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An Econometric Analysis of Spatial Economic Growth in Northern Ireland

Undertaken as part of the DARD E&I project
'Resources in Spatial Rural Economic Development'

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Executive Summary

Regional employment and population change have displayed considerable spatial disparities within Northern Ireland in recent years. It is important to gain a better understanding of the causes of these spatial disparities to facilitate the development of effective policies to promote economic growth within the rural economy. Using data from rural wards in Northern Ireland over the period 2001 to 2007, this paper describes findings from the application of a growth equilibrium model framework to analyse the determinants of regional economic growth.

The key findings are summarised below:

- Employment and population growth are interdependent. An increase in population has a positive impact on employment, while an increase in employment has a positive impact on population. This finding suggests that rural development policies should not only focus on creation of work schemes, but should also strive to make rural places desirable places to live.

- Changes in employment/population growth in one region has knock-on impacts on neighbouring regions. As a result, rural development policies should cover wide areas and take into consideration the regional connectivity of places, rather than focus on small localised regions.

- Due to urban-rural linkages the success of rural areas partly depends on the economic growth potential of proximate urban areas. This suggests that rural development policies should not just target rural areas, but should also aim to strengthen urban-rural linkages.

Contents

An Econometric Analysis of Spatial Economic Growth in Northern Ireland

1. Introduction

There are considerable spatial disparities in terms of regional economic growth, measured in terms of employment and population changes over time, within the rural economy of Northern Ireland in recent years. While some rural areas within Northern Ireland have waned, others have displayed strong economic growth. This presents challenges to policy makers in terms of provision of adequate infrastructure such as roads, schools and other public services. In addition, residential and industrial development associated with strong economic growth may lead to loss of agricultural land; habitat fragmentation; degradation of the rural landscape; and increased traffic levels. Understanding the causes of spatial disparities in economic growth will facilitate the development of effective policies to promote rural development. This requires a systematic framework to accurately identify the drivers of growth.

Growth equilibrium models provide a means to examine the multiple, integrated economic, social and geographical factors that contribute to economic growth and analyse their synergistic effect on each other (Adelaja *et al.*, 2009). This modelling framework has been developed to analyse the interaction of economic phenomena occurring in spatial dimensions and account for interdependencies between population and employment change. Using data from rural wards in Northern Ireland over the period 2001 to 2007, this paper describes the application of a growth equilibrium model framework to analyse the linkages between population and employment patterns and other exogenous determinants of spatial growth. The model framework provides an insight into:

- the relative responsiveness of different forms of economic growth (employment and population) to a variety of growth drivers, e.g. infrastructure and socio-economic conditions;
- how different forms of economic growth work together (the extent to which ‘people follow jobs’ and/or ‘jobs follow people’); and
- the linkages between economic growth in rural and urban areas.

2. Methodology and Data

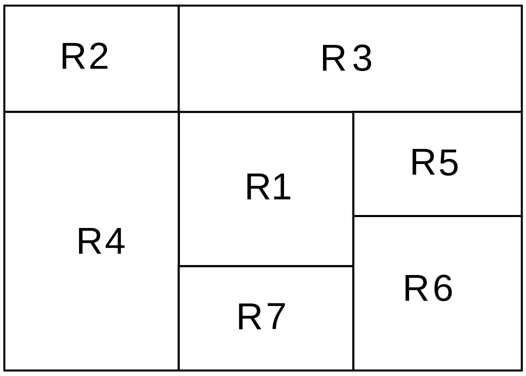
Methodology

The growth equilibrium modelling framework used to estimate the relative contributions of alternative drivers of growth is outlined below. Growth equilibrium models measure the linkages between population and employment change patterns and other exogenous determinants of economic growth. They are based on the premise that residential and firm location choices are interdependent. People move to regions in which employment growth is high. The reverse also potentially applies, firms move to regions in which population growth is high due to the availability of labour and demand for final goods. This interdependence implies that a simultaneous relationship exists between regional population and employment changes. In addition to being interdependent, employment and population growth are each affected by a variety of other factors. For example, population growth may be affected by house prices, socio-economic conditions, amenities, etc., while factors such as infrastructure, availability of an educated labour force and structure of the economy may affect employment growth (Adelaja *et al.*, 2009).

Growth in population or employment in one area could spillover to neighbouring areas. Population change in an area may depend not only on employment changes in that area but also employment changes in a labour market that extends beyond the unit of observation. Similarly, employment changes may depend on population changes in surrounding areas. Such spillover effects are particularly important where there is extensive commuting across the units of analysis, rendering individual units too small to be their own labour market.

Following Boarnet (1994), spatial spillover effects are accounted for by incorporating spatial lags of the endogenous variable (weighted averages of neighbouring areas). Namely, population change is dependent upon the change in employment aggregated over all areas within commuting range, while employment change is dependent upon the change in population within commuting range of the area in question. Within the spatial econometric literature this is known as a 'Spatial Cross-Regressive Lag Model'. This is illustrated in Figure 1, where seven geographical areas are depicted. Within the Spatial Cross-Regressive Lag Model population (employment) change within region 1 is dependent upon employment (population) change within regions R1 to R7.

Figure 1: Spillover Effects within the Spatial Cross-Regressive Lag Model



In addition, population (employment) change in one unit is also affected by population (employment) changes in the neighbouring units. These effects can be either positive due to for example benefits of agglomeration, or negative due to competition among these units. Whether the net effect is positive or negative is an empirical question; within the literature this is referred to the spread versus backwash debate (REF). This is the conventional spatial simultaneity effect, which is usually captured by spatial autoregressive lags (Rey and Boarnet,..). It is important to capture these effects particularly when the geographical unit under investigation is small, similar to the cross regressive case in which decision makers are unlikely to confine their location choices to the boundaries of the units.

Within this study a range of specifications are considered, including a basic model and a model that allows for differential spatial spillover effects for rural and urban wards (Urban-Rural Spillover Model). Further details on the model specifications are provided in Box 1.

Box 1: Model Specifications

The basic specification for the 'Spatial Cross-Regressive Lag Autoregressive Model' used in this study is shown below:

(i) $\Delta E = \alpha_E + \beta_{1E}E_{t-1} + \gamma_{1E}(I+W)\Delta P + \Sigma\delta_{iE}\Omega^E + \eta_{1E}M\Delta E + \mu$

(ii) $\Delta P = \alpha_P + \beta_{1P}P_{t-1} + \gamma_{1P}(I+W)\Delta E + \Sigma\delta_{iP}\Omega^P + \eta_{1P}M\Delta P + \varepsilon$

where ΔE and ΔP are the changes in employment and population density in a particular ward in Northern Ireland between 2001 and 2007. I is an identity matrix and W and M are spatial weight matrices (with diagonal terms equal to zero), which define how geographic units of observation relate to their neighbours. $(I+W)\Delta P$ and $(I+W)\Delta E$ are the spatial cross-regressive terms within the employment and population equations respectively, while $M\Delta E$ and $M\Delta P$ are the spatial autoregressive lags. The different notations for the spatial weight matrices (W and M) are used to emphasise the possibility that they can be different, which is the case in this analysis. Further information on the weight matrices used in this analysis is provided in Box 2. If the autoregressive terms are suppressed, the model becomes the basic Spatial Cross-Regressive Lag Model.

Essentially, the spatial cross-regressive term $(I+W)\Delta P$ is the weighted average of population change within the area in question and neighbouring areas, while $(I+W)\Delta E$ is the weighted average of employment change within the area in question and neighbouring areas. Similarly, $M\Delta E$ and $M\Delta P$ are the weighted average of the employment change and the population change of the neighbouring areas with the area in question excluded.

However, spatial spillover effects may differ between rural and urban wards due to underlying differences in the linkages between these areas. Differential spatial spillover effects for rural and urban wards can be accounted for by decomposing the spatial cross regressive term into rural and urban effects. To allow for these differential spatial spillover effects an 'Urban-Rural Spillover Model' is further employed, in which urban-rural spillover effects are further differentiated:

(iii) $\Delta E = \alpha_E + \beta_{1E}E_{t-1} + \gamma_{1E}'\Delta P + \gamma_{2E}W_U\Delta P_U + \gamma_{3E}W_M\Delta P_M + \gamma_{4E}W_R\Delta P_R + \Sigma\delta_{iE}\Omega^E + \eta_{1E}M\Delta E + \mu$

(iv) $\Delta P = \alpha_P + \beta_{1P}P_{t-1} + \gamma_{1P}'\Delta E + \gamma_{2P}W_U\Delta E_U + \gamma_{3P}W_M\Delta E_M + \gamma_{4P}W_R\Delta E_R + \Sigma\delta_{iP}\Omega^P + \eta_{1P}M\Delta P + \varepsilon$

This is similar to Fesser and Isserman (2006). The main difference is that in the employment equation the population variable is decomposed [rather than the employment variable as in Fesser and Isserman (2006)]; and vice versa. The main advantage of our framework is that the interactions between employment and population, as suggested by the theory of location choice of individual economic entities, are well kept.

All the variables are defined in the same way as in the basic spatial cross-regressive lag autoregressive model, except the commuting matrix is partitioned into urban/mixed/rural components.

Within the employment change equation [Specifcation (iii)], γ_{2E} to γ_{4E} are coefficients for spatially weighted change in population in urban/mixed/rural areas.

Within the population change equation [Specifcation (iv)], γ_{2P} to γ_{4P} are coefficients for spatially weighted change in employment in urban/mixed/rural areas.

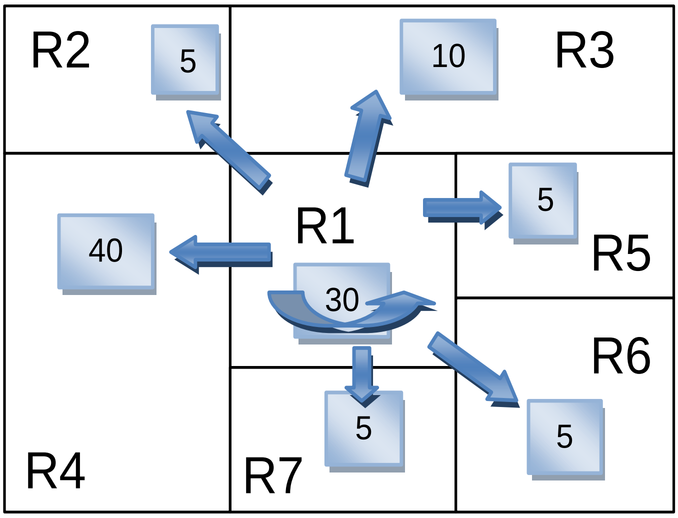
Again, the spatial autoregressive terms are included.

Box 2: Weight Matrices

A distance matrix is applied to the autoregressive lag terms, wherein geographic regions that are further away are weighted less heavily and hence, the spatial spillover effect diminishes with distance (distance decay).

In terms of the interaction between population and employment, distance does not necessarily accurately capture regional connectivity. Therefore, to reflect the location where people are employed, this study employs a weight matrix based on commuting data for the cross-regressive lag terms. The commuting data are from the 2001 census, with each element in the matrix equal to the number of commuters travelling between specific wards[#]. Compared to the standard distance weight matrix, the commuting weight matrix is regarded as preferable from a theoretical point of view since it directly provides a measure of regional connectivity. As shown in the example in Figure 2, the number of individuals commuting to a particular region does not necessarily vary with distance.

