increases by more than 1 per cent. Two models are estimated, one including Dublin and one excluding Dublin. For the model including Dublin a 1 per cent increase in the population is associated with a 1.39 per cent increase in foreign owned job density while for the model excluding Dublin the elasticity is 1.09. While the estimated relationship is not a causal relationship, it shows the positive relationship between the size of agglomerations and their attractiveness to MNCs, that suggests that an increase in the size of urban centres could increase foreign owned employment nationally.

TABLE 6.1 REGRESSION RESULTS OF COUNTY FOREIGN JOB DENSITY ON COUNTY POPULATION

	All Counties	Excluding Dublin
Log Population	1.39***	1.09***
Constant	-16.15***	-12.78***
R^2	0.51	0.28
Observations	26	25

Source: Author's calculations.
Note: Both the dependent and the explanatory variable are in logs. *** denotes statistical significance at the p<0.01 level.

For Ireland research has found that the fast growth in the 2001-2004 period did not lead to higher start up activity nationally but there was a degree of convergence across counties, particularly for counties close to Dublin (Anyadike-Danes et al., 2011). A forthcoming study by McCoy et al. (2018) investigates the factors that determine the location of indigenous start-up firms and multinational enterprises in Ireland. In particular they consider a range of infrastructures as well as human capital, market size/agglomeration, labour costs and specialisation. They find that agglomeration has a consistently positive effect on firm start-ups and the attraction of multinationals, while specialisation reduces firm start-ups for all types of firms. They found that a 10 per cent increase in agglomeration as measured by total jobs in an area increases the start-up numbers of indigenous firms by 0.46 per cent and increases the attraction of foreign firms by 0.96 per cent. A 10 per cent increase in specialisation reduces the attraction of foreign firms by 1.32 per cent and reduces start-ups by 2.44 per cent. Their analysis also shows that a higher share of the population with a third-level qualification and proximity to a third-level institution also increase start-up rates for all firm types highlighting the role of human capital as a driver of firm formation and as an attractor for foreign firms. While broadband availability is a significant factor in start-ups of most types of firms, proximity to airports, motorways and railway stations is only a significant factor for some types of enterprises. Importantly their analysis shows that the benefit of broadband availability depends on the level of human capital present in the area. This suggests that for areas with relatively low human capital, the roll-out of broadband may not significantly alter firm start-ups and FDI attraction rates, unless the level of human capital is raised. The results also show that transport infrastructure is not necessarily going to help attract firms.

While enterprise demography contributes significantly to economic performance, within-enterprise productivity is also important. A number of papers have considered this issue, finding evidence of a positive impact of clustering on enterprise performance. Beaudry and Swann (2009) found that growth of an enterprise is positively affected by the size of employment in the same sector in manufacturing industries, and that the relationship between enterprise growth and the size of other sectors is weak. However, employment growth in high-tech SMEs has been found to be much faster in clusters, but that the spatial scale over which the clustering benefit operates differs across sectors (Fingleton et al., 2004). Finally, co-operation with universities was found to impact positively on enterprise growth (see Arita et al., 2006).

6.5 SPATIAL DISPARITIES AND NATIONAL GROWTH

The research considered so far has focused largely on local phenomena rather than the implications for national development, which reflects the focus of most of the literature. While agglomerations and density clearly have local benefits

