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Growth Equilibrium Models: A Review of the Theoretical and Empirical Literature

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Executive Summary

Growth equilibrium models have been widely applied to explore the drivers and impediments of regional population and employment growth. This modelling framework is based on the premise that people are not only drawn to locations that offer economic opportunities, but jobs are also drawn to locations that appeal to personal preference. The modelling framework provides a means to quantify the extent to which people follow jobs or jobs follow people. Furthermore, by allowing for interdependencies between population and employment growth, growth equilibrium models yield unbiased estimates for other explanatory variables which are of policy interest.

The basic modelling system has been extended in a variety of ways to allow for more detailed policy questions to be explored. Of particular interest is the sub-division of population into different age-group components. Sub-dividing population in this manner provides a means to examine what motivates people of different age categories to move, which segments of the population should be targeted to move to a region and how should regional development policies be adapted to ensure economic prosperity. Moreover, recent model developments have allowed for spatial spill-over effects in which population change is not only dependent upon the change in employment within the region in question but also within the commuting range of that region. In addition to the two-way relationship between population and employment growth a wide range of explanatory factors have been explored, covering demographic, housing market, socio-economic, education, government, grey infrastructure, amenities and economic structure. The impact of these factors varies across studies and in order to gain an insight into their contribution in Northern Ireland it is necessary to test for these factors empirically.

Growth Equilibrium Models: A Review of the Theoretical and Empirical Literature

1) Introduction

The rural economy in Northern Ireland has experienced widespread changes in recent years. Employment within traditional sectors such as manufacturing and agriculture has declined in recent years, while the number of people employed within the service and construction sectors (up until the recession in 2008) have increased[1]. Concurrently, the rural population has expanded[2], partly due to counter-urbanisation with the net migration of people from large urban areas to small towns, villages and the open countryside. Moreover, it is evident that there are considerable spatial disparities in terms of employment and population changes within the rural economy. While some rural economies have waned, others have displayed strong economic growth, which presents challenges in terms of provision of adequate infrastructure such as roads, schools and other public services; loss of agricultural land; habitat fragmentation; degradation of the rural landscape; and increased traffic levels with associated air pollution and congestion.

Understanding the causes of spatial disparities in economic growth in Northern Ireland is central to developing effective policies to promote rural development. This requires a systematic framework that accounts for the interdependencies between measures of economic growth and other drivers. Failure to account for interdependencies would yield biased coefficient estimates and thus misleading policy conclusions. Growth equilibrium models have been developed to analyse the complex interaction of economic phenomena occurring in spatial dimensions and account for interdependencies. The following review lays the foundations for building an empirical model of population and employment growth which will be applied to Northern Ireland. The literature review covers recent model developments to ensure the applied model is up-to-date and discusses the wide range of explanatory variables that have been explored. The theoretical foundations of a growth equilibrium model are set out in Section 2. This is followed by a discussion of empirical applications in conjunction with model developments in Section 3. The explanatory variables that have been used to explain population and employment growth are covered in Section 4 and some conclusions are drawn in Section 5.

2) Theoretical Foundations

Growth equilibrium models measure the linkages between population and employment migration patterns and other exogenous determinants of growth. They are based on the premise that household residential and firm location choices are interdependent. People move to regions in which employment growth is high. The reverse is also true, firms move to regions in which population growth is high due to the availability of labour and demand for final goods. People are not only drawn to locations that offer economic opportunity, jobs are drawn to locations that appeal to personal preference (Carruthers and Mulligan, 2008). This interdependence implies that a simultaneous relationship exists between regional population and employment changes. Steinnes

[1] DETI Census of Employment data 2001 to 2007. Rural defined using Local Government District definition.
[2] NISRA Mid-year Population estimates, 2001 to 2007. Rural defined using 2005 Settlement Classification Band.

and Fisher (1974) developed a simultaneous modelling system, which explains the location of both population and employment.

This growth model is based on a partial adjustment framework to simulate population and employment levels adjusting toward some unknown spatial equilibrium. Following the description of this model by Carruthers and Vias (2005), if this spatial equilibrium were ever reached, all households would be distributed so that each individual's utility was maximised with respect to their consumption of goods and services, proximity to workplace and access to location-specific non-market amenities, such as public services or environmental attractions. Concurrently, in spatial equilibrium, profit maximising firms would be distributed to make optimal use of agglomeration economies, regional comparative advantage, wage differentials, transportation networks, labour supply and other factors that affect the variable costs of production. Mathematically, the simultaneous interaction of equilibrium population and employment may be expressed as follows:

$$1)\ P^* = f_P(E^*, \Omega^P)$$
$$2)\ E^* = f_E(P^*, \Omega^E)$$

where, P* and E* refer to equilibrium levels of population and employment and Ω^{P*} and Ω^E refer to vectors of other exogenous variables having a direct or indirect impact on population and employment. Equation (1) indicates that the equilibrium level of population depends on the level of employment and a vector of exogenous variables which may influence equilibrium population (Hailu and Rosenberger (2004)). Similarly, the equilibrium level of employment depends on the level of population and a vector of other exogenous variables that may affect employment.

In reality, population and employment are constantly adjusting in an effort to attain an ideal spatial distribution. Population and employment are likely to adjust to their equilibrium values with substantial lags, leading to lagged adjustment equations:

$$3)\ P_t = P_{t-1} + \lambda_P(P^* - P_{t-1})$$
$$4)\ E_t = E_{t-1} + \lambda_E(E^* - E_{t-1})$$

where λ_P and λ_E are speed of adjustment coefficients with values between zero and one and t-1 is a one period lag. Thus, current population and employment are dependent on their one period lagged values and on the change between equilibrium values and one period lagged values, adjusted at their respective speed-of-adjustment rates (Hailu and Brown, 2007). Rearranging terms and using Δ to represent change between the two periods in the respective variables, results in the following equations:

$$5)\ \Delta P = P_t - P_{t-1} = \lambda_P(P^* - P_{t-1})$$
$$6)\ \Delta E = E_t - E_{t-1} = \lambda_E(E^* - E_{t-1})$$