Figure 2: Commuting Example



In this example the blue boxes show the number of commutes from region R1 to all the other regions, including commutes within the own region (30). The number of commutes from R1 to the various workplaces shown ranges from 5 (R2, R5, R6, R7) to 40 (R4). Within the commuting weight matrix, R4 would be weighted more heavily to reflect the higher number of commutes compared to a standard distance weight matrix in which R4 is given equal weight relative to the other regions.

Within the population change equation, the weight matrix used for the employment change variable refers to where people commute to since it is hypothesised that population is dependent upon nearby employment opportunities. In contrast, the weight matrix for population change within the employment change equation is based on where people come from.

The inclusion of cross-regressive and autoregressive terms gives rise to the endogeneity problem in econometrics. Therefore, the GMM (General Method of Moment) procedure is applied, which involves the use of instrumental variables. Following Rey and Boarnet (2004), the generation of instruments is based on the exogenous explanatory variables. The exogenous variables within the employment equation include the following:

- '% of employment in construction' and
- 'Distance to key corridor'[1].

The exogenous variables within the population equation include the following:

- '% of ward agriculture land',
- '% 25 to 44 age group',
- 'Distance to secondary school',
- 'Median income 2001' and
- 'Distance to key corridor'.

Data Definitions and Descriptive Statistics

Wards within Northern Ireland are used as the unit of observation within the analysis outlined in this paper[2]. Wards are classified as rural, urban or mixed using the settlement-based approach adopted by the Inter-Departmental Urban-Rural Definition Group (NISRA, 2005). The inter-departmental group defined settlements on the basis of settlement development boundaries. Settlements are classified into 8 bands from A to H based on population. Those with a population above 4,500 (i.e. band A to E) are classified as urban and geographic areas outside these boundaries as rural (band F to H). Census output areas are defined as urban or rural depending on whether the population weighted centroid of an area falls inside or outside these boundaries. These are then aggregated to create definitions at the ward level. Where a ward is composed of both urban and rural census output areas with neither one dominating the other it is classified as mixed. Under this classification system 212 wards are classified as rural, 306 as urban and 64 as mixed. This classification system is depicted graphically at the ward level in Figure 2.

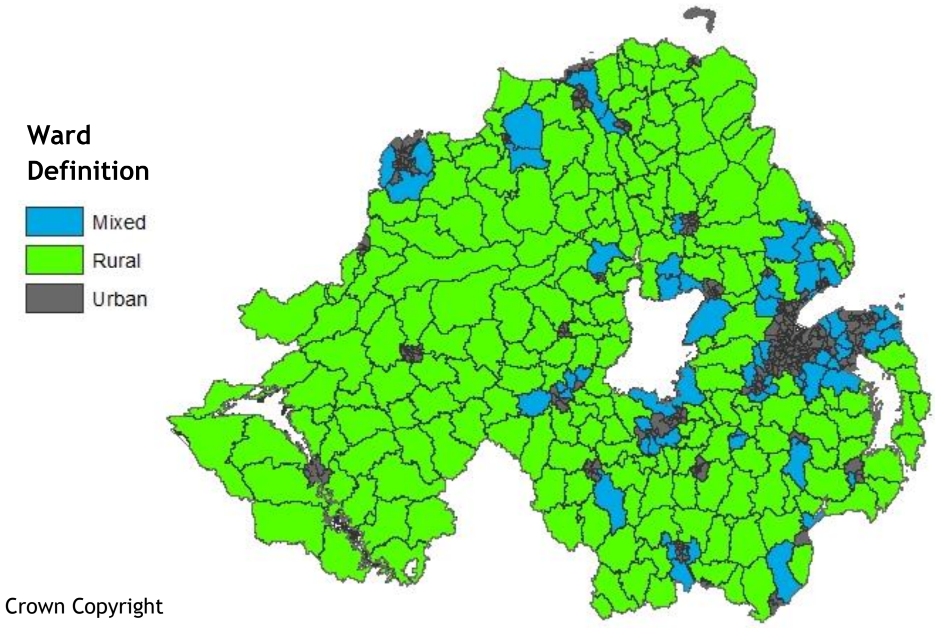
The extent to which drivers of economic growth may influence employment/population change may differ for urban and rural wards. Since the focus of this study is on the rural economy, model specifications (i) to (iv) are restricted to just rural wards. Supplementary analysis is undertaken in which the dataset is sub-divided into Accessible Rural and Remote Rural. In addition, the robustness of the results is assessed using an alternative definition of rural is explored. The model is also applied to different population age groups in order

[1] These key corridors are based on the Regional Strategic Transport Network developed by the Department of Regional Development (see Appendix).

[2] It would be desirable to account for interdependencies between NI and RoI but the commuting dataset used in this study provides information on commutes to RoI as a whole, rather than specific small areas within RoI.

to explore the extent to which the drivers of population growth vary across population cohorts.

Figure 2: Rural-urban definition of wards based on the inter-departmental group settlement classification system



Descriptive statistics for the main variables of interest are given in Table 1. The descriptive statistics refer to 202 rural wards, with 10 rural wards excluded due to missing data. Employment data is obtained from the Census of Employment and refers to non-agricultural businesses. Employment density growth between 2001 and 2007[3] displays considerable variation, with a mean increase of 3 persons per square km within rural wards. This average increase reflects the favourable economic climate, particularly in the construction sector, over the time period of the data[4]. This is controlled for within the employment equation by including the term 'Percentage of employment construction'. As indicated in Figure 3, employment growth between 2001 and 2007 exhibits some spatial patterns, with spatial clusters of high (red and orange) and low (dark and light green) growth.

Population data is sourced from the small area population estimates provided by NISRA. The variation in population density change is less marked, but the overall average change is positive. Similar to employment change, it appears from the geographic depiction of population change shown in Figure 4 that this variable exhibits some spatial patterns. The spatial econometric techniques applied in this study will help to explain this spatial variation in both employment and population change.

[3] Subsequent analysis will examine changes in economic growth post-2007 to determine whether the drivers of economic growth differ during a recessionary period.
[4] At the Northern Ireland level, employment in the construction sector grew by 23 per cent between 2001 and 2007, while the service sector grew by 16 per cent and the manufacturing sector fell by 13 per cent (Census of employment data).

Table 1: Descriptive Statistics

	Mean	Standard Deviation	Maximum	Minimum
Employment Density 07-Employment Density 01	3.25	15.85	120.03	-85.95
Population Density 07-Population Density 01	6.51	13.87	79.28	-73.80
Initial Employment Density	25.16	73.73	790.88	0.95
Initial Population Density	103.68	200.59	1966.74	10.70
% of Employment Construction	15.07	5.33	29.80	4.30
Distance to Key Corridor (meters)	10506.35	8208.76	37134.87	220.88
% 25 to 44 Age Group	28.59	2.43	36.56	23.39
% Ward Agriculture Land	93.32	6.64	99.65	46.67
Distance to Secondary School (meters)	5355.60	2675.70	13751.60	365.09
Median Income 2001 (£)	14108.91	2341.60	17500.00	12500.00

Figure 3: Change in Employment Density within Rural Wards 2001 to 2007 (Classification based on quantiles)

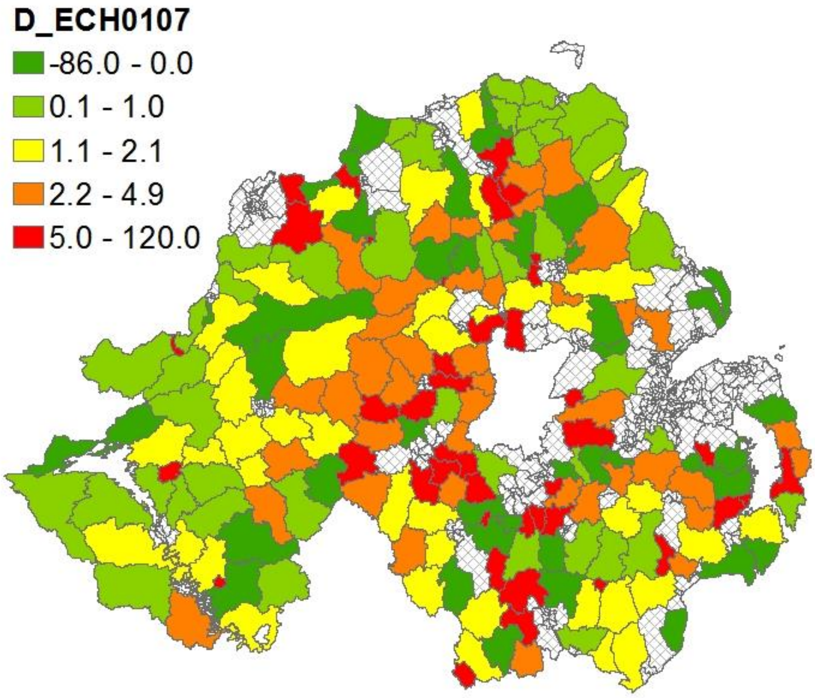
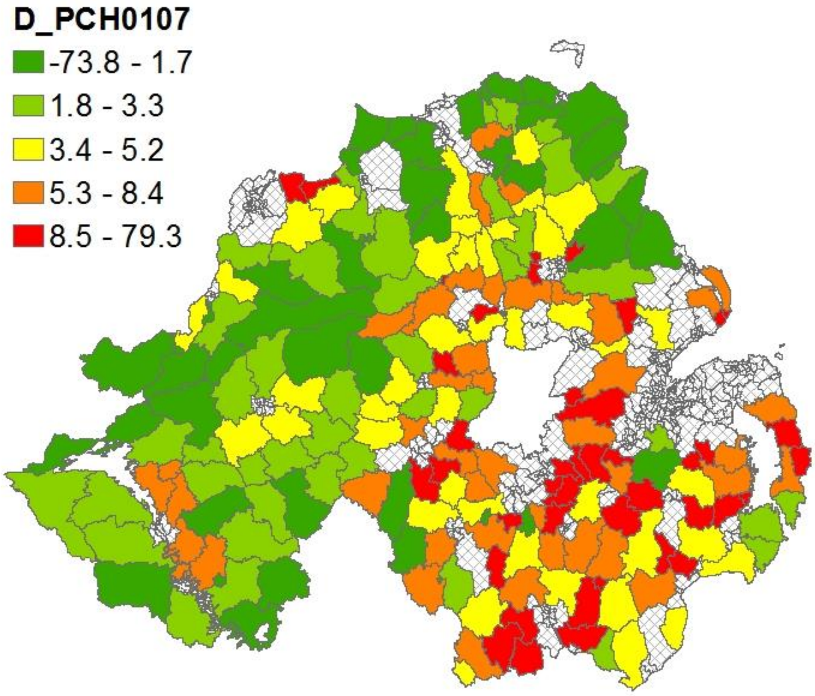


Figure: 4: Change in Population Density within Rural Wards 2001 to 2007 (Classification based on quantiles)



3. Findings

3.1 All Rural Wards

The results in this section refer to the entire sample of rural wards (excluding missing data). Rural wards are further categorised based on their remoteness. Separate regressions are estimating using these sub-samples and these results are presented in Section 3.2. Supplementary analysis using different population age groups is presented in section 3.3.