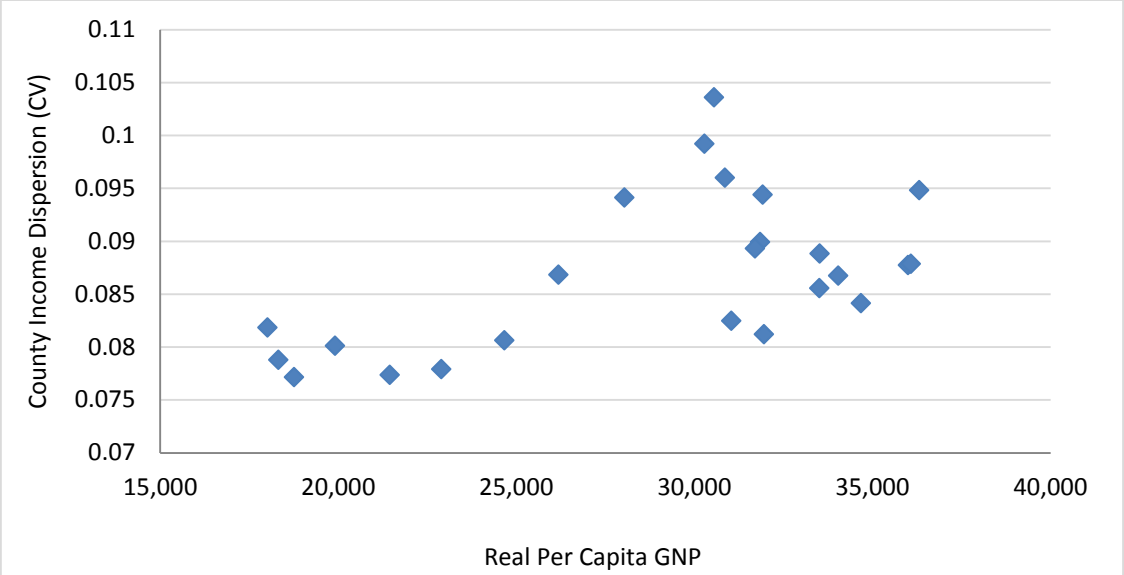
there is a question as to how different spatial development patterns affect national development. The work by Henderson (2002; 2003) suggests that too few agglomerations and in particular too much primacy of one agglomeration reduce national output. A different literature has postulated a trade-off between national efficiency and spatial inequalities (Williamson, 1965).

Various models discussed above suggest that agglomeration and concentration are optimal in terms of aggregate economic performance. This might suggest that reallocating resources to lagging regions, thereby reducing the differences between regions, would result in a loss of aggregate efficiency. This type of trade-off between efficiency and spatial equity is often asserted to exist. Some research has considered this trade-off and in particular, following the work by Williamson (1965), has considered whether the relationship between spatial inequality and national development is characterised by a process of increasing disparities as a country develops up to a point where disparities decline. Thus, the hypothesis is of an inverted U-shaped relationship between the aggregate development of a country and differences between regions. A number of papers find support for Williamson's hypothesis. Amos (1988) builds on the work by Williamson and hypothesises that at the most advanced stages of development, regional disparities increase again, for which he finds empirical support. In contrast Enzurra and Rapun (2006) find that at the advanced stage of development regional disparities decline as do Barrios and Strobl (2009). The relationship between regional concentration of economic activity, as measured by urbanisation shares and concentration measures, and national growth has also been investigated by Brülhart and Sbergami (2009) and also find support for Williamson's hypothesis. Their results suggest that the point at which the trade-off reverses is relatively low and declining, and that the cost of tackling regional differences are greatest for the poorest countries. Finally, the analysis by Lessmann (2014) also finds support for the inverted U-shaped relationship between the regional inequalities and national development and he also finds some evidence for increasing disparities at very high levels of development.

For Ireland, no estimates of the relationship between regional inequalities and national growth have been published. However, it is possible to analyse the relationship with some simple data analysis. Figure 6.7 shows a scatter plot of the dispersion of county per capita income for the years 1991 to 2014 plotted against the national real per capita GNP. The plot supports the Williamson hypothesis, in that county disparities peak at a per capita GNP of around €30,000, which was reached in 2001, but are lower at higher levels of per capita GNP. Interestingly, the highest level of county disparities at the higher levels of per capita GNP are found for 2014. This might suggest that as the country is recovering, disparities are again increasing. Overall, the correlation between per capita GNP and county income disparities is positive (r=0.57). Regression analysis also confirms this

positive relationship and that this reduces somewhat at higher levels of GNP. A simple regression of the coefficient of variation of county per capita income on GNP and squared GNP suggests that regional inequalities in Ireland will decline with increasing development.[34]

FIGURE 6.7 SCATTER PLOT OF COUNTY INCOME DISPERSION AND NATIONAL REAL PER CAPITA GNP



Source: Author's calculations based on data from CSO County Incomes and Regional GDP, CSO National Accounts and CSO Population estimates.