The right hand-side equilibrium variables are not observable in equations (5) and (6), but following Deller *et al.* (2001), through substitution the econometric equation can be linearly expressed as:

$$7)\ \Delta P = \alpha_P + \beta_{1P}P_{t-1} + \beta_{2P}E_{t-1} + \gamma_{1P}\Delta E + \sum\delta_{iP}\Omega^P + \varepsilon$$
$$8)\ \Delta E = \alpha_E + \beta_{1E}E_{t-1} + \beta_{2E}P_{t-1} + \gamma_{1E}\Delta P + \sum\delta_{iE}\Omega^E + \mu$$

where $\sum\delta_{ij}\Omega^j$ refers to the exogenous variables and ε and μ are the error terms. The speed of adjustment coefficient becomes embedded in the linear coefficient

parameters α, ß, γ and δ. This framework provides a means to capture structural relationships while simultaneously isolating the influence of amenity attributes on regional economic growth (Deller *et al*. (2001)). In essence, the system models short-term adjustments (i.e. ΔP and ΔE) to long-term equilibrium (i.e. P* and E*). In this specification, ΔP and ΔE are the region's changes in population and employment; P_{t-1} and E_{t-1} are initial conditions of population and employment. The set of variables contained in Ω represents the characteristics of the region at the beginning of the period. Equations (7) and (8) indicate that population and employment changes depend on their own initial levels, respective changes in population and employment and a vector of exogenous factors.

The model formulation captures the impact of both direct and indirect impacts. With regards to population, direct impacts are captured by the variables included within the population equation. In addition, some variables excluded from the population equation may impact population change through their impact on the endogenous variable Δ Employment. Similarly, employment is influenced by the endogenous variable Δ Population, which in turn depends on a range of exogenous factors in the population equation. These indirect, feedback impacts need to be taken into consideration in order to determine the total (direct plus indirect) impact of specific factors. The structural equation estimates can be used to calculate reduced-form equations, which incorporate direct and indirect effects (Carlino and Mills, 1987). These reduced form equations may, in turn, be used to compute elasticities for selected variables, evaluated at sample means.

3) Empirical Applications and Model Development

3.1) Steinnes and Fisher application

The theoretical simultaneous model developed by Steinnes and Fisher (1974) was applied by the authors to the Chicago metropolitan area to explain the intraurban location of residents and employment. Within the empirical model population was divided into four categories (white residents with white collar jobs, white residents with blue collar jobs, black residents with white collar jobs and black residents with blue collar jobs). The results indicated that employment has little impact on population location. In contrast, OLS estimation of just population (i.e. ignoring potential simultaneous effects) yields significant coefficients for employment. This is attributed to misspecification, which means that OLS also estimates a reverse causal relationship – i.e. the effect of residence on employment. It is concluded that the importance often attached to employment as an exogenous determinant of population location should be questioned and that the opposite causal relationship should be more fully investigated.

3.2) 'Jobs follow people' or 'People follow jobs' debate

While Steinnes and Fisher (1974) applied the theoretical simultaneous model to an urban area, the model framework is applicable to other contexts and became more widespread following a US wide study of county growth by Carlino and Mills (1987). In particular, Carlino and Mills (1987) used the two equation system to help inform the development issue of whether 'people follow jobs' or 'jobs follow people'. The results

indicated that population and employment are highly interdependent. The computed elasticities revealed that high employment density is slightly more attractive to households than high population density is to total employment. The authors concluded that the finding of interdependence between population and employment points to economic development strategies to retain or attract population, which will encourage employment to follow and consequently public funds may be better spent, for example, on educating the resident population than used to lure employment.

Carruthers and Vias (2005) also obtained empirical evidence that there is positive feedback between population and employment in the Rocky Mountain West USA, indicating that jobs follow people in addition to the better known process of people following jobs. As a result, they argued that from a policy perspective, traditional economic development programmes which focus heavily on the creation of work, may only address part of the picture. They further posited that sustainable economic development may ultimately depend upon other forms of policy that make them desirable places to live. This is especially true of high amenity regions that draw people for their environmental attractions and abundant recreational opportunities. The positive feedback between population and employment underscores the need for quality of life to be made central to planning and economic development. To the extent that people base their location decisions at least in part upon places' environmental attractiveness, its long-term economic prosperity may depend upon the preservation of natural amenities. The authors concluded that the government should engage in land conservation in order to promote sustainable economic development.

3.3) Sub-division of employment

In addition to estimating a total employment system (i.e. total employment and population), Carlino and Mills (1987) estimated a manufacturing employment system (i.e. manufacturing employment and population). Manufacturing was separated out since it is a basic factor for many counties in the study area. The authors noted that the decline in manufacturing employment has led to large losses in population and nonmanufacturing employment in certain areas and thus it was deemed useful to investigate these determinants separately. Estimation of this system indicated that, in contrast to the main system, high population density deters manufacturing employment. This finding was attributed to the higher cost of land in densely populated areas since manufacturing is generally land intensive.

Clark and Murphy (1996) estimated a standard model of population and employment growth at the county level in the US (see Section 4 for further details). In addition, due to sectoral differences in employment growth the authors sub-divided employment into five different sectors: manufacturing, construction, services, finance and trade. The five employment equations were estimated simultaneously with total population. The results revealed some differential impacts across sectors, e.g. the endogenous population growth variable was statistically significant in two of the employment equations, namely construction and finance. In addition, although amenities were not statistically important in the total employment equation, they appeared to have some influence for individual sectors.

In a study of the impact of government wilderness designation on economic growth in the intermountain western US, Duffy-Deno (1998) sub-divided employment into resource and non-resource sectors to determine whether wilderness designation has a

differential impact on these sectors. The author argued that since resource-based firms are immobile it is unlikely that such firms follow population and thus excluded population as an explanatory variable in a resource employment equation. Non-resource employment, however, was specified as a function of contemporaneous resource-based employment and exogenous federal employment to account for spillovers from these sectors, contemporaneous population, lagged non-resource employment and a vector of exogenous characteristics. Non-resource employment and population were estimated simultaneously using two-least squares, while resource employment was estimated separately using ordinary least squares.

In a further study by Duffy-Deno (1997) resource and non-resource employment were again segmented. A variable for resource sector employment is included within the total employment equation to account for spillover to the rest of the local economy. Estimation yielded few statistically significant coefficients within the resource employment equation, in contrast to the non-resource employment equation. It was argued that this is consistent with the resource sector being heavily dependent on resource prices and resource geology. Again, it was noted that population should perhaps be excluded from the resource employment equation due to the immobile nature of resource firms.

3.4) Sub-division of population

As noted above, population was sub-divided into different categories within the seminal study by Steinnes and Fisher (1974). Specifically, population was divided into four categories (white residents with white collar jobs, white residents with blue collar jobs, black residents with white collar jobs and black residents with blue collar jobs). Estimation yields some differential impacts for the different population categories, supporting the sub-division of population in this manner. Despite this, very few subsequent studies have subdivided population. Within the paper by Clark and Murphy (1996), see above, it is noted that a modelling system with six separate population equations, one for each sector of employment, was estimated in addition to a system with just total population. However, it was noted that the findings were almost identical to the basic population model and consequently, these results were not presented in the paper.