Employment Change

Estimates of the *Basic* and *Urban-Rural Spillover* models for employment change [Specifications (i) and (iii)] are shown in Table 2. Both these models contain spatial cross regressive lag and autoregressive lag terms. None of the explanatory variables are significant using the basic model specification (Spec. (i), Col. A).

The results improve upon using the *Urban-Rural Spillover* specification (Spec. (iii)), which allows for differential spatial spillover effects for rural, urban and mixed wards. Focusing firstly on the full sample (Col. B), this specification yields a significant coefficient for population change within the own ward (ΔP), indicating that an increase in population within the same ward has a positive effect on employment change. In contrast, there is evidence that employment growth within a ward is hindered by population growth within neighbouring rural wards (statistically significant negative coefficient for the $W\Delta PR$ term). These results imply that employment growth in rural wards is driven by increased demand for goods and services due to population growth but that there is potentially competition among the rural wards.

There is also evidence using the *Urban-Rural Spillover* specification that agglomeration effects are important in determining employment growth as indicated by the positive and significant coefficient estimate for the spatial autoregressive lag variable ($M\Delta E$). This indicates that employment growth in a particular ward spills over to neighbouring wards and has a positive effect on employment. Rural areas experiencing employment growth lead to increased opportunities for neighbouring areas causing employment to increase.

Furthermore, the variables '% of Employment in Construction' and 'Distance to Key Corridor' are both significant, with the expected signs. The positive coefficient for the former indicates that the economic structure at the beginning of the period affects employment growth. This is unsurprising given that the economic conditions during the time period used in the analysis favoured growth in the construction sector. The statistically significant negative coefficient for 'Distance to key corridor' indicates that proximity to key corridors is a driver of employment growth (employment growth is lower the further the distance).

Due to problems in the population equation (discussed below), the *Urban-Rural Spillover* specification is also estimated using a sample in which the most extreme observations are removed. Within this restricted sample 2.5 per cent of the observations in both tails are removed. The estimation results using this sample are shown in Column C of Table 3. As before, the 'Self Population Change', 'Cross Regressive Rural Population Change' and 'Autoregressive Employment Change' variables are significant. However, as indicated by the size of the coefficients their impact on employment change are diminished. Note that the two exogenous variables ('% of Employment in Construction' and 'Distance to Key Corridor') are no longer significant.

Table 2: Employment Change Equation: Basic and Urban-Rural Spillover Models

			Basic Spatial Model Spec. (i) Full Sample Col. A	Urban-Rural Spillover Model Spec. (iii) Full Sample Col. B	Urban-Rural Spillover Model Spec. (iii) 2.5% of Sample at the Tails Removed Col. C
Weighted Population Change	$(I+W)\Delta P$	Coef.	0.19		
		P-value	0.17		
		Elasticity	0.27		
Self Population Change	ΔP	Coef.		0.30	0.21
		P-value		0.00	0.02
		Elasticity		0.61	0.50
Cross Regressive Urban Population Change	$W\Delta P_U$	Coef.		0.01	0.00
		P-value		0.52	0.43
		Elasticity		0.02	0.01
Cross Regressive Rural Population Change	$W\Delta P_R$	Coef.		-0.40	-0.11
		P-value		0.01	0.02
		Elasticity		-0.83	-0.30
Cross Regressive Mixed Population Change	$W\Delta P_M$	Coef.		-0.01	0.00
		P-value		0.70	0.88
		Elasticity		-0.09	0.02
Autoregresive Employment Change	AR ($M\Delta E$)	Coef.	0.14	0.28	0.13
		P-value	0.27	0.00	0.01
% of Employment in Construction	CONST	Coef.	0.15	0.28	0.05
		P-value	0.27	0.00	0.23
Distance to Key Corridor	CORRIDOR	Coef.	0.0000	-0.0001	0.0000
		P-value	0.49	0.07	0.80

Note: Cells shaded red are statistically significant at the 10% level

Population Change

Estimates of the *Basic* and *Urban-Rural Spillover* models for population change [Specifications (ii) and (iv)] are shown in Table 3. Using the basic specification (Spec. (ii), Col. A), the following exogenous variables are statistically significant at the 10 per cent level: '% 25 to 44 Age Group' and 'Distance to Secondary School'. The positive coefficient for the former suggests that wards with a high proportion of people within the young age group attract additional people. On the other hand, the negative coefficient for the latter indicates that people are less attracted to areas the further the distance from a secondary school. This variable may also be capturing the positive impact of amenities provided within an urban area in which schools of this type are present. In addition, the spatially weighted employment change variable is statistically significant and positive, indicating that increases in employment within commuting distance of a particular ward lead to population growth within that ward.

The results reveal a richer story when differential urban-rural spillover effects are allowed for, i.e. specification (iv). Using the full sample (Col. B), employment growth in a particular ward has negative impact on population growth within that ward. In contrast, employment growth in neighbouring urban wards has a positive impact on population growth in rural wards. The negative coefficient for the former is unexpected but may be due to problems associated with congestion or depending on the nature of employment growth the construction of large businesses or factory buildings may reduce the aesthetic value of the location. The variables '% 25 to 44 Age Group' and 'Distance to Secondary School' are again significant. In addition, the variable 'Median Income' is significant, signifying that people are attracted to areas with higher average incomes. Finally, the spatial autoregressive lag variable (MΔP) is not quite significant at the 10 per cent level. However, the positive sign suggests the population growth in a particular ward spills over to neighbouring wards.

In light of the unexpected result concerning employment change the system of equations were re-estimated using a restricted sample in which the extreme observations were eliminated (2.5 per cent of the observations in each tail were removed). In contrast to the full sample, estimation using the restricted sample yields a statistically significant positive coefficient for employment change within the own ward (Col. C). In this case, an increase in employment within the own rural ward leads to an increase in population. This suggests that the negative coefficient in the full sample is driven by extreme observations in which large changes in employment may have undesirable consequences in terms of attracting population. Using this restricted sample, the variables 'Distance to Secondary School' and 'Median Income' are no longer significant, but 'Distance to Key Corridor' is statistically significant and negative (population increases as distance declines). This indicates that accessibility is an important factor in determining regional population growth.

Table 3: Population Change Equation: Basic and Urban-Rural Spillover Models

			Basic Spatial Model Spec. (ii) Full Sample Col. A	Urban-Rural Spillover Model Spec. (iv) Full Sample Col. B	Urban-Rural Spillover Model Spec. (iv) 2.5% of Sample at the Tails Removed Col. C
Weighted Employment Change	(I+W)ΔE	Coef.	0.03		
		P-value	0.02		
		Elasticity	0.64		
Self Employment Change	ΔE	Coef.		-0.42	0.25
		P-value		0.00	0.08
		Elasticity		-0.21	0.11
Cross Regressive Urban Employment Change	$W\Delta E_U$	Coef.		0.02	0.00
		P-value		0.03	0.23
		Elasticity		1.09	0.24
Cross Regressive Rural Employment Change	$W\Delta E_R$	Coef.		-0.11	-0.03
		P-value		0.60	0.37
		Elasticity		-0.08	-0.03
Cross Regressive Mixed Employment Change	$W\Delta E_M$	Coef.		-0.01	0.05
		P-value		0.91	0.14
		Elasticity		-0.04	0.24
Autoregressive Population Change	AR (MΔP)	Coef.	0.08	0.25	0.07
		P-value	0.63	0.11	0.32
% of Ward Agricultural Land	%AG	Coef.	0.06	0.07	0.06
		P-value	0.52	0.57	0.19
% 25 to 44 Age Group	%25TO44	Coef.	1.07	1.41	0.68
		P-value	0.00	0.00	0.00
Distance to Secondary School	SCHOOL	Coef.	-0.00075	-0.00071	-0.00008
		P-value	0.00	0.00	0.36
Median Income	INCOME	Coef.	0.00031	0.00041	-0.00012
		P-value	0.24	0.07	0.14
Distance to Key Corridor	CORRIDOR	Coef.	0.00002	-0.00006	-0.00008
		P-value	0.85	0.37	0.00

Note: Cells shaded red are statistically significant at the 10% level

3.2 Examination of different definitions of rural

Remote Rural and Accessible Rural

The analysis in the previous section implicitly assumes that there are no differences in the drivers for employment and population growth across different rural classifications. Within this section, this assumption is investigated further be firstly estimating separate models for Remote and Accessible Rural regions. Rural wards are sub-divided into Remote Rural or Accessible Rural based on the classification of local government district councils. After deleting missing data, this classification system yields X Remote Rural wards and X Accessible Rural wards.

Focusing initially on employment change, the results for Accessible Rural are shown in Column A, Table 4. These results are largely consistent with those for all rural wards, with statistically significant coefficients for 'Self Population Change', 'Cross Regressive Rural Population Change', 'Autoregressive Population Change', '% of Employment in Construction' and 'Distance to Key Corridor'.

With regards to Remote Rural areas, none of the population change variables are significant at the 10 per cent level within the employment equation using the full sample (Column B, Table 4). In contrast, the autoregressive employment change variable is statistically positive, with a similar coefficient to the all rural sample. The 'Distance to key Corridor Variable' is also significant, with a coefficient twice as large as the Accessible Rural sample. This highlights the importance of proximity to road infrastructure within remote rural regions. When 2.5 per cent of the sample is removed at the tails only the cross-regressive variable is significant, with a positive coefficient.

In terms of the drivers of population change, there is evidence that employment opportunities within commutable urban areas is an important factor within Accessible Rural areas (Col. A, Table 5). Note that 'Distance to Key Corridor' is significant but has a positive coefficient in this sub-sample, indicating that population growth is greater the further the distance from key roads. By definition, all the wards within this sub-sample are relatively accessible and thus the positive sign may be capturing the attractiveness of being located in outlying areas.

The population change equation results for the Remote Rural sub-sample are shown in columns B and C for the full-sample and the restricted sample respectively. Similar to the All Rural sample, the sign of the 'Self Employment Change' variable changes from negative to positive upon switching from the full to restricted sample. Using the restricted sample, the following variables are also significant: 'Cross Regressive Urban Employment Change', 'Autoregressive Population Change', '% of Ward Agricultural Land', '%25 to 44 Age Group', 'Distance to Secondary School' and 'Distance to Key Corridor'. In contrast to the Accessible Rural sample, the latter variable has a negative coefficient.

Care needs to be taken when using sub-samples due to the smaller number of available observations for estimation. Bearing this in mind, the results generally suggest that the employment equation performs better than the population equation for Accessible Rural areas, while the opposite is the case for Remote Rural areas. This can perhaps be attributed to the relatively low levels of employment within Remote Rural areas.