Note: The coefficient of variation is measured as the standard deviation of county per capita income divided by average national income.

[34] The estimated regression in levels is CV =0.0185786+0.00000448*GNP- 0.00000000007*GNP^2, which explains just over 40 per cent of the variation in county disparities.

CHAPTER 7

Summary, conclusions and commentary

The review of regional development trends in Chapter 2 argued that regional output measures are subject to the same distortions affecting Irish GDP, and therefore may not accurately reflect the underlying regional economic trends. While output measures show increasing differences between the regions, data on household income measures indicate that there have been periods of both convergence and divergence for real per capita income over the period 1991 to 2014. Since 2010 per capita income growth has been faster in the regions with higher income levels.

The significant population growth between 1991 and 2016 was not evenly spread, with the Mid-East region in particular registering significantly faster population growth. This has contributed to a growing share of the population residing in the Greater Dublin Area, including spillovers in Louth and Midland counties. Age dependency rates have increased, but over the period the child age dependency rate exceeded the old age dependency rate, highlighting the still favourable age structure in Ireland. As deaths are increasing while births are falling, the natural increase of the population is declining.

Employment, the number of persons resident in a region that are employed, has grown significantly since the early 1990s. The recovery in employment since the economic crash has been stronger in the Dublin, Border and South-East regions than elsewhere, although the level of employment has not reached peak levels in any region yet. While the unemployment rate across the regions follows a very similar time path, there are differences between the regions. On average over the full period, the highest unemployment rates were recorded in the Border, South-East and Midland regions. The lowest rates were recorded in the Mid-East, Mid-West and West.

The data relating to the location of jobs show that the highest growth rates in this variable in the 2002 to 2006 period were achieved in Meath, Leitrim and Kildare. However, those counties that experienced the fastest growth in the 2002 to 2006 period also on average experienced a greater decline in the 2006 to 2011 period.

The projections for the population, employment and jobs developed in Chapter 3 under ‘current trends’ assumptions suggest spatial development patterns characterised by urban focus and sprawl. The national population is projected to

grow to 5.64 million by 2040, an increase of just over one million over the 2011 population. Population growth is projected to be greatest in and around the major cities and in particular Dublin, with the population share of the Dublin and Mid-East regions projected to increase to 41.6 per cent, with significant growth also projected for Louth. The old age dependency rate is projected to increase significantly throughout the country but is projected to be highest in the Border and South-East regions.

Under the 'current trends' scenario, above average employment growth rates are projected particularly for the Mid-East and to a lesser extent in the South-West, West and Border regions. Dublin and the Mid-East are projected to have above average jobs growth. The jobs growth in the South-West and West is projected to be just under the national average, which is largely due to the influence of Cork and Galway. Overall, the projections imply economic divergence across the regions, with Dublin in particular growing significantly faster. Consequently, Dublin and the Greater Dublin Area are projected to increase their share of jobs between 2016 and 2040 from 33.3 per cent to 35.4 per cent and 43.7 per cent to 46.5 per cent, which is greater than the respective shares in the population.

Chapter 4 presented some alternative demographic scenarios to those suggested by a pattern that follows current trends. Specifically, three scenarios regarding the broad regional distribution of population growth were considered and for those that aim to distribute growth more evenly or away from the East and Midland region, two alternative scenarios for the distribution of population growth within regions were examined, resulting in five scenarios.