Gebremeskel *et al.* (2007) modelled in-migration and out-migration rather than population change in order to identify differential effects. It is argued that the endogenous variable population change includes both natural population increase and the difference between in-migration and out-migration. Unless the characteristics of in-migrants and out-migrants are assumed to be the same (with respect to their effects on the regional economy), taking population change as a net figure glosses over the differential effects of in-migrants and out-migrants. Certain variables that are relevant to explaining in-migration are not relevant to explaining out-migration and the magnitudes of the influence of certain variables on in-migration is likely to be different from the magnitudes of these variables on out-migration. The results revealed that in-migration and out-migration are inversely related, indicating that counties with high (low) in-migration growth rates are also counties with low (high) out-migration rates. It is argued that this is consistent with the macroeconomic literature where migration is considered as an equilibrating factor in regional labour markets, i.e. job seekers move away from high unemployment areas where they

cannot find jobs to low unemployment regions where the prospects of finding employment are more favourable.

Within a conference presentation (no paper available at time of writing), Adelaja and Hailu (2010) presented some preliminary findings for a growth equilibrium model of population, employment and income change in which population is sub-divided into different age-group components. The presenters argued that it is likely that the determinants of population change differ across age groups and thus studies of total population change gloss over some important differential effects. Specifically, population is divided into six age groups: 18 to 21, 22-24, 25-34, 35-54, 55-64 and 65 & older. Sub-dividing population in this manner provides a means to examine what motivates people of different age categories to move, which segments of the population should be targeted to move to a region and how should regional development policies be adapted to ensure economic prosperity. For example, some amenities play a key role in where people choose to live, but some amenities attract some age groups, while others attract other age groups. It is concluded that economic development strategies should be concerned about what amenities attract high-impact young adults (recent college graduates and 24 to 35 year olds) since this group has the most significant impact on employment growth. In addition, within some regions the '65 and older age group' has a significant positive impact on job growth due to their place concentration, e.g. retirement community focused.

3.5) Model extensions

Income

Deller *et al*. (2001) extended the classic two equation systems model to a three equation model to include income within the structural framework on the basis that people also migrate to capture higher income. This development provided a means to trace the role of income in regional growth. Deller *et al*. (2001) derived the following empirical model:

$$9) \quad \Delta P = \alpha_P + \beta_{1P}P_{t-1} + \beta_{2P}E_{t-1} + \beta_{3P}I_{t-1} + \gamma_{1P}\Delta E + \gamma_{2P}\Delta I + \sum\delta_{iP}\Omega^P + \varepsilon$$

$$10) \quad \Delta E = \alpha_E + \beta_{1E}E_{t-1} + \beta_{2E}P_{t-1} + \beta_{3E}I_{t-1} + \gamma_{1E}\Delta P + \gamma_{2E}\Delta I + \sum\delta_{iE}\Omega^E + \mu$$

$$11) \quad \Delta I = \alpha_I + \beta_{1I}I_{t-1} + \beta_{2I}P_{t-1} + \beta_{3I}E_{t-1} + \gamma_{1I}\Delta P + \gamma_{2I}\Delta E + \sum\delta_{iI}\Omega^I + \tau$$

Under this specification, population, employment and income changes depend on their own initial levels, respective changes in population, employment and income and a vector of exogenous factors. This study reported the impact of amenity attribute on measures of economic growth (i.e. population, employment and income (see discussion in section 4)), but did not examine the interplay of the endogenous variables. Park *et al*. (2008) applied a similar model, with the emphasis again on the role of the amenity variables on economic growth rates.

In a study of income inequality in West Virginia, Hailu *et al*. (2005) estimated a three equation simultaneous growth equilibrium model with population, employment and income. The findings indicated that population, employment and income are interdependent. Within the population equation, the endogenous variables 'change in per capita income' and 'change in employment density' were significant and positively related to population density, indicating that counties with high income growth and growing job opportunities experience population growth, one way being from in-

migration. Within the employment equation, the endogenous variables 'per capita income' and 'population density' were significant and positively related to employment growth, supporting the hypotheses that growing income and population densities attract new investment to capture growing markets and also support the economic base for new businesses to emerge. Within the per capita income equation, the endogenous variables 'population density growth' and 'employment density growth' were positively significant. A growing employment opportunity may expand income opportunities and an increase in population density may provide a market incentive for investment and a tax base for social investment.

Similarly, Adelaja, Hailu and Abdulla (2009) estimated a growth equilibrium model with the endogenous variables population, employment and income to explain the drivers of economic growth, with a particular emphasis on the New Economy, in a nation-wide study of the US[3]. The results indicated that growth in population, employment and income are synergistic. It is concluded that the findings of growth interdependence may suggest that communities can find themselves either in the mode of synergistic growth or synergistic decline. Hence, economies that find themselves on the wrong side of growth may continue to spiral down if they don't employ effective strategies to avert a freefall.

Agricultural land

Hailu and Rosenberger (2004) incorporated agricultural land within a growth equilibrium model, which accounted for interactions between population, employment and agricultural land density. Within the empirical model population and employment changes depend on their own initial levels, respective changes in employment and population and a vector of exogenous variables. The change in agricultural land is affected by its initial level, changes in employment and population and a vector of other exogenous variables influencing agricultural land changes. Those factors that directly affect changes in population and employment are indirectly captured in the agricultural land change equation through changes in population and employment. The results indicated that there is significant simultaneity between population density change and employment density change, but no simultaneity between changes in employment and population with changes in agricultural land density. This result was regarded as troubling as the primary objective of the model was to measure the marginal contribution of these factors in land use change.

Hailu and Brown (2007) also included the stock of agricultural land within a growth equilibrium growth model. The modelling system consisted of five simultaneous equations, namely population, employment, per capita income, the value of agricultural land and the stock of agricultural land. Within the agricultural land density change equation, the endogenous variable 'change in income' displayed a statistically significant coefficient. This accorded with *a priori* expectations that regional growth has a negative impact of the stock of agricultural land. On the other hand, the per acre farmland value coefficient was positively significant, indicating that higher farmland values result in greater stocks of agricultural land. In addition, the exogenous variable was positively related to agricultural land density change,

[3]See Adelaja, Hailu and Abdulla (2009) 'Chasing Our Past – Investing in the Future' for an in-depth discussion of the policy implications of the results.

indicating that farmland density can more easily be maintained when farm income is high.