Table 4: Employment Change Equation: Different Definitions of Rural

			Urban-Rural Spillover Spec. (iii) Full Sample Col. A	Urban-Rural Spillover Model Spec. (iii) Full Sample Col. B	Urban-Rural Spillover Model Spec. (iii) 2.5% of Sample at the Tails Removed Col. C	Urban-Rural Spillover Spec. (iii) Full Sample Col. D	Urban-Rural Spillover Model Spec. (iii) 2.5% of Sample at the Tails Col. E
			Accessible Rural	Remote Rural		Rural consisted of F-G settlements only	
Weighted Population Change	$(I+W)\Delta P$	Coef. P-value					
Self Population Change	ΔP	Coef. P-value	0.35 0.00	0.00 1.00	0.04 0.69	0.43 0.00	-0.04 0.60
Cross Regressive Urban Population Change	$W\Delta P_U$	Coef. P-value	-0.02 0.22	0.01 0.51	0.00 0.17	0.00 0.76	0.00 0.60
Cross Regressive Rural Population Change	$W\Delta P_R$	Coef. P-value	-0.16 0.07	-0.22 0.15	0.12 0.05	-0.22 0.10	-0.02 0.69
Cross Regressive Mixed Population Change	$W\Delta P_M$	Coef. P-value	0.00 0.97	-0.03 0.19	0.01 0.26	0.00 0.97	0.02 0.14
Autoregresive Employment Change	AR $(M\Delta E)$	Coef. P-value	0.23 0.01	0.29 0.03	0.00 0.99	0.11 0.38	0.09 0.12
% of Employment in Construction	CONST	Coef. P-value	0.40 0.00	0.13 0.13	0.01 0.66	0.34 0.00	0.09 0.05
Distance to Key Corridor	CORRIDOR	Coef. P-value	-0.0001 0.08	-0.0002 0.00	0.0000 0.88	-0.0002 0.00	0.0000 0.47

Note: Cells shaded red are statistically significant at the 10% level

Table 5: Population Change Equation: Different Definitions of Rural

			Urban-Rural Spillover Spec. (iii) Full Sample Col. A	Urban-Rural Spillover Model Spec. (iii) Full Sample Col. B	Urban-Rural Spillover Model Spec. (iii) 2.5% of Sample at the Tails Removed Col. C	Urban-Rural Spillover Spec. (iii) Full Sample Col. D	Urban-Rural Spillover Model Spec. (iii) 2.5% of Sample at the Tails Col. E
			Accessible Rural	Remote Rural		Rural consisted of F-G settlements only	
Weighted Employment Change	(I+W)ΔE	Coef. P-value					
Self Employment Change	ΔE	Coef. P-value	0.01 0.97	-0.10 0.10	0.35 0.01	-0.38 0.05	0.19 0.32
Cross Regressive Urban Employment Change	$W\Delta E_U$	Coef. P-value	0.02 0.07	0.01 0.28	0.01 0.00	0.01 0.03	0.01 0.00
Cross Regressive Rural Employment Change	$W\Delta E_R$	Coef. P-value	-0.28 0.36	0.14 0.27	-0.03 0.46	-0.12 0.41	-0.11 0.01
Cross Regressive Mixed Employment Change	$W\Delta E_M$	Coef. P-value	-0.21 0.00	0.02 0.74	0.02 0.35	0.01 0.77	-0.01 0.65
Autoregressive Population Change	AR (MΔP)	Coef. P-value	0.30 0.01	0.18 0.16	0.11 0.01	-0.04 0.64	0.02 0.75
% of Ward Agricultural Land	%AG	Coef. P-value	-0.45 0.40	0.21 0.00	0.06 0.05	0.04 0.71	-0.01 0.76
% 25 to 44 Age Group	%25TO44	Coef. P-value	-0.13 0.54	0.80 0.00	0.62 0.00	1.17 0.00	0.57 0.00
Distance to Secondary School	SCHOOL	Coef. P-value	-0.00023 0.45	-0.00042 0.00	-0.00019 0.00	-0.00079 0.00	-0.00019 0.07
Median Income	INCOME	Coef. P-value	-0.00004 0.92	-0.00007 0.66	-0.00009 0.13	0.00039 0.18	0.00008 0.44
Distance to Key Corridor	CORRIDOR	Coef. P-value	0.00044 0.01	-0.00005 0.39	-0.00008 0.00	-0.00015 0.10	-0.00015 0.00

Note: Cells shaded red are statistically significant at the 10% level

Alternative Definition of Rural

The robustness of the results are further explored using an alternative definition of rural. Within the main analysis (Section 3.1), which employs the 'the Inter-Departmental Urban-Rural Definition Group' definition of rural, the 212 (306) rural (urban) wards are not rural (urban) to the same extent. Some of the rural (urban) wards include urban (rural) settlements while others are purely rural (urban). The number of purely rural (urban) wards is 168 (124); these are wards with exclusively rural (urban) settlements. Supplementary analysis is undertaken in which we reclassify the wards based on this concept; i.e. the 582 wards are classified as (purely) rural, (purely) urban and mixed, with the latter being ones with both types of settlements regardless of the mixture of the types.

The estimation results for employment change using the alternative definition of rural for the full sample are shown in Column D, Table 4. Similar to the main analysis there is evidence that population growth within the own ward has a positive impact on employment but that population growth within neighbouring wards has a depressing impact. The exogenous variables '% of Employment in Construction' and 'Distance to key Corridor Variable' are both statistically significant, with the latter yielding a larger coefficient compared to the main analysis. Fewer variables are significant upon using the restricted sample (Col. E, Table 4).

With regards to the population change equation, the following discussion refers to the restricted sample (Col. E, Table 5) as the full sample (Col. D) yields a negative coefficient for 'Self Employment Change'. The coefficients for the cross-regressive *urban* and *rural* employment change variables differ, exerting a positive and negative impact on employment change respectively. This suggests that the linkages to urban settlements in terms of employment opportunities are more important in determining location choices within rural wards than employment opportunities in other rural wards. Similar to the Remote Rural sub-sample the following exogenous variables are significant: '%25 to 44 Age Group', 'Distance to Secondary School' and 'Distance to Key Corridor'. However, as indicated by the size of the coefficient, accessibility is more important in this sub-sample.

3.3 Different Age-Group Subsamples

Population is disaggregated into different age-group components to determine whether the impact of underlying explanatory factors for population growth vary according to these groupings. Gaining a better understanding of how various age groups respond to different drivers will provide a richer evidence base and enable strategies for economic development to be tailored to specific population dynamics (Hailu and Abdulla, 2010). The disaggregation in this study is based on the Small Area Population Estimates provided by NISRA. This source sub-divides population into the following age groupings: 0-15, 16-39, 40-59/64 and 60/65+. The first source is not considered as this population segment is below the working age. The latter group refers to 60+ for females and 65+ for males.

Estimation results for the employment change equation are provided in Table 6. Within this equation we are specifically interested in how population change for different age groups influences employment growth within rural areas. It is apparent from Table 6 that an increase in population within the own ward in the 16-39 and 40-59/64 age groups leads to a rise in employment. This implies that the attraction of individuals within these age groups stimulates employment growth. The beneficial impact is largest for the younger age group. In contrast, the variable 'Self Employment Change' is not significant for the older age group. This is unsurprising as this age group is largely comprised of retirees and thus the supply of labour is not a driving factor in this case.

The principal interest is in the underlying drivers of population change for different age groupings, as revealed by the coefficients of the explanatory variables within the population equation (Table 7). The results show that employment opportunities, as captured by the change in employment variables, are particularly important for the 16-39 age group (at least for the restricted sample). This perhaps reflects the mobility of this younger age group, which means that individuals are more prepared to change job locations in response to improved employment prospects. The results concerning the employment change variables are more mixed for the other age groups, suggesting that employment opportunities are less important in determining their location choices.

In terms of the exogenous variables, the variable '% of Ward Agriculture Land' exhibits the opposite sign for the 40-59/64 (positive for the restricted sample) and 60+ (negative for both samples) age groups. This variable is perhaps acting as a proxy for the environmental attractiveness of a region, with individuals within the 40-59/64 age group attracted to more open space. On the other hand, retirees within the 60+ age group may have preferences for the convenience of amenities provided in nearby urban areas. Similarly, the variable 'Median Income' exerts differing effects within the 16-39 and 40-59/64 age groups. The negative effect in the former may be a reflection of affordability issues for younger segments of the population, while individuals within the latter age group may be attracted to areas with higher average incomes as it is an indication of the prosperity of an area and signify low social problems.

It is not straightforward to draw exact conclusions due to the smaller number of observations within age group subsamples. Nevertheless, the results support the view that age groups respond differently to underlying drivers of population change and therefore the need for focused strategies to attract and retain population and stimulate economic development.

Table 6: Employment Change Equation: Different Age-Group Subsamples

			Main Analysis (All)		16 to 39 years		40 to 59/64 years		60/65+	
			Urban-Rural Spillover Model Spec. (iii)	Urban-Rural Spillover Model Spec. (iii)	Urban-Rural Spillover Model Spec. (iii)	Urban-Rural Spillover Model Spec. (iii)	Urban-Rural Spillover Model Spec. (iii)	Urban-Rural Spillover Model Spec. (iii)	Urban-Rural Spillover Model Spec. (iii)	Urban-Rural Spillover Model Spec. (iii)
			Full Sample	2.5% of Sample at the Tails Removed	Full Sample	2.5% of Sample at the Tails Removed	Full Sample	2.5% of Sample at the Tails Removed	Full Sample	2.5% of Sample at the Tails Removed
			Col. A	Col. B	Col. C	Col. D	Col. E	Col. F	Col. G	Col. H
Self Population Change	ΔP	Coef.	0.30	0.21	0.76	0.41	0.52	0.37	-0.49	0.43
		P-value	0.00	0.02	0.00	0.06	0.00	0.03	0.17	0.41
Cross Regressive Urban Population Change	$W\Delta P_U$	Coef.	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.00
		P-value	0.52	0.43	0.78	0.88	0.93	0.41	0.53	0.89
Cross Regressive Rural Population Change	$W\Delta P_R$	Coef.	-0.40	-0.11	0.22	0.09	-0.64	-0.38	-0.27	-0.43
		P-value	0.01	0.02	0.42	0.41	0.01	0.00	0.18	0.01
Cross Regressive Mixed Population Change	$W\Delta P_M$	Coef.	-0.01	0.00	-0.07	0.00	-0.14	-0.02	-0.18	0.02
		P-value	0.70	0.88	0.15	0.98	0.07	0.55	0.12	0.74
Autoregresive Employment Change	AR ($M\Delta E$)	Coef.	0.28	0.13	0.10	0.04	0.34	0.14	0.25	0.13
		P-value	0.00	0.01	0.15	0.29	0.00	0.00	0.01	0.00
% of Employment in Construction	CONST	Coef.	0.28	0.05	0.17	0.02	0.25	0.04	0.21	0.06
		P-value	0.00	0.23	0.06	0.70	0.00	0.31	0.02	0.30
Distance to Key Corridor	CORRIDOR	Coef.	-0.0001	0.0000	-0.0001	0.0000	-0.0001	0.0000	0.0000	0.0000
		P-value	0.07	0.80	0.03	0.73	0.03	0.97	0.42	0.87