In all scenarios the total national population was held roughly constant in order to identify whether the changed patterns across regions are feasible. While the scenarios where absolute growth of the population is split roughly 50:50 between the Eastern and Midland region and the rest of the country imply changes that are potentially achievable, the scenarios where less than 50 per cent of growth takes place in the Eastern and Midland region require very large changes that are unlikely to be feasible.

Achieving altered spatial development patterns will crucially depend on spatial migration patterns. The empirical evidence internationally, and for Ireland, suggests that housing and labour market factors are significant drivers of internal migration. Simulations based on new Irish estimates suggest that the magnitude of change required to achieve the '50:50' scenarios could be met with some modest changes. For example, a 1.6 per cent increase in Dublin house prices relative to house prices elsewhere would divert the number of internal migrants assumed under the '50:50' scenarios away from Dublin. Of course many are

currently diverted to neighbouring counties, which means that the improvements must also be made relative to other East and Midland region counties.

Apart from house prices, improved wages and reduced unemployment rates relative outside the Eastern and Midland region would also achieve a shift in the internal migration patterns required to achieve the '50:50' scenario. The analysis thus suggests that both the '50:50 NSS' and '50:50 City' scenarios are feasible scenarios. Economic analysis suggests that from a regional development perspective as well as from a macroeconomic perspective, the city focused scenario, where the second tier cities grow by more, is likely to be the better option in the long run.

Developing scale in the second tier cities will enable them to benefit from greater agglomeration economies. This has a benefit for the wider region as larger second tier cities are able to provide services and functions that are currently only available in Dublin. By having these available within the region, other parts of the region outside the urban centres are able to benefit from this scale of development. The alternative would see growth spread more evenly across the region, which while it would allow smaller centres to grow, would not allow these to attain a scale that would lead to significant agglomeration economies.

The analysis provides important insights for planning policy but also raises questions about the implications of the projected development pattern. Importantly, the projections are produced under the assumption that the resulting requirements in terms of housing and infrastructure needs are met and that the projected pattern does not affect the national projections.

The implications and trends are best interpreted with reference to the literature on regional development which provides important insights into the efficiency of alternative development patterns. This literature points to the benefits of agglomeration and scale but also shows that too much concentration in one centre may have negative effects.

The international literature has shown that the scale economies inherent in larger urban centres or conurbations result in higher productivity (see Ciccone and Hall, 1996; Ciccone, 2002), reduce the cost of providing infrastructure (see Büttner et al., 2004; Hortas Rico and Sole-Olle, 2010), and allow for a greater diversity of economic activities which have been found to be growth enhancing (Quigley, 1998).

Innovation and knowledge development have also been found to be very place specific, which reinforces agglomeration economies. For example, knowledge spillovers have been found to be spatially restricted and thus create agglomeration economies (Audretsch, 1998). It is therefore not surprising that industries in which knowledge spillovers are greater have a greater propensity to cluster than industries where knowledge externalities are less important (Audretsch and Feldman, 1996). An important reason for the limited spatial reach of knowledge spillovers is the fact that particularly in knowledge intensive industries, informal contacts play an important role in facilitating spillovers. While such informal contacts may arise more readily in smaller places, the volume and range of such contacts is significantly greater in agglomerations (e.g. Dahl and Pedersen, 2004).

The literature has also shown that more highly skilled individuals, which are key driver of growth, agglomerate in the larger, more dense and more skilled labour markets and up to half of the differences in wage rates across local labour markets can be attributed to differences in human capital (see Combes et al., 2008). One of the reasons for this is that a larger labour market makes it easier to get a job that is commensurate with the level of qualification, which is particularly relevant for two-earner families where both earners have a university degree (see Costa and Kahn, 2000).

The evidence for Ireland supports this finding as the percentage of the population with a third=level qualification has been diverging strongly. In 2011, 75 per cent of PhD holders resided in urban areas compared to 58.5 per cent of the population, and just 5.5 per cent resided in remote areas compared to 11 per cent. Glaeser et al. (2001) have shown that cities with better consumer amenities such as shops and restaurants have faster growth. Larger centres can maintain a higher level of consumer amenities and thereby attract additional population.