Government expenditure

Gebremeskel et al. (2007) specified a five equation simultaneous equation model with in-mgration, out-migration, non-farm employment, per-capita government expenditure and household income. Government expenditure is introduced as an endogenous variable within the system of equations, since in addition to households and firms location decisions being influenced by the provision of local government services, it is posited that local government expenditures approximate the choices of the utility maximising median voter and so depend on income and other revenue sources such as property taxes, income taxes and factors that determine consumer preferences. The results demonstrated the existence of significant feed-back simultaneity with three of the endogenous variables having a significant effect on the growth rate of direct local government expenditures per capita.

Endangered species

In order to examine the impact of the Endangered Species Act on economic growth Duffy-Deno (1997) extended the growth equilibrium model to include endangered species density. The authors included the number of listed and endangered species by county within the employment equations to capture the direct effect of listing species on total employment growth. The author hypothesised that listing species increases the costs of doing business in the county and thus discourages firms from moving to or expanding in counties with relatively higher species density. Employment growth and population density were incorporated within the endangered species density equation since the in-migration of firms and households can lead to increased pressure on local ecosystems and endemic species habitat. Such pressure may endanger endemic species that depend on this localised habitat and, hence, may lead to the Federal listing of these species. Estimation of the equilibrium modelling system revealed no evidence of a statistical relationship between the density of the Federal listed and endangered species and employment density growth.

3.6) Spatial spillover effects

Regional growth patterns may display spatial spillover effects, wherein growth in population or employment in one area could spillover to neighbouring areas. These spillover effects lead to spatial interdependence, which needs to be explicitly recognised within the model specification. If unaccounted for these spatial effects may yield inconsistent, inefficient and biased coefficient estimates (Anselin (1988) and Anselin and Bera (1998)).

The seminal paper by Steinnes and Fisher (1974) incorporated spatial interactions to a certain extent using 'potential' endogenous variables that aggregated regional area and population into larger units. These larger units are intended to correspond to labour markets since residents may commute across the smaller regions on which the

analysis is based (community areas within Chicago), i.e. they may be interpreted as commuter sheds. Thus, the population equation contained the endogenous variable spatial weighted average of employment and the employment equation contained spatial weighted average of population.

Despite this allowance for spatial interactions, many subsequent papers included standard population and employment variables, which do not account for spatial effects. This may reflect the level of analysis. While the study by Steinnes and Fisher (1974) examined economic growth within small areas in a metropolitan setting, many of the studies that followed employed datasets for large geographic areas, e.g. nationwide or several states. Within these broader geographic area studies the difference between the unit of analysis and the labour market areas is likely to be less of a problem. Within their study of the role of natural amenities on economic growth in England, Park *et al*. (2008) acknowledged in the conclusions that the performance of the modelling system would probably have been improved by including spatial effects due to the small size of the units of analysis and the large scale of commuting across these units.

One study that explicitly recognised the importance of spatial spillover effects is Boarnet (1994). Boarnet (1994) modelled intrametropolitan population and employment growth in New Jersey municipalities. The author argued that residents commuted across municipalities in New Jersey and thus the municipalities are too small to be their own labour market. Consequently, he added spatial lags of the endogenous variable (weighted using a distance decay matrix) to the classic Carlino-Mills model. Within this specification, community population change is dependent upon the change in employment aggregated over all communities within commuting range, while community employment change is dependent upon the change in population within commuting range of that community. Within the spatial econometric literature this is known as a spatial cross-regressive lag model.

The authors also included a range of amenity and transportation variables. These are mostly defined using individual municipalities. However, the authors included two agglomeration variables based on a spatial weighted average of manufacturing and retail employment. The agglomeration benefits are assumed to decline quadratically with distance, which is a faster damping rate than used in the endogenous variables. This reflects the assumption that agglomeration benefits operate over shorter distances than labour market areas since agglomeration benefits reflect opportunities for face-to-face communication, which requires relatively close proximity.

Henry *et al*. (1997) extended the Boarnet (1994) model to account for the impact of growth rates in the urban core and fringe on rural economic growth. In addition to the spatial lags of the endogenous variables, this model contains interaction terms between urban growth rates and the spatial lag terms. Essentially, this specification decomposes the spatial cross regressive term into rural area, urban core and fringe effects. The coefficient estimates on the interaction variables indicate if faster urban growth has a spread or a backwash effect on nearby rural communities. Within the Boarnet (1994) model the spatial endogenous variables are not explicitly linked to urban areas (i.e. just based on distance and thus includes neighbouring rural and urban areas), while the specification employed by Henry *et al*. (1997) means that urban growth patterns affect how households and firms view the desirability of rural areas. The results indicated that if the urban area is 'decentralising' – rapid fringe population growth and slow urban core population growth – rural population growth will be enhanced. Slower rural population change occurs in tracts with large but slow growing

labour market areas, especially if the urban area is 'centralising' – high urban core population growth and slow urban fringe population growth. The results also demonstrated that the provision of public services is important to residents. It is concluded that rural areas close to decentralising urban areas can position themselves to take advantage of urban spillovers through prudent use of public services. The long-term goal for rural development policy should be to improve the quality of life, not simply to promote population or employment growth.

Henry *et al*. (2001) compared several different spatial econometric specifications:

(i) classic model without spatial effects (Carlino-Mills model),
(ii) model with spatial lag endogenous variables (spatial cross-regressive lag model used by Boarnet (1994)),
(iii) model with interactions with urban growth (Henry *et al*. (1997) model);

and three models with spatially lagged dependent variables:

(iv) spatial autoregressive model (SAR), without the endogenous variable;
(v) SAR model with the other endogenous variable (Carlino-Mills model with SAR)
(vi) SAR model with a spatially lagged endogenous variable (Boarnet (1994) model with SAR).

Within the spatial autoregressive models a positive coefficient on the SAR variable indicates that a community gains growth as a spillover from growth in nearby communities (the local spread effect), while a negative coefficient means that a community is losing population or jobs to growth in nearby communities. While significant SAR coefficients indicate there are spread or backwash effects from growth in communities within a commuting range, there is no direct link to urban fringe or core growth. The results indicated that the inclusion of the spatial cross regressive term to the basic Carlino-Mills model (i.e. equivalent to the Boarnet (1994) model) provides an important correction since the basic model is dynamically unstable (estimation yields a negative coefficient for λ_P). In addition, estimation of the SAR models (iv, v and vi) indicated that population growth spreads to rural communities from nearby areas, but the evidence for employment spread is less robust.