Note: Cells shaded red are statistically significant at the 10% level

Table 7: Population Change Equation: Different Age-Group Subsamples

			Main Analysis (All)		16 to 39 years		40 to 59/64 years		60/65+	
			Urban-Rural Spillover Model Spec. (iv) Full Sample	Urban-Rural Spillover Model Spec. (iv) 2.5% of Sample at the Tails Removed	Urban-Rural Spillover Model Spec. (iv) Full Sample	Urban-Rural Spillover Model Spec. (iv) 2.5% of Sample at the Tails Removed	Urban-Rural Spillover Model Spec. (iv) Full Sample	Urban-Rural Spillover Model Spec. (iv) 2.5% of Sample at the Tails Removed	Urban-Rural Spillover Model Spec. (iv) Full Sample	Urban-Rural Spillover Model Spec. (iv) 2.5% of Sample at the Tails Removed
			Col. A	Col. B	Col. C	Col. D	Col. E	Col. F	Col. G	Col. H
Self Employment Change	ΔE	Coef.	-0.42	0.25	0.09	0.24	0.02	-0.03	-0.14	0.11
		P-value	0.00	0.08	0.33	0.00	0.67	0.68	0.00	0.01
Cross Regressive Urban Employment Change	$W\Delta E_U$	Coef.	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00
		P-value	0.03	0.23	0.81	0.51	0.03	0.85	0.01	0.00
Cross Regressive Rural Employment Change	$W\Delta E_R$	Coef.	-0.11	-0.03	0.13	0.06	-0.13	0.03	0.02	-0.05
		P-value	0.60	0.37	0.28	0.01	0.06	0.23	0.55	0.00
Cross Regressive Mixed Employment Change	$W\Delta E_M$	Coef.	-0.01	0.05	0.10	0.05	0.01	0.03	-0.03	-0.03
		P-value	0.91	0.14	0.11	0.01	0.63	0.01	0.02	0.00
Autoregressive Population Change	AR (MΔP)	Coef.	0.25	0.07	-0.02	0.07	-0.06	0.05	-0.27	-0.19
		P-value	0.11	0.32	0.90	0.09	0.72	0.60	0.02	0.00
% of Ward Agricultural Land	%AG	Coef.	0.07	0.06	0.06	0.03	0.00	0.04	-0.03	-0.04
		P-value	0.57	0.19	0.48	0.16	0.95	0.05	0.08	0.03
% 25 to 44 Age Group	%25TO44	Coef.	1.41	0.68	0.24	0.12	0.82	0.55	0.15	0.11
		P-value	0.00	0.00	0.12	0.06	0.00	0.00	0.02	0.00
Distance to Secondary School	SCHOOL	Coef.	-0.00071	-0.00008	-0.00016	-0.00003	-0.00020	0.00001	-0.00002	-0.00002
		P-value	0.00	0.36	0.26	0.53	0.03	0.72	0.64	0.57
Median Income	INCOME	Coef.	0.00041	-0.00012	-0.00006	-0.00009	0.00017	0.00009	0.00006	0.00003
		P-value	0.07	0.14	0.70	0.10	0.08	0.05	0.22	0.39
Distance to Key Corridor	CORRIDOR	Coef.	-0.00006	-0.00008	-0.00005	0.00000	-0.00001	0.00001	0.00002	0.00001
		P-value	0.37	0.00	0.35	0.84	0.79	0.32	0.25	0.49

Note: Cells shaded red are statistically significant at the 10% level

4. Simulations

4.1 Simulation Methodology

Simulations are implemented based on the urban-rural spillover model. Three broad types of scenarios are investigated, including upgrading of existing roads, changes in public service provision (exemplified by closing down of a secondary school) and changes in employment and population in urban wards in certain regions. All of these scenarios are relevant from a policy perspective. The first two refer to policies that directly target rural areas, while the latter captures the knock on impacts of policies targeted at urban areas.

To begin with, the procedure of setting up the simulation is explained using the example of upgrading A29. Firstly, it is convenient to repeat the urban-rural spill over model.

$$\text{(iii)} \quad \Delta E = \alpha_E + \beta_{1E}E_{t-1} + \gamma_{1E}{}'\Delta P + \gamma_{2E}W_U\Delta P_U + \gamma_{3E}W_M\Delta P_M + \gamma_{4E}W_R\Delta P_R + \Sigma\delta_{iE}\Omega^E + \eta_{1E}M\Delta E + \mu$$

$$\text{(iv)} \quad \Delta P = \alpha_P + \beta_{1P}P_{t-1} + \gamma_{1P}{}'\Delta E + \gamma_{2P}W_U\Delta E_U + \gamma_{3P}W_M\Delta E_M + \gamma_{4P}W_R\Delta E_R + \Sigma\delta_{iP}\Omega^P + \eta_{1P}M\Delta P + \varepsilon$$

Re-arrange the model as:

$$\text{(v)} \quad (I- \eta_{1E}M)\Delta E = \alpha_E + \beta_{1E}E_{t-1} + \gamma_{1E}{}'\Delta P + \gamma_{2E}W_U\Delta P_U + \gamma_{3E}W_M\Delta P_M + \gamma_{4E}W_R\Delta P_R + \Sigma\delta_{iE}\Omega^E + \mu$$

$$\text{(vi)} \quad (I- \eta_{1P}M)\Delta P = \alpha_P + \beta_{1P}P_{t-1} + \gamma_{1P}{}'\Delta E + \gamma_{2P}W_U\Delta E_U + \gamma_{3P}W_M\Delta E_M + \gamma_{4P}W_R\Delta E_R + \Sigma\delta_{iP}\Omega^P + \varepsilon$$

Multiply both sides by the inverse matrices of $(I- \eta_{1E}M)$ for Equation (v) and $(I- \eta_{1E}M)$ for Equation (vi):

$$\text{(vii)} \quad \Delta E = (I- \eta_{1E}M)^{-1}[\alpha_E + \beta_{1E}E_{t-1} + \gamma_{1E}{}'\Delta P + \gamma_{2E}W_U\Delta P_U + \gamma_{3E}W_M\Delta P_M + \gamma_{4E}W_R\Delta P_R + \Sigma\delta_{iE}\Omega^E + \mu]$$

$$\text{(viii)} \quad \Delta P = (I- \eta_{1P}M)^{-1}[\alpha_P + \beta_{1P}P_{t-1} + \gamma_{1P}{}'\Delta E + \gamma_{2P}W_U\Delta E_U + \gamma_{3P}W_M\Delta E_M + \gamma_{4P}W_R\Delta E_R + \Sigma\delta_{iP}\Omega^P + \varepsilon].$$

Estimates from the model using the restricted sample with 2.5% at both tails removed are used to parameterise the model.[5] Calibration is implemented by setting the error terms μ and ε at levels such that ΔE **and** ΔP replicate the observed data. It should be noted that since the estimates are based on rural wards, the simulations focus on rural wards only and regard urban/mixed wards as exogenous. Some policies may benefit rural and non-rural areas at the same time, e.g. upgrading of the road network. We acknowledge that our simulation results tend to underestimate the benefits of such policies. As a partial remedy, a combined scenario of upgrading road network and employment increase in urban areas is presented at the end.

After calibration, the exogenous variables representing the shocks (e.g. the distance to key corridor variable in the case of upgrading roads) are recalculated. These lead to a new set

[5] Note: for the distance matrix M in Equations (vii) and (viii), a threshold of 20 kilometres is imposed. This means if the distance of two wards *i* and *j* is greater than 20 kilometres, they are not considered as "neighbours" and the elements m_{ij} and m_{ji} in the matrix M are set to zero. This implies the spillover effect from the autoregressive term is restricted to within 20 kilometres (no restriction for the effect from the cross regressive term as long as there is existing commuting). The 20 kilometre threshold is chosen based on the average commuting distance in Northern Ireland.

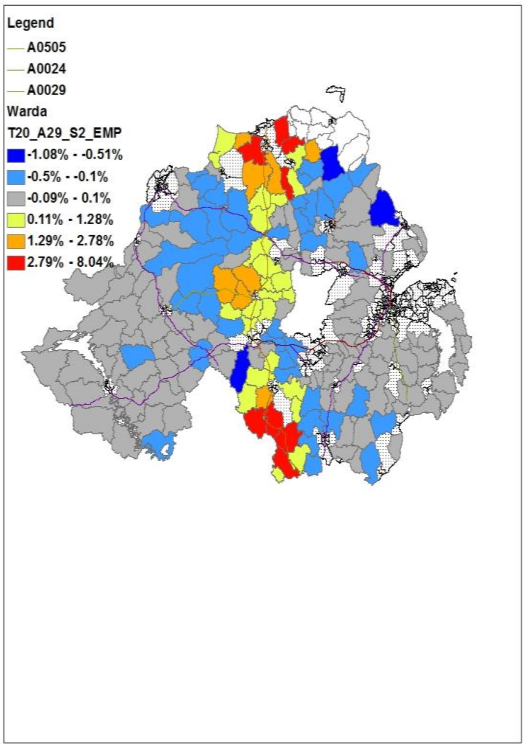
of ΔP and $W_R \Delta P_R$ (and/ or ΔE and $W_R \Delta E_R$) values, which are then fed into the employment (and/or population) equations, i.e. Equation (vii) and/or (viii). The iterative updating and feeding ΔP and $W_R \Delta P_R$ (and/ or ΔE and $W_R \Delta E_R$) values to the equations are carried out until convergence is reached. This iterative procedure allows for the full feedback effects between the two equations to be fully captured. Upon obtaining the new ΔP and ΔE in the scenarios, E_{2007} and P_{2007} in the scenarios are calculated and compared to the data (called baseline in what follows). Differences in percentage between the scenarios and baseline are presented in the form of maps. The colour red and blue are used to represent increase and decrease respectively and grey for changes close to zero.

4.2 Upgrading existing roads to key corridor: A29, A24, A505

Figures 5, 6 and 7 present the simulated employment and population changes resulting from the upgrading of different existing roads to equivalent level of quality as key corridors, namely the A29, A24 and A505. The A29 runs from Portrush to the Louth border, the A24 from Belfast to Clough and the A505 from Omagh to Cookstown. Generally, population shows greater increases than employment in most cases. This is consistent with the regression model estimates in which accessibility have a much greater impact on population than on employment. Employment growth is driven by internal population growth. Wards benefiting from the upgrading trace out the route of the roads. Moreover, wards that experience the most improvement in distance to key corridor show the largest increases both in population and employment. In the case of A29 and A24, these are wards located at the end(s) of the roads and the largest increases for employment are 8.04 and 3.79 per cent respectively and for population 6.34 and 4.74 per cent. In the case of A505, these are wards in the middle of the road and the largest increases for employment and population are 4.95 and 7.06 per cent.

However, the upgrading causes certain wards to experience decreases in population and employment. These are wards that do not directly see improvements in their distances to key corridor but are close to the beneficiaries. It should be noted that close is defined in the sense of commuting, *i.e.* heavy commuting flows as captured by the commuting matrix. Therefore, although most of the “blue” wards are geographically close to the “red” wards, a few of them are far away in geographical terms.