This would suggest that the projected development pattern under the '50:50 City' scenario would be growth enhancing. However, the projected pattern also implies significant sprawl, which has the potential to undermine the positive effects of agglomeration. Agglomeration economies, the positive effect due to scale effects in urban centres, are dependent on the density of activity, which is reduced by sprawl. The literature has shown that the agglomeration benefits are tightly concentrated in the more dense areas and that only the immediate neighbouring areas can benefit from spillovers (see Graham, 2009).

While there appears to be a preference to reside in or proximate to urban areas, individuals do not necessarily prefer central locations (Senior et al., 2004). There is also evidence that high skilled workers may be more footloose and willing to

tolerate longer commutes and choose their residential location on the basis of amenities and the quality of housing (van Oort et al., 2003). This corresponds with the evidence for Ireland, where a negative correlation between population density and population growth has been increasing, which is consistent with projected spatial patterns of population growth (Map 4.3).

With economic activity concentrating due to agglomeration economies and individuals choosing to live around these agglomerations there is increasing mismatch between residential location and job location. This has important transport implications as the nature of spatial residential patterns has been shown to be a significant driver of car based travel (Bento et al., 2005). The share of Irish commuters driving to work has increased from 45 per cent to 62 per cent between 1981 and 2016, which has put additional pressure on roads infrastructure. The projected patterns imply a significant increase in commuting across regions, particularly to Dublin.

For example, the northern half of the M50 has annual average daily traffic (AADT) in excess of 120,000 vehicles, but more importantly peak hourly levels exceed capacity, thereby significantly impacting on flow speeds (NRA, 2012). With only limited scope for capacity enhancement, traffic management on the M50 only is unlikely to be able to accommodate the additional traffic flows implied by the projected patterns. There is thus a risk that the projected patterns of population, employment and jobs growth will lead to significant congestion, which would undermine the positive effect of agglomeration economies. Thus, to accommodate this type of spatial development pattern would require significant investment in transport infrastructure, and in particular public transport infrastructure in and around the cities on which growth is focused.

The projected increase in the population and economic activity also imply that investment in infrastructure more generally will have to increase and also have significant implications for housing. For example, the projected population growth implies an increase of the number of households by more than 500,000, which will need to be housed. The spatial patterns that are projected under a current trends scenario imply a particular need for additional housing units in Dublin and the Mid-East as well as Cork and Galway, which are areas that have already been identified as having housing shortages unless housing completions increase significantly (see Morgenroth, 2014b). The projections under the current trends scenario imply even large housing deficits in the Mid-East region than previously estimated in Morgenroth (2014b).

Facilitating this housing development and the requirements of a growing economy will also put more pressure on infrastructure. For example, water

supply constraints have already been identified for the Greater Dublin Area which is projected to grow faster than other parts of the country, implying that the need for investment in water and wastewater infrastructure in that region is likely to be even more acute.

While the literature shows the benefits of agglomeration, there is also a literature that shows that if economic activity is either too much or little concentrated in one urban centre, national growth is negatively affected (Henderson, 2003). Given the empirical findings of that paper, economic activity in Ireland may already be too concentrated in Dublin, and the projections suggest that the dominance of Dublin is set to increase further, which implies that the dominance of Dublin reduces national growth. The literature shows that deconcentration can be achieved through investment in interregional infrastructure, fiscal decentralisation and the strengthening of local and regional political autonomy (see Davis and Henderson, 2003). There is also a literature which investigates a hypothesised trade-off between regional disparities and national growth, which finds that for more developed countries lower levels of regional disparities are associated with faster national growth (e.g. Brülhart and Sbergami, 2009).

These are important findings as they suggest that excessive concentration in and around Dublin may have negative effects on national growth as would a strategy to significantly shrink Dublin's role and spread economic activity evenly. This points to the potential benefits of developing counter-poles to Dublin. Given the size of Ireland and the fact that agglomeration economies only arise for urban areas of significant size, the optimal number of counter-poles is small. However, even the development of just one sizable counter-pole per region would allow a larger number of rural areas to benefit from the urban led growth.