Gebremeskel *et al*. (2007) included a spatial autoregressive and spatial cross-regressive lag variables (i.e. equivalent to the vi model within Henry *et al*. (2001)) within the five equation simultaneous equation model (see Section 3.5 for further details). The results showed the existence of spatial autoregressive lag and cross-regressive lag simultaneities among the data set with respect to the growth rates of in-migration, out-migration, non-farm employment, per-capita government expenditure and household income. As a result, each of the dependent variables in the model are not only dependent on the characteristics of that county but also on the characteristics of its neighbours. It is concluded that the evidence of spatial effects indicates that there are cross county interdependencies among the growth equilibrium model endogenous variables, which would necessitate economic development policy coordination at the regional level.

The authors also incorporated a spatially autoregressive error term in order to control for the effects of unobservable spatial processes. These were found to be significant, indicating that random shocks in the system with respect to each of the endogenous variables do not only affect the county/counties where the shock originated from and its/their neighbours, but also create shock waves across the study area. Lewis *et al*.

(2002) also tested for spatial autocorrelation of the residuals but failed to reject the null hypothesis of no spatial autocorrelation.

Similarly, Hailu and Brown (2007) included spatial autoregressive and spatial cross-regressive effects in each equation of the five equation simultaneous model (see Section 3.5). The authors also tested for the spatial correlation in the errors. Tests confirmed the existence of spatial correlation both in the endogenous variables and in the model errors and as a result, the generalised method of moments approach was used for estimation purposes. Estimation yielded significant spatial spillover effects. For example, within the population equation, spillover effects from neighbouring counties were found for population, employment and farmland values. This indicates that population and employment growth in neighbouring counties encourage population growth in the county of interest.

An important factor in incorporating spatial effects within growth equilibrium models is the spatial weights matrix. The spatial weights matrix defines how geographic units of observation relate to one another and is defined *a priori* (Boarnet *et al.*, 2005). Each element within the spatial weights matrix, w_{ij}, weights the degree of spatial interaction between observation i and j. A variety of weight matrices have been employed within growth equilibrium studies. Boarnet (1994) employed an inverse distance decay matrix:

$$w_{ij} = \frac{1}{(d_{ij})^{\alpha}} \quad \text{(where } i \neq j \text{)}$$

where d_{ij} measures the distance between each pair of observations. With this weight matrix, labour market areas are potential variables, with areas closer to any particular area weighted more heavily, while areas that are far apart are assigned a low weighting. The magnitude of the coefficient α determines how quickly the labour market relation declines with distance. Boarnet (1994) imposed a value of 0.67 estimated from a previous study on national commuting (Boarnet, 1992). As noted above, this study also included two agglomeration variables using a distance decay matrix with a faster damping rate.

Henry *et al*. (1997) employed a fixed distance matrix in which a matrix element, w_{ij}, is equal to one if the distance between areas i and area j is less than 30 miles and zero otherwise. The distance of 30 miles was based on the definition commonly used by analysts at the South Carolina (SC) Department of Commerce to delineate labour market sheds for new firms expressing an interest in a SC location. While this weight matrix incorporates information about commute flows, all commuter sheds are of equal size, thereby ignoring any variation in commuting patterns. Similarly, Henry *et al*. (2001) employed a fixed distance weights matrix. The cut-off point in this study was 15km, based on the mean commuting distance in France. Note that although this study just focuses on economic growth within rural areas, the spatial weights matrix includes both rural and urban areas.

The studies by Gebremeskel *et al*. (2007) and Hailu and Brown (2007) employ a simple contiguity weights matrix in which element w_{ij}, equals one if tracts i and j border each other and zero otherwise. This type of weights matrix does not incorporate any information on commute flows.

In order to assess the implications of specifying different spatial weight matrices Boarnet *et al*. (2005) estimated a growth equilibrium model using four different matrices. This included the contiguity, fixed distance and inverse distance decay matrices. In addition, the authors considered a tract-to-tract flow matrix based on census data on the number of commutes between tracts, with elements, w_{ij}, being the number of commuters travelling between tracts *i* and *j*. The authors argued that this weights matrix is more theoretically appealing compared to other weight matrices since it allows the labour market area (or commuter-shed) centred on any one tract to be based on commute patterns between that tract and other tracts. Thus, commuter-sheds vary within the study region in line with variations within commuting patterns within the region, e.g. residents at some locations might commute somewhat more than residents at other locations more proximate to jobs. The results for the different weight matrices indicated that although the nature of the simultaneous interaction between population and employment growth was sensitive to the specification of the weight matrix, the coefficients of most of the other independent variables were not impacted by the choice of matrix.

4) Explanatory Variables

4.1. Introduction

A wide variety of factors have been used to explain regional economic growth. Differences among studies reflect geographic coverage, sectoral coverage, underlying model structure, research policy questions and data availability. Following Adelaja, Hailu and Abdulla (2009), the factors hypothesised to affect regional economic growth may be classified into eleven broad categories:

- Endogenous
- Initial Conditions
- Demographic
- Housing Market
- Socio-economic
- Education
- Government
- Grey Infrastructure
- Amenities
- Regional Dummy
- Economic Structure

These categories and variables within the categories are discussed below. In discussing the results of empirical studies, particular emphasis is placed on the recent study by Adelaja, Hailu and Abdulla (2009) since this study distinguishes between rural and urban areas.

4.2. Endogenous Variables

As outlined in Section 3.2, the statistical significance of the endogenous variables (i.e. change in population in the employment growth equation and change in employment in

the population equation) within the system of growth equilibrium equations has been used to shed light on the 'Jobs follow people' or 'People follow jobs' debate. Within the aggregate model (no distinction for rural or urban areas) estimated by Adelaja *et al*. (2009) the estimates indicated two-way causality, i.e. 'Jobs follow people' and 'People follow jobs'. Further analysis revealed that when a distinction is made between rural and urban counties there is still two-way causality, but the impact differs. Population increase, in and of itself, leads to new jobs in both rural and urban counties but the marginal impact is greater in urban areas. It is argued that within urban areas an influx of people creates significant service opportunities, but these opportunities are limited in rural areas. With regards to the population equation, an increase (decrease) in jobs leads to a greater increase (decrease) in population in rural counties compared to urban counties. Evidence of two-way causality is further supported in the empirical studies by Carlino and Mills (1987), Clark and Murphy (1996), Duffy-Deno (1998), Lewis *et al*. (2002) and Carruthers and Vias (2005).