Figure 5: **Simulated employment and population changes resulting from upgrading A29 (Left: employment; Right, population)**



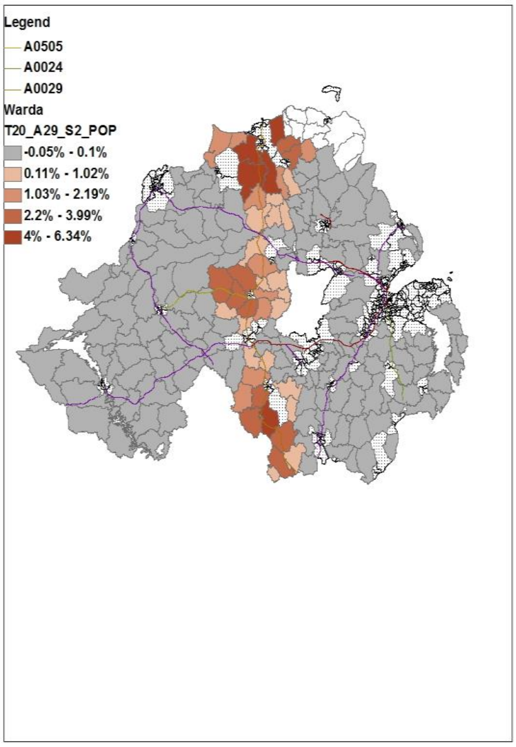
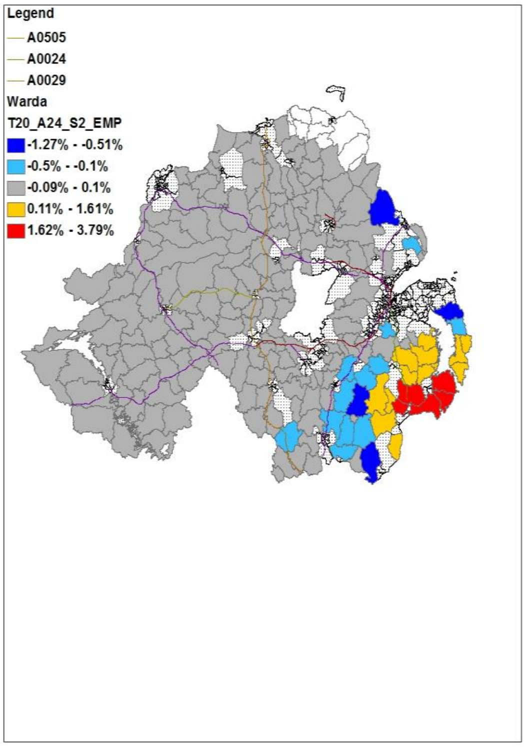


Figure 6: **Simulated employment and population changes resulting from upgrading A24 (Left: employment; Right, population)**



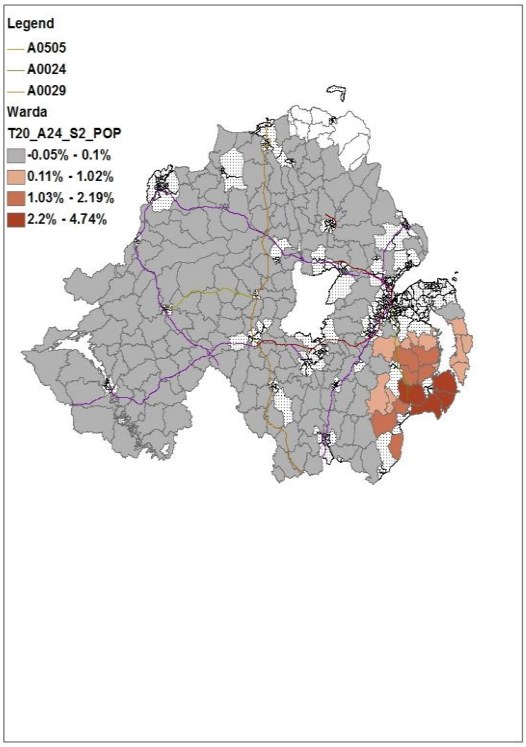
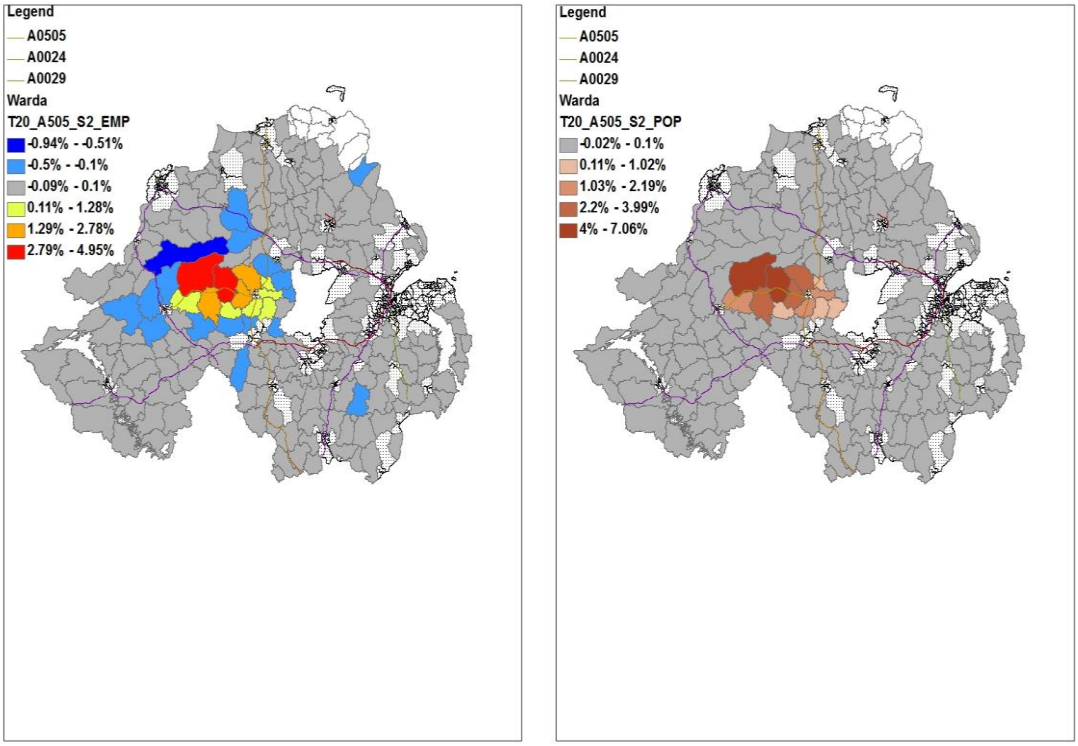


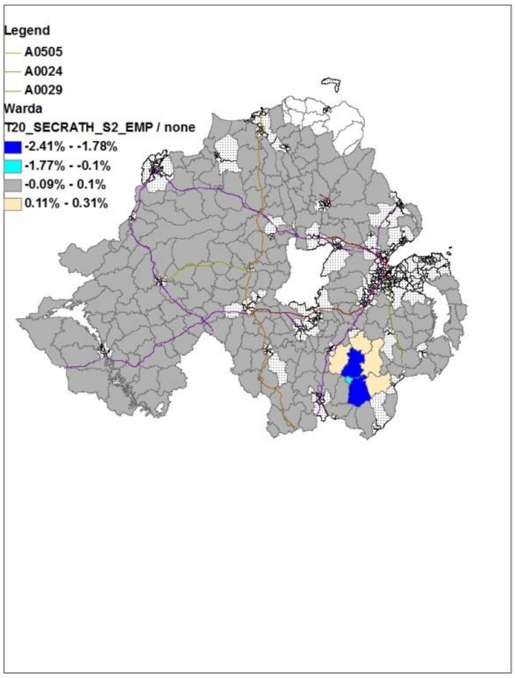
Figure 7: **Simulated employment and population changes resulting from upgrading A505 (Left: employment; Right, population)**

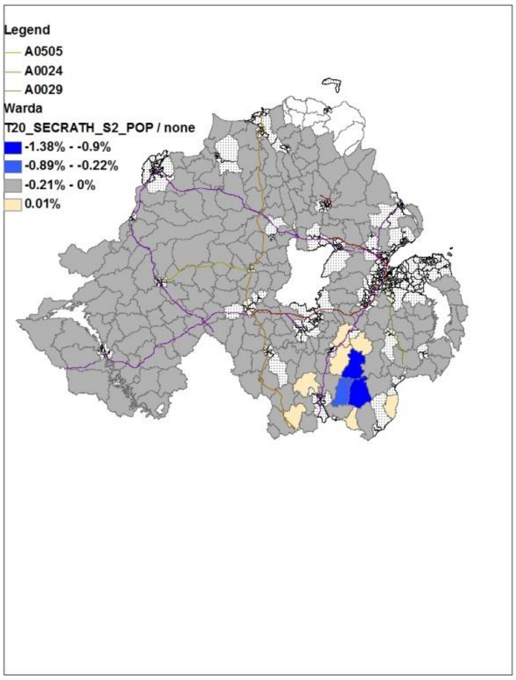


4.3 Change in public service provision

Figure 8 presents the simulated employment and population changes resulting from the closure of the existing secondary school in Rathfriland. It is important to stress that this scenario is purely hypothetical and Rathfriland is chosen as an example within a largely rural area and in no way reflects proposed changes. The closure of the secondary school leads to decreases in both population and employment in the surrounding area. The closure of a service such as a secondary school may be accompanied by the disappearance of other amenities. This scenario should be regarded as an example of reducing public service provision plus other amenities in specific areas since our model is not able to capture and distinguish the impacts of different public service provision due to the multicollinearity issue as indicated in our discussion of the estimation results.

Figure 8: Simulated employment and population changes resulting from closure of secondary school in Rathfriland (Left: employment; Right, population)





4.4 Employment/population changes in urban wards: example of Omagh

4.4.1: 2 per cent increase/ decrease in employment in urban wards in Omagh

Figures 9 and 10 present the simulated employment and population changes resulting from a 2 per cent increase/decrease in employment in urban wards in Omagh. Although the impacts of increase and decrease may be different in reality, they are not distinguished in our model (or in other words, the positive and negative shocks are assumed to have symmetric impacts). It is, therefore, expected that the changes in absolute value are the same in both directions following the exogenous shock.

Since densities of employment are generally higher in urban wards than in rural wards, a 2 per cent change results in larger increases/decreases in employment (maximum 7.9 per cent) in rural wards. These larger increases/decreases are contributed both directly (by the autoregressive term) and indirectly (by the cross regressive term, in which population in rural wards increases/decreases first and further drives employment to change). Population in rural wards also show modest increases/decreases (maximum 0.74 per cent).

Furthermore, the maps show a spatial diffusion process. Rural wards that are immediate neighbours to urban wards generally benefit the most from an increase in employment in Omagh and as the distance from the urban wards increases the impacts of the shock diminish. Wards that are further away from the urban wards of Omagh but still have residents commuting to Omagh may experience loss from the positive shocks, albeit very limited. This is due to the competition relationship imbedded in the modelling system.