Importantly, the projections presented in this paper are produced under the assumption that the required investments that make the projected developments possible would be put in place. If for example, housing completions are insufficient to accommodate what is projected then this will increase house prices further and push people further away from their workplace, resulting in even more significant transport challenges. Likewise, even if the housing needs that are implied by the projections are met, but other infrastructure needs such as those for transport are not, then this is likely result in an increase in disamenities such as congestion which will have a negative impact on both Ireland's ability to attract FDI and attract and retain talented individuals.

To achieve the benefits from a city based pattern, growth in the second tier cities needs to be facilitated i.e. it has to be planned for and the appropriate infrastructure must be put in place. The aim should be to achieve compact high

density development that is attractive, such that it will draw in internal and international migrants, and the scale and density will support the attraction of more economic activity. Thus, infrastructure development should be in the cities rather than between them. The latter facilitates sprawl and thus leads to reduced densities.

The literature on urban hierarchies suggests that the range and value of functions carried out by urban centres is dependent on their scale with larger centres providing a larger range and higher value functions. The Irish urban system is dominated by the scale of Dublin relative to other centres, which implies that the second tier cities are unable to provide the range of functions to their hinterland seen in cities of similar rank in other countries. This reinforces the dominance of Dublin and limits the development potential of the other regions.

An important aspect of spatial development patterns is the functioning of the housing market and its interaction with individuals' residential location decisions. Research shows the role of so-called fundamentals, such as income and demographic change in driving local house prices. The limited literature on this for Irish local housing markets suggests that house prices respond more to demographic change than other factors. Residential location decisions are made on the basis of access to jobs, house prices and amenities. New research for Ireland shows that if areas with the highest value in terms of jobs and amenities are not affordable, then individuals choose to locate as close to those areas as they can afford, which results in sprawl.

Firm start-ups and the location of new FDI contribute significantly to regional economic performance. A range of factors affects start-up rates and FDI attraction. Agglomeration has a positive effect on new firm establishment reinforcing the role of cities, while specialisation has a negative effect on new firm formation. Importantly, new research on Ireland shows that human capital plays a more important role in fostering start-ups than infrastructure. The analysis above also shows that FDI is disproportionately drawn to larger centres.

The literature on the relationship between spatial disparities and national performance has found evidence for an inverted-U shaped relationship where disparities increase during the development process and decrease once development has reached a certain level. There is some limited evidence that at very high levels of development, spatial equity increases again. This suggests that a trade-off between spatial equity and economic efficiency does not exist at all levels of development. The limited evidence for Ireland presented above suggests that the inverted-U relationship also applies to Ireland.

Overall, the analysis shows that agglomeration economies are pervasive and add to national economic development, but that the urban hierarchy in Ireland is characterised by excessive primacy and a lack of scale among second tier cities. Developing the scale of these second tier cities is likely to yield significant benefits both from a regional and national development perspective. However, increased scale also implies increased demand for housing which in turn implies increased house prices, which will lead to sprawl and could undermine efforts to increase the scale of the second tier cities. The only way to effectively address this is to ensure that housing supply is significantly expanded in the cities. It is also imperative to ensure that residential development is accompanied by the development of amenities that will attract residents. The implication for policy is that the required infrastructure be put in place in the cities, and that development of infrastructure between cities which fosters sprawl be limited. Consideration also needs to be given to measures to restrict unsustainable sprawl.

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APPENDIX A METHODOLOGY

A1 POPULATION PROJECTIONS

The population projections are constructed using a cohort component model which is applied for each county separately. The cohort component model is based on the fundamental balancing equation of 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. In relation to the natural increase this 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 woman in order to project the number of births. In practice the model is run to project the population in each year over the projection horizon. Thus, P_t is used as a new baseline for the projection of the population in the next year.