4.3. Initial Conditions

The derivation of the growth equilibrium model means that it is necessary to incorporate initial levels of population and employment (see equations 7 and 8 in Section 2). The statistical significance of these variables within their respective growth equations provides an insight into whether past performance affects subsequent growth. The results in the study by Adelaja *et al*. (2009) indicated that places with high initial population attract more people, but places with high initial employment experience lower subsequent employment growth. The rural based studies by Deller *et al*. (2001) and Nzaku and Bukenya (2005) found that initial levels of population and employment had a negative effect in their respective growth equations, i.e. areas with higher (lower) initial levels of population and employment exhibit lower (higher) rates of growth. The authors conclude that this provides an indication of convergence.

4.4. Demographic

Adelaja *et al*. (2009) explored the impact of the following demographic variables on economic performance:

- % of the young (25-34 years old) age group
- % of the retirees (65 years old and over) age group
- % urban population
- % of foreign-born residents (immigrants)
- net migration

The results from the study by Adelaja *et al*. (2009) indicated that regions with a high proportion of the population within the age group 25-34 years old have a significant job creation effect in urban areas. It is argued that this age group is more innovative, creative, entrepreneurial and contains more economic-generating potential than other age groups. However, the results revealed that this variable has different impacts in urban and rural areas. The presence of this age group had no significant effect on job growth in rural areas. In terms of the population equation, the presence of the young age group does not attract additional population. In a study of the Appalachia counties

in the US, Gebremeskel *et al.* (2007) also found that the proportion of the population within the 25 to 44 age group has a positive impact on employment growth (note this study did not distinguish between rural and urban areas). It is hypothesised that this variable captures the beneficial effect of a pool of potential entrepreneurs that encourage business formation.

Adelaja *et al.* (2009) found that regions with a high proportion of retirees have a significant job creation effect in urban areas but not rural areas. In urban areas it is hypothesised that this age group contributes to job growth through their spending on healthcare, entertainment, food and other services. On the other hand, the presence of this age group has a negative impact on population growth in urban areas but not rural areas. Other studies that have included a variable capturing the proportion of retirees include Deller *et al.* (2001), Deller and Lledlo (2007), Nzaku an Buykenya (2005) and Carruthers and Vias (2005). The studies by Deller *et al.* (2001) and Deller and Lledlo (2007) focused on economic growth in rural US counties and the results indicated that the proportion of the population over sixty-five has a dampening effect on employment and population growth. The study by Nzaku and Buykenya (2005) covered rural and urban areas in the south west of the US and showed that the proportion of retirees has a significant negative effect on employment. Meanwhile, the study by Carruthers and Vias (2005), which examined regional economic growth in rural and urban areas in the Rocky Mountain West in the US, indicated that a greater proportion of retirees has a significant negative impact on population growth.

Adelaja *et al.* (2009) also demonstrated that although the growth of the percent of the urban population does not affect job growth, it adversely affects population growth. It is hypothesised that this reflects the declining economies of urban areas in the US. Within the study by Deller and Lledlo (2007), which is based on rural counties, the variable percentage of population living on farms has a negative impact on population. Other studies included dummy variables to capture whether the potential impact of nearby urbanisation. Nzaku and Buykenya (2005) found that rural areas next to urban areas have a strong positive impact on employment growth since these regions have more access to employment opportunities. Alternatively, other studies have employed a proximity to urban areas variable to capture the impact of the degree of urbanisation.

With regards to the percentage of foreign-born residents term, the results within the study by Adelaja *et al.* (2009) indicated that immigrants have a significant positive impact on jobs in urban areas but not rural areas. The impact on jobs in urban areas is attributed to the changing nature of immigrants in the US, whom increasingly tend to be knowledge workers and hold advanced degrees and therefore contribute to the revitalisation of many US cities. Within the study by Deller and Lledlo (2007), which is based on rural counties, this variable had a negative impact on employment growth.

Finally, Adelaja *et al.* (2009) showed that net migration is positively related to population growth. This finding is supported by Lewis *et al.* (2002) and Nzaku and Buykenya (2005). Nzaku and Buykenya (2005) also found that net migration has a positive impact on employment growth. Similarly, Gebremeskel *et al.* (2007) found that in migration has a positive impact on employment. Note that this study also showed that employment growth has a positive impact on in-migration, i.e. they are interdependent.

Potential demographic variables within NI study

- Proportion of population within different age groups and proportion of foreign born residents available from the 2001 census.
- Migration data from census.
- Wards defined as urban, rural and mixed within 2005 Settlement Classification Band.
- Proximity to urban areas can be computed using GIS.

4.5. Housing Market

Adelaja *et al*. (2009) considered three housing market variables:

- % of vacant homes
- Median housing value
- Rent to income ratio

The results within the study by Adelaja *et al*. (2009) indicated that the proportion of homes that are vacant has a positive impact on population growth in both rural and urban areas. However, this variable exerted a negative impact on population growth within the model that did not distinguish between rural and urban areas, suggesting that these findings should be treated with care. Nzaku and Buykenya (2005) found that owner occupancy has a strong positive effect on population growth and this is attributed to a stronger sense of community. Within the study by Carruthers and Vias (2005) greater vacancy rates are associated with lower population growth, while a larger proportion of home ownership leads to population growth.

Adelaja *et al*. (2009) showed that while the median housing value has no impact on population growth within urban areas, it has a positive impact on housing value within rural areas. This is partly attributed to the correlation between property values and amenities, services and quality of life, which encourage people to move to expensive communities. In terms of employment, Adelaja *et al*. (2009) found that the median housing value has negative impact on job growth in both urban and rural areas. It is argued that this is consistent with recent trends in the US in which high-income neighbourhoods increasingly serve as bedroom communities rather than employment places. The study by Hailu and Abdulla(2010), which divided population growth into different age groups, found that affordable homes appeal to middle age groups and the young in rural areas, rising home environments are preferred by pre-retirement and retiree age groups. The authors concluded that these trade-offs imply that population attraction strategies that rely on affordable home policies will need to properly target responsive age groups, while promoting healthy real estate markets that appeal to older age groups that may rely on such properties as a form of wealth accumulation.