Figure 9: **Simulated employment and population changes resulting from 2 per cent increase in employment in urban wards in Omagh (Left: employment; Right, population)**

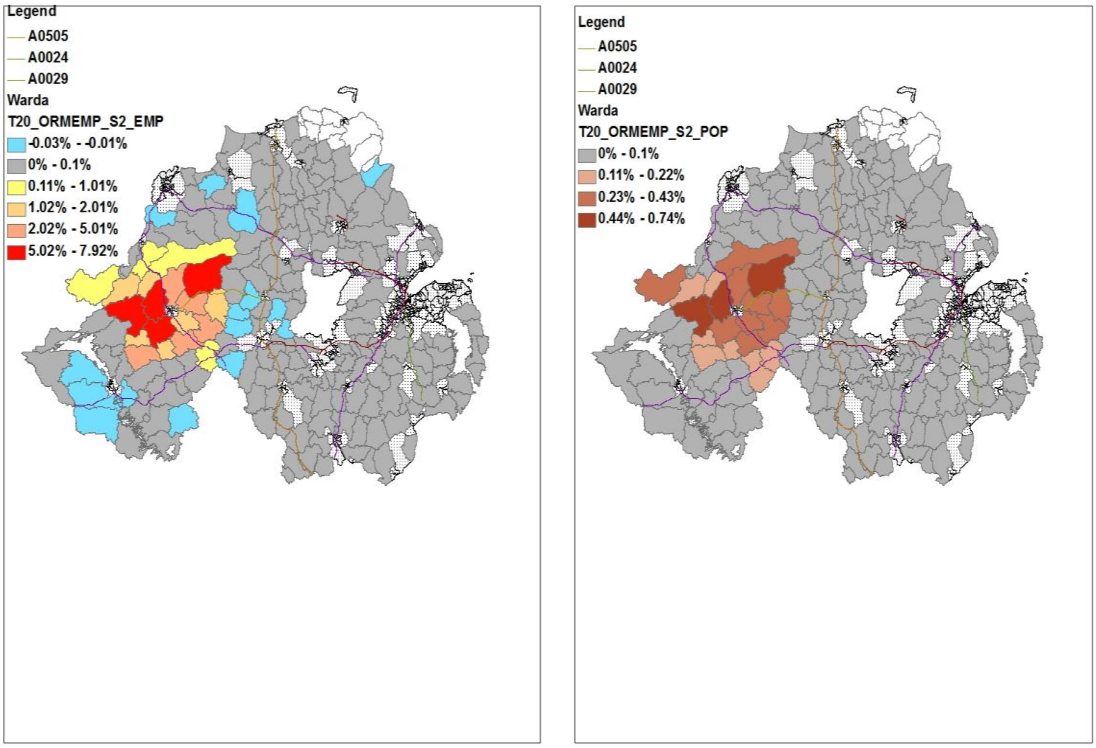
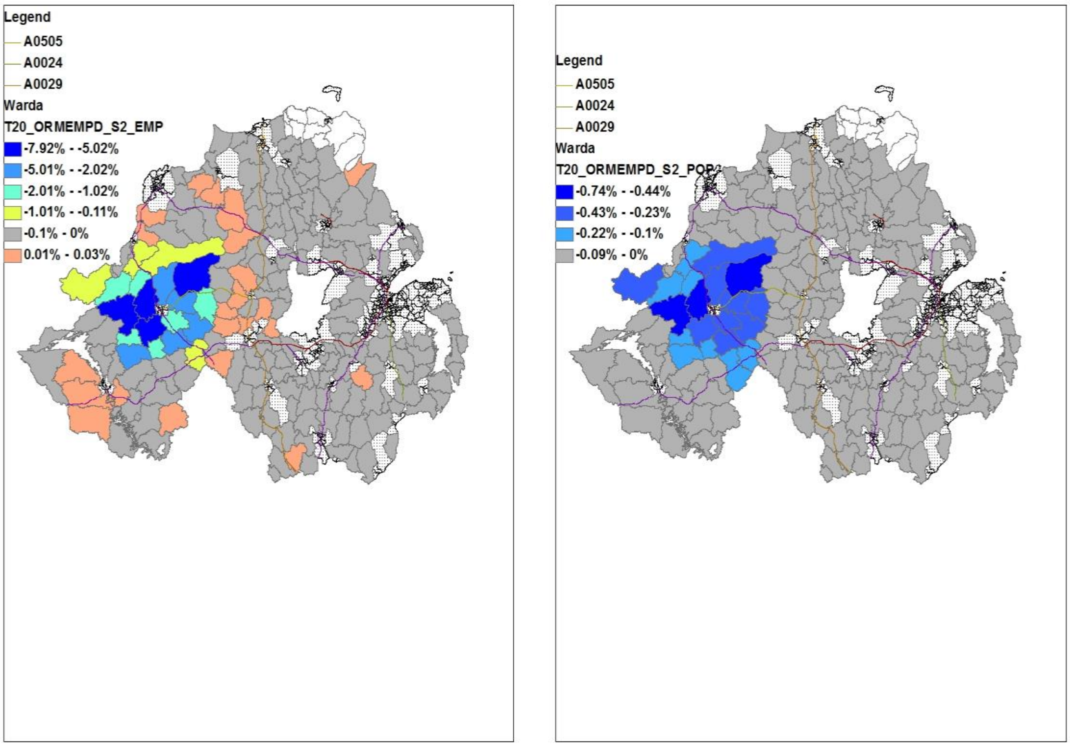


Figure 10 Simulated employment and population changes resulting from 2 per cent decrease in employment in urban wards in Omagh (Left: employment; Right, population)



4.4.2: 2 per cent increase/ decrease in population in urban wards in Omagh

Figures 11 and 12 present the simulated employment and population changes resulting from a 2 per cent increase/decrease in population in urban wards in Omagh. Again due to the assumed symmetry in the impacts of positive and negative shocks, the changes in absolute value are the same in both directions following the exogenous shock.

It should be noted that the 2 per cent shocks in population and in employment are different in magnitude as the levels of population and employment are different. Caution is required when comparing the results of the two subsections. Compared to the employment shocks in the previous scenario, employment increases/decreases are smaller (the greatest increase/decrease in employment is 5.51 per cent) but more widespread in this scenario. This is because population and employment are linked by the commuting matrix in which specific elements for wards more than 20 kilometres apart will be positive if there exists commuting between them. This is not uncommon as 20 kilometre is the average commuting distance. The implication is that when population declines in urban wards both demand for final goods & services and labour supply decrease and this in turn affects business location decisions in all rural wards within the commuting shed.

There is hardly any spillover effect in population. Population changes in rural wards are mainly driven by employment changes. Therefore, extents of population changes are limited.

The two subscenarios together suggest that employment is the key variable for changes in urban wards to trickle down to rural wards. Moreover, if this scenario is compared to the scenarios of upgrading existing roads, increases in these scenarios are different in nature: the former is a result of “knock on” impacts while the latter is driven by internal factors; nevertheless, the extent of the greatest increases in percentage in employment are comparable. Although the differences in the nature of scenarios make the comparison at best coarse, this indicates the importance of indigenous growth forces.

Figure 11: Simulated employment and population changes resulting from 2 per cent increase in population in urban wards in Omagh (Left: employment; Right, population)

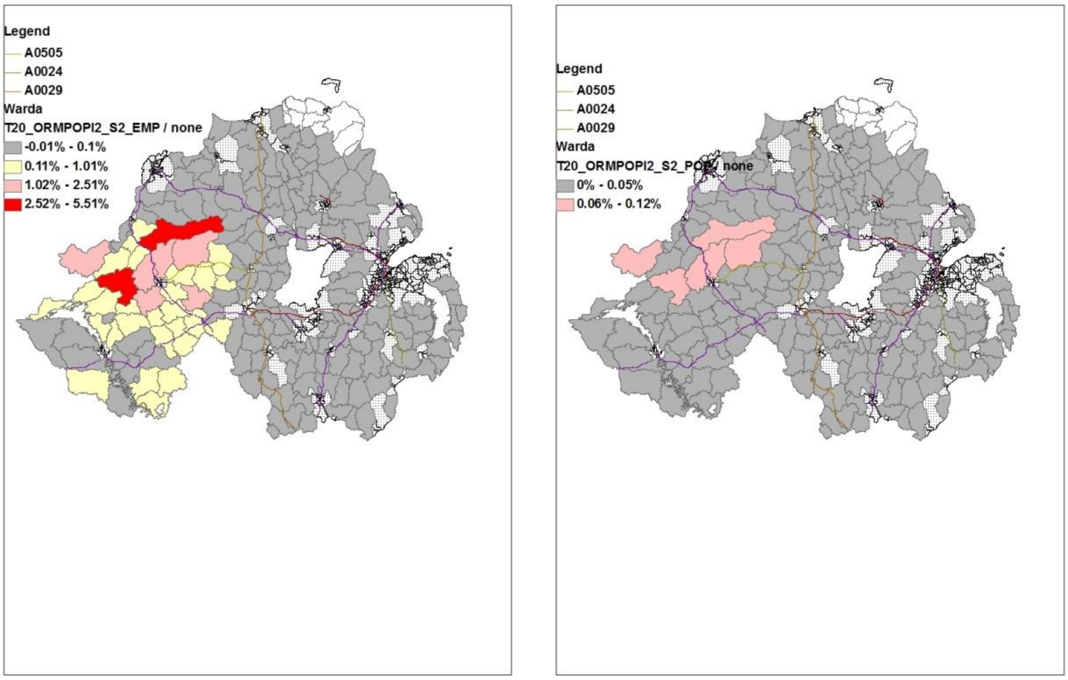
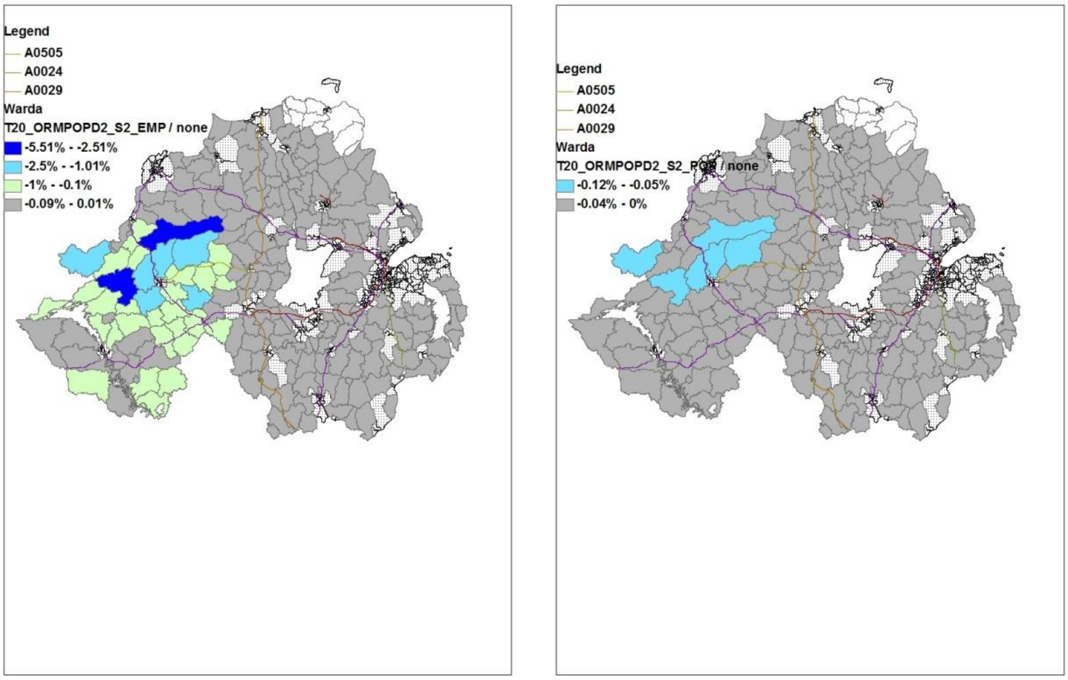