The model is applied to population broken down into single year of age groups and gender which allows for the application of age and gender specific mortality rates. Migration is also broken down into single year of age groups.

A2 EMPLOYMENT

The approach used to project employment, that is the number of persons employed by region of residential location, is to estimate a simple model for each region and sector where employment in each region is a function of national employment and the lag of the regional employment in each sector. The sectors are the internationally traded sector, the non-internationally traded market sector and the government sector.

The inclusion of national employment means that the model follows a top-down approach, but by adding the lagged regional employment and by estimating the model separately for each region, regional differences are also accounted for.

Formally the model can be written as

$$E_{r,i,t} = \alpha_{r,i} + \beta_{r,i}E_{i,t} + \rho_{r,i}E_{r,i,t-1} + \epsilon_{r,i,t}$$

Where *E* denotes employment, $E_{r,i,t}$ denotes employment in region *r*, sector *i* at time *t*, and $E_{i,t}$ denotes total national employment in sector i at time t. α, ß and ρ are parameters that are to be estimated and ε denotes a residual. Given estimates of the parameters and projections for national employment in each sector from the ESRI Economic Outlook (see Bergin et al., 2016a) it is possible to project employment.

TABLE A.1 ESTIMATION RESULTS FOR THE EMPLOYMENT MODELS

	National Employment in the Sector	Lag of Regional Employment	Constant	R^2
Traded				
Border	0.02	0.53	14.45	0.49
Midland	0.02	0.54	3.09	0.75
West	0.01	0.80	3.92	0.92
Dublin	0.32	0.00	16.77	0.92
Mid-East	0.08	0.54	-11.60	0.93
Mid-West	0.03	0.29	13.82	0.58
South-East	0.08	0.16	-3.18	0.86
South-West	0.13	0.11	-5.63	0.92
Non-Traded				
Border	0.13	-0.10	-11.67	0.97
Midland	0.03	0.49	-2.19	0.93
West	0.05	0.39	11.20	0.89
Dublin	0.25	0.06	-2.40	0.97
Mid-East	0.10	0.28	-14.82	0.97
Mid-West	0.06	0.17	7.27	0.89
South-East	0.12	-0.01	0.10	0.98
South-West	0.12	0.08	13.44	0.97
Government				
Border	0.11	-0.08	-0.72	0.97
Midland	0.03	0.49	-1.68	0.94
West	0.07	0.34	-3.55	0.96
Dublin	0.18	0.25	23.58	0.98
Mid-East	0.11	0.21	-7.11	0.97
Mid-West	0.10	-0.24	-1.57	0.97
South-East	0.09	0.18	-3.08	0.96
South-West	0.13	0.08	-2.29	0.97

Source: Author's calculations.

A3 JOBS PROJECTIONS

Jobs projections, that is projections of the number of jobs by region in which the job is located, are also provided for the three sectors. Different modelling strategies are used due to differences in data availability across sectors.

For the internationally traded sector a panel of data for both regions and counties was available from the DBEI/Forfás Employment Survey. This allowed for an estimation strategy similar to that used for employment where jobs in a region are a function of total national jobs and lagged regional jobs. The model can formally be written as:

$$J_{r,t} = \alpha_r + \beta_r J_t + \rho_{r,i} J_{r,t-1} + \delta t + \epsilon_{r,t}$$

where *J* denotes employment, $J_{r,t}$ denotes jobs in region *r*, at time *t*, in the traded sector J_t denote total national traded sector jobs. One change to the specification used for employment is the inclusion of a time trend *t*. In the Border region a model including a lag was found to yield implausible results, and instead a model without lag was preferred. Table A3.1 shows the results of regressions at the regional level, which show that the models have a very good fit.