The expected sign of the 'Rent to income ratio' included in the study by Adelaja *et al*. (2009) is difficult to specify *a priori* as low rent communities may be attractive for people who cannot afford to buy but wish to rent or it may be an indicator of the attractiveness of an area. The authors found that this variable has a positive impact on population growth, suggesting that people or not looking for cheap places to live

but that high rent communities are attractive places to live. Within the same study, the 'Rent to income ratio' variable was found not to be significant within the employment equation, indicating that cheap rent or low cost of living does not necessarily spur employment growth. The study by Hailu and Abdulla(2010) found that cost of living does not significantly affect population growth in urban or rural areas. They argued that this may be a disadvantage to rural communities where the cost-of-living has been promoted as an attraction strategy. The study by Carruthers and Vias (2005) used average rent as a housing market variable and found that this had a positive impact on population and employment growth.

Potential housing market variables within NI study

- Proportion of vacant homes and owner occupancy available.
- Average capital value available for 2008 on NINIS (preferable to have data close to beginning period, i.e. 2001). Average new house prices available for 2001, but only at the district council level (possibly compute hedonic regression using data that is also available at the ward level).
- Affordability available at the district council level but not below.

4.6. Socio-economic

Adelaja *et al.* (2009) employed the following variables to measure the impact of socio-economic performance on subsequent economic growth:

- Unemployment rate
- % of families in poverty

Adelaja *et al.* (2009) found using the aggregate model and the model that disaggregates between rural and urban areas that the unemployment rate has no statistically significant effect on population or job growth. This suggests that places that are currently economically stressed have as much chance of economic recovery as places that or not, holding other factors constant. A review of regional growth studies by Kusmin (1994) indicates that the impact of unemployment on economic growth is uncertain. On the one hand, high unemployment may be attractive to businesses as they should be able to recruit employees without bidding up local wage rates. In addition, areas which are initially near a cyclical high in unemployment are likely to experience more rapid subsequent growth as economic activity returns to more normal local levels[4]. On the other hand, persistent high unemployment may be a proxy for unmeasured local conditions that are unfavourable to economic activity. Also, extended unemployment reduces worker quality due to loss of skills and work habits. The results by Nzaku and Bukenya (2005) indicated that in this study area unemployment had a negative impact on job creation, suggesting that it is difficult for economic stressed regions to rebound.

[4] Similarly, areas with especially low employment rates may have been boosted by short-term economic conditions (e.g. a construction boom), which means that these areas are likely to grow slowly or decline as these conditions return to normal.

In contrast to the unemployment variable, Adelaja *et al*. (2009) found that the poverty rate does affect the potential for economic turnaround, suggesting that there are legacy effects associated with poverty, which results in economic development deterrents. Poverty is associated with a decline in population growth in urban areas but has no significant population effect in rural areas. These different results are attributed to urban residents tending to move out when poverty sets in, which contrasts with rural residents who tend to be less mobile.

Potential socio-economic variables within NI study

- Unemployment rate – claimant account data available for 2005. Alternatively, long-term unemployed available for 2001 from census.
- Proportion of households in poverty available from small area income deprivation estimate using 2003-05 data

4.7. Education

Adelaja *et al*. (2009) included two variables to determine the role of education in economic performance:

- % of the population with a bachelors degree
- Number of colleges, universities and other higher educational institutes

The authors hypothesised that education is associated with a greater degree of entrepreneurship, risk taking and creativity, which are regarded as important for economic growth. Estimation yielded different results for rural and urban areas. In urban areas, a high concentration of educated graduates helps attract further population but not job growth. In rural areas, a high concentration of graduates affects employment growth but not population growth. The authors concluded that this suggests that the attraction of graduates serves as a population attraction strategy in urban areas and a job creation strategy in rural areas. The review of regional growth studies by Kusmin (1994) concludes that there is widespread agreement that the level of skill and education demanded in the labour market is increasing and thus areas with a greater supply of more educated labour experience more economic growth. E.g. Gebremeskel *et al*. (2007) found that education has a positive impact on employment growth and contends that entrepreneurs with good education are more likely to know how to transform innovative ideas into marketable products. However, Kusmin (1994) acknowledges that the demand for educated labour varies across industries. In line with this theory, Killian and Parker (1991) found that education is not significant in rural areas but has a statistically significant positive impact in urban areas. They propose that while some employers are seeking educated, skilled workers, others are seeking local economies where the labour pool is relatively uneducated and nonunionised. They also suggest that growing economies in general require substantial numbers of relatively unskilled workers to provide support services for other workers and local businesses.

Adelaja *et al*. (2009) found that the presence of a college or university has a positive impact on population and job growth in urban areas but no impact in rural areas. Other studies, e.g. McNamara *et al*. (1988), employ a distance to educational

institutions variable to capture the importance of access to higher educational institutions

Potential education variables within NI study

- Proportion of people with various qualifications available from 2001 census.
- Number of schools and higher education colleges – location data for institutes of higher education available from NINIS website (can compute proximity using GIS) or obtain distance variables from deprivation studies.

4.8. Government

Adelaja *et al.* (2009) employed the following variable to help explain the role of government in economic growth:

- Ratio of taxes to government expenditure

The authors contended that while low tax areas are expected to perform better, government provided amenities are also important and thus employed a ratio that captures the impact of taxes relative to public services. The results indicated that the level of taxes relative to expenditure is a significant determinant of population growth, especially in rural areas. However, no significant effect on job growth in rural or urban areas was observed.

Other studies have examined the impact of government expenditure and taxes separately. Carruthers and Vias (2005) found that increased government spending leads to employment growth and argued that this expenditure helps to create enterprise zones and other forms of stimuli for agglomeration economies. Similarly, Gebremeskel *et al.* (2007) found that local government expenditure is positively associated with employment growth. In addition, this study showed that government expenditure in neighbouring counties has a positive impact on the rate of job growth in a given county, possibly because government expenditures may have positive cross border impacts that could benefit firm location on the other side of the county border. The authors also found that local government expenditure has a negative impact on in-migration and this is attributed to the higher taxes required to finance this expenditure. The results in a study by Clark and Murphy (1996) indicated that employment growth is less responsive to government spending levels and more responsive in the distribution of that spending (% of expenditure on police, education welfare *etc.*).

Monchuk *et al.* (2005) showed that within the US Midwest counties with higher taxes are less attractive to investors, which leads to lower economic growth. Deller *et al.* (2001) found that local taxes have a negative impact on population and income growth. However, the results also showed that government expenditures have a positive influence on population growth but a negative impact on income growth. This latter result accords with the argument that people and firms consider the balance between taxes and services.