Figure 12: Simulated employment and population changes resulting from 2 per cent decrease in population in urban wards in Omagh (Left: employment; Right, population)

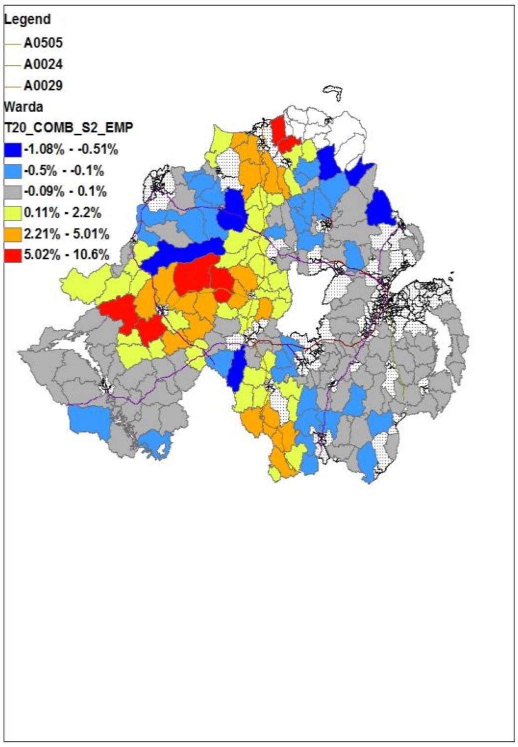


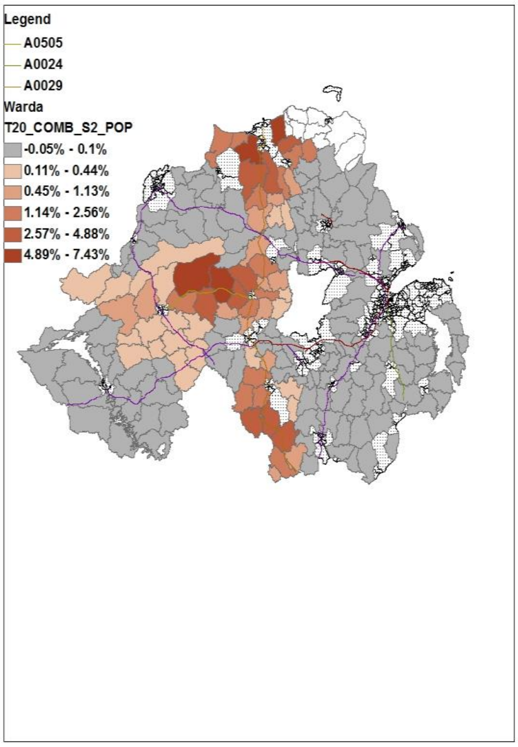
4.5 Combined Scenario

Figure 13 presents the simulated employment and population changes of a combined scenario in which A29 and A505 is upgraded at the same time plus 2 per cent increases in employment in urban wards of both Omagh and Cookstown. Employment growth in some wards are as much as three or four times as those in the separate scenarios, while population growth may reach 50 per cent higher. Again, there are a few "blue" wards that may lose out due to competition effects.

It should be noted that the upgrading of roads and the employment growth in urban wards are combined in an ad hoc way as the impacts of improvement of accessibility on employment and population in urban areas are not investigated and therefore upgrading the roads may lead to a greater or a smaller increase than 2 per cent. Furthermore, our results will underestimate the changes if there are interactions between upgrading the two roads and between upgrading the roads and urban growth.

Figure 13: **Simulated employment and population changes of combined scenario (Left: employment; Right, population)**





5. Conclusions

The results in this paper indicate that employment and population growth in Northern Ireland are interdependent. The finding that (i) population change influences employment growth and (ii) employment change affects population growth, indicates that 'jobs are drawn to locations that appeal to personal preference' (jobs follow people), in addition to the better known process of 'people are drawn to locations that offer economic opportunities' (people following jobs). Moreover, as revealed by results based on fine spatial scale (wards in our case), people balance job opportunities and amenities for life. Generally, population grows with employment. However, employment growth may not necessarily result in population growth in the same ward as people may trade off more commuting for a desirable living environment. Or in other words, factors beyond employment opportunities (amenities, accessibility etc.) are valued in household location decisions. From a policy perspective this suggests that rural development strategies should not only focus on creation of work schemes, but should also strive to make rural places desirable places to live. Policies that help to retain or attract people will encourage employment to follow.

The sustainability of rural development polices should be assessed in terms of the knock-on impact of economic growth to ensure that they do not undermine the desirability of rural areas as places to live. Rural development policies designed to directly stimulate employment growth should be carefully balanced so as to consider the implications on population growth.

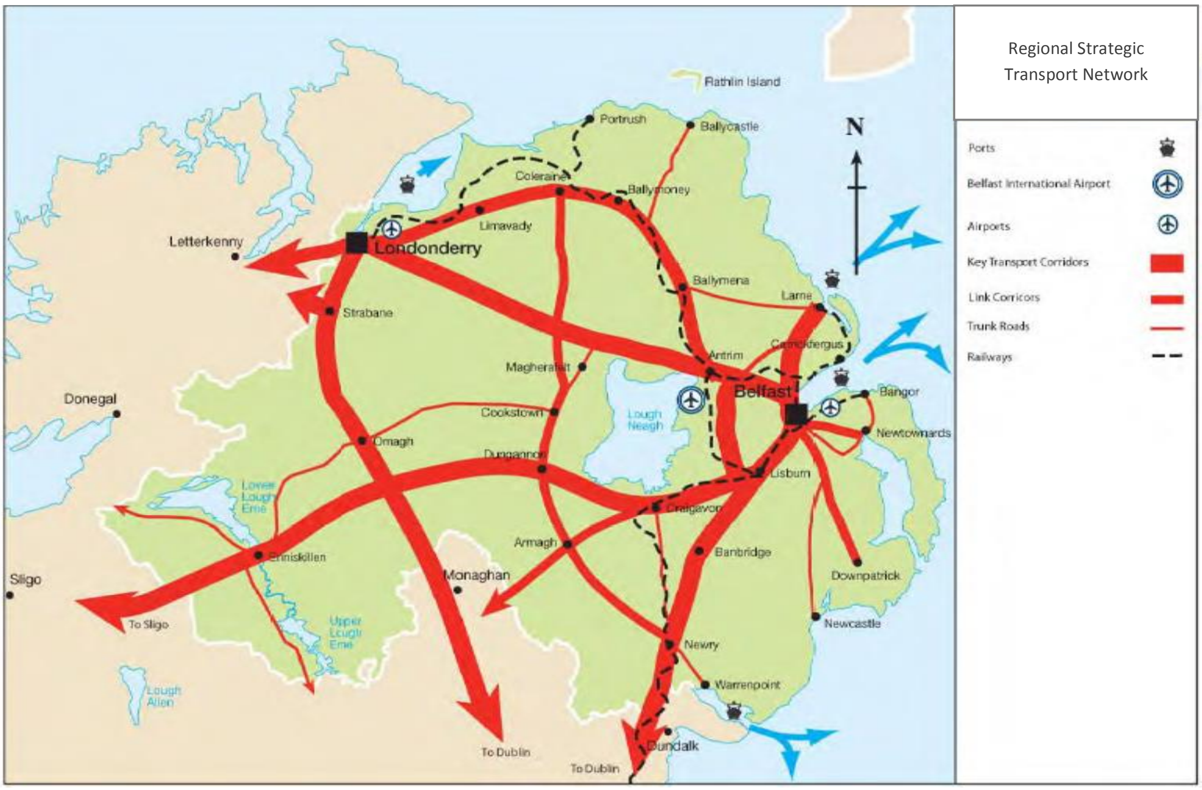
In addition, the finding of spatial spillover effects means that changes in economic growth in one region has knock-on impacts on neighbouring regions. This implies that rural development policies should not focus on small localised regions but should cover a wider area and take into consideration the regional connectivity of places.

The research also sheds light on the linkages between urban and rural areas. The success of rural areas partly depends on the economic growth potential of urban areas that are within commuting distance. This suggests that rural development policies should not just target rural areas, but should also aim to strengthen urban-rural linkages. Moreover, government policies should be co-ordinated across departments to ensure rural development policies are integrated within the wider regional policy agenda.

References

- Adelaja S., Hailu Y.G. and Abdulla M. (2009) "Chasing Our Past or Investing in the Future." Land Policy Institute at Michigan State University, New Economy Report Series, Report number LPR-2009-NE-04, 20 May 2009.
- Boarnet M.G. (1994) "An Empirical Model of Intra-metropolitan Population and Employment Growth." *Papers in Regional Science*, 73 (April): 135-153.
- Deller, S. C., T. Tsai, D. W. Marcouiller, and D. B.K. English. (2001) "The Role of Amenities and Quality of Life in Rural Economic Growth." A*merican Journal of Agricultural Economics*, 83(2), 352-365.
- Department of Regional Development (2001). "Shaping our future: Regional Development Strategy 2025." Available at: http://www.drdni.gov.uk/publications-details.htm?docid=308
- Fesser Edward and Isserman Andrew M. (2006). "Harnessing Growth Spillovers for Rural Development: The Effects of Regional Spatial Structure." University of Illinois report prepared for the USDA Rural Development.
- Hailu Y.G. and Abdulla M. (2010) "Talent-Laden Population Dynamics, Spillovers and Economic Impacts: Implications to Population and Talent Attraction Strategies". http://www.kc.frb.org/eventinfo/community/hailu-paper.pdf
- Henry M.S., Scmitt B., Kristensen K, Barkley D. and Bao S. (1999). "Extending Carlino-Mills Models to Examine Urban Size and Growth Impacts on Proximate Rural Areas. *Growth and Change*, Vol. 30 (Fall I999), pp, 524-5423.
- NISRA (2005) Report of the Inter-Departmental Urban-Rural Definition Group. Available at: http://www.nisra.gov.uk/archive/demography/publications/urban_rural/ur_report.pdf
- Patton M. (2012). "Growth Equilibrium Models: A Review of the Theoretical and Empirical Literature." AFBI working paper submitted to DARD March 2012.
- Rey S.J. and M.G. Boarnet (2004). "A Taxonomy of Spatial Econometric Models for Simultaneous Equations Systems". In L. Anselin, R.J.G.M. Florax and S.J. Rey, (eds.), Advances in Spatial Econometrics: methodology, Tools and Applications, Berlin: Springer.

Appendix : Key Transport Corridors



Source: Department of Regional Development (2001).