TABLE A.3.1 ESTIMATION RESULTS REGIONAL TRADED SECTOR JOBS

	Lagged Regional Jobs	Total Jobs	Year	Constant	Adjusted R^2
Border		0.11	-424.19	845,848.9	0.99
Midland	0.39	0.02	-63.11	127,881.6	0.76
West	-0.18	0.10	123.11	-245,450.0	0.98
Dublin	0.26	0.28	646.51	-1,304,997.0	0.99
Mid-East	0.63	0.06	-97.90	188,776.2	0.96
Mid-West	0.10	0.13	-458.89	907,309.2	0.95
South-East	0.58	0.04	-132.13	266,311.2	0.86
South-West	0.17	0.08	299.44	-587,081.0	0.96

Source: Author's calculations.

At county level the same regression is run but national jobs are replaced by regional jobs. The results are shown in Table A3.2. Again the fit is very good with most models explaining at least 80 per cent of the variation. These results can be used in the same way as those for the regions to project the county level traded sector jobs, but an additional constraint that the county jobs need to sum to the projected region totals.

TABLE A.3.2 ESTIMATION RESULTS COUNTY TRADED SECTOR JOBS

	Lagged Region Jobs	Total Regional Jobs	Year	Constant	Adjusted R^2
Cork	-0.05	0.81	197.07	-390,918.00	0.99
Clare	0.21	0.20	23.82	-45,905.89	0.97
Cavan	0.82	0.05	15.35	-31,143.69	0.84
Carlow	0.65	0.03	-19.28	38,937.74	0.85
Dublin	0.26	0.28	646.51	-1,304,997.00	0.99
Donegal	0.68	0.03	-71.38	144,453.80	0.95
Galway	-0.01	0.66	119.78	-240,223.40	0.99
Kildare	0.03	0.58	145.47	-293,146.10	0.99
Kilkenny	0.49	0.13	22.11	-45,716.33	0.88
Kerry	0.28	0.17	-139.37	276,289.80	0.93
Longford	0.42	0.13	7.08	-14,383.25	0.78
Louth	0.50	0.13	-38.51	76,567.68	0.90
Limerick	0.00	0.64	26.75	-56,402.18	0.99
Leitrim	0.88	0.02	5.31	-10,944.02	0.74
Laois	0.39	0.06	-32.64	65,576.30	0.94
Meath	0.21	0.11	-12.80	27,469.56	0.87
Monaghan	0.53	0.12	20.15	-41,728.71	0.86
Mayo	0.40	0.11	-26.61	54,454.25	0.86
Offaly	0.23	0.33	6.24	-13,492.91	0.82
Roscommon	0.58	0.08	-43.87	86,937.35	0.94
Sligo	0.55	0.08	26.85	-54,390.19	0.92
Tipperary N.R.	0.39	0.07	-44.40	89,222.71	0.94
Tipperary S.R.	0.73	0.13	9.23	-20,519.30	0.81
Waterford	0.20	0.40	-58.30	113,497.80	0.92
Westmeath	0.21	0.26	20.23	-40,279.38	0.73
Wicklow	0.15	0.22	-122.65	245,114.50	0.92
Wexford	0.69	0.01	-3.01	7,494.66	0.58

Source: Author's calculations.

The data availability for the non-traded and government sectors is more limited, comprising data derived from special tabulations of the travel to work data from the CSO Census of Population, 2006 and 2011, so that the approach to estimate a time series model is not feasible. Instead county level cross-section models are estimated and used to project county level government and non-traded sector jobs with regional totals constructed from the county level data. A variety of different models was tested before settling on the approach used here.

The county non-traded jobs are modelled using a regression of the share of non-traded county level jobs as a function of the lagged share of non-traded jobs and the population. The resulting regression equation is the following:

$$SJ_{c,t} = 0.0001 + 0.521 * SJ_{c,t-1} + 0.0000000542 * Pop_{c,t}$$

The government sector jobs are modelled more simply using as a ratio of the population reflecting an assumption that public services are provided according to demand. The ESRI economic outlook projects a higher number of government sector employees per person which is reflected in the projections.

Given projections of the population the non-traded and government sector jobs can readily projected using the models.

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