Potential government variables within NI study

While the tax system in Northern Ireland is less localised compared to the US, the provision of government services is likely to influence population and employment growth and may be captured using non-expenditure variables such as proximity to service variables e.g. schools (see Section 4.7) and hospitals. Also, some studies account for the role of health care on population and employment growth using the number of doctors within an area (e.g. Deller *et al*. (2001) and Nzaku and Bukenya (2005)). Similarly, the provision of infrastructure government services may be captured in terms of area road lengths or distance to major roads (see Section 4.9 below). Within a UK context, it would be interesting to consider the impact of regional financial assistance. For example, in a study of small firm growth in the UK between 1994 and 1997 Hart and McGuiness (2003) found that government expenditure on regional preferential assistance to industry had a positive impact on small firm growth. (Note that within this UK study Northern Ireland is modelled as a single entity).

4.9. Grey Infrastructure

Adelaja *et al*. (2009) used the following variables to assess the extent to which grey infrastructure assets contribute to population and employment growth:

- Infrastructure index
- Average commuting time

The infrastructure index variable is a combined variable, which measures spending on roads, airports and broadband capacity. It was necessary to use a combined variable since separate variables suffered from multicollinearity problems. The results indicated that investment in grey infrastructure has a positive impact on population and employment growth in both urban and rural areas, although the impact is greater in the former. The authors posited that grey infrastructure enhances economic growth since it facilitates commerce and integration to broader markets. Carlino and Mills (1987) found that access to major roads had a significant positive impact on population and employment growth, while it only had a significant impact on employment growth on the latter in the study by Nzaku and Bukenya (2005). Within the study by Duffy-Deno (1997) road density was negatively associated with employment growth. The author suggested that the road density variable may be picking up a congestion effect.

With regards to the average commuting time variable, the results in the study by Adelaja *et al*. (2009) indicated that places with a higher average travel time attract population, although it is acknowledged that there may be causality issues.

Potential grey infrastructure variables within NI study

- Road lengths available at district council level. Possible to compute road lengths for wards or distance to major roads (e.g. dual carriageways and above) using GIS.
- Average travel time to work – explore further whether it is possible to obtain NISRA COA-to-COA travel times/distance databases.

4.10. Amenities

Adelaja *et al*. (2009) examined the impact of five amenity variables on population and employment growth:

- Developed amenities index (index includes parks, playgrounds, tennis courts, museums etc.)
- Land amenities index (index includes campground sites, state park areas, cropland, pastureland, rangeland, area of forest land etc.)
- Water amenities index (index includes marinas, lakes, wetland acres, rivers etc.)
- Winter amenities index (index includes ski areas, annual snowfall)
- Climate amenities index (index includes July temperature, the number of days with sunlight, average January temperature etc.)

The indicies used by Adelaja *et al*. (2009) follow Deller *et al*. (2001), who sought to obtain consistent and meaningful empirical measures of natural amenities and quality of life characteristics that move beyond *ad hoc* descriptions of amenities. Deller *et al*. (2001) argued that natural amenity attributes are latent non-market inputs into the production process of local economies. E.g. forest resources once viewed as a source of raw materials for wood products are now valued for their recreational uses or as aesthetic backdrops. The non-market nature of natural amenities means that the contribution of these factors tends to be underappreciated within the economic growth literature. The authors argued that earlier studies are undermined by the inclusion of single dimensional, simplistic and to a large extent *ad hoc* amenity attributes, such as climate or crime rates. They recommended identifying more rigorously which amenity attributes most influence regional economic performance so as to gain a better insight to preserve and advance those attributes, particularly latent non-market attributes, which are likely to be undervalued within the regional economy.

The authors employed principal components analysis to compress fifty-four variables into five indices of amenity and quality of life attributes: climate (temperature, precipitation, sun winters and dry summers), developed recreational infrastructure (region's facilities such as golf courses, tennis courts, swimming pools, playgrounds and significant and historic cultural dimensions), land (region's land resources such as the percentage of acres included in federal wilderness areas, forestland, farmland and state park land), water (region's wealth of water resources, including the percentage of the county's land area comprised of rivers, lakes and bay and associated resources for recreational activities such as canoeing, diving and fishing) and winter (region's winter ski facilities and activities). The results confirmed that areas which are endowed with high levels of key natural resource amenity endowments and overall

quality of life experience higher overall levels of growth. Of the five amenity attributes included in the models, all were positively related to at least one measure of growth. The authors concluded that in terms of policy implications, rural areas endowed with key natural resource amenities can manage those resources to capture growth more effectively. This may entail expansion beyond policies that have historically been focused on the extraction of the resource base. However, it is acknowledged by the authors that the analysis does not offer any advice to those areas that may be classified as 'amenity poor'.

Similarly, Deller and Lledo (2007) used principal components analysis to derive five broad-based indices of amenity and quality of life attributes. As in Deller *et al.* (2001), an index is employed for developed recreational infrastructure, in addition to indices for natural amenities. It is argued that simply having access to natural amenities is insufficient to ensure growth. Some basic infrastructure (or built amenities), such as recreation businesses, need to be in place to capture economic activity. It is acknowledged that while the use of principal components analysis to derive broad based indices of amenities and quality of life is superior to simplistic single dimension measures, it is not without limitations. Firstly, it is noted that the breath or number of input variables, of each factor scale is debatable. The higher the number of input variables, the greater the variability of the collection of inputs that a single component can capture. While it is possible to narrow the amenity measure by reducing the number of inputs, the measure may become too simplistic. Secondly, it is not clear cut which is the best way to build the principal components measure. Finally, interpretation of the principal components measure can be difficult. By statistically merging single dimensional measures, insights into specific policy interpretations are diminished.

Monchuk *et al.* (2005) argued that the definition of amenities should include amenities in neighbouring areas since residents tend to travel across amenities to consume amenity services, with the willingness to travel constrained by the opportunity cost of time, transportation costs and household budgets. Within the empirical application the definition for amenities included the own county plus the nearest four counties. As expected, higher recreational amenities had a positive impact on regional economic growth.

Duffy-Deno (1998) used the growth equilibrium framework to test the impact of government wilderness designation on economic growth in the intermountain western US. The motivation for this study is based on the perceived tradeoff between jobs and the wilderness designation. Opponents of wilderness designation argue that this designation reduces the supply of land available to extractive industries, which may lead to higher land prices and dissuade firms from locating in counties with relatively greater amounts of wilderness. Proponents of wilderness designation, on the other hand, argue that wilderness designation can lead to job creation by enhancing the amenity value of the locality and thereby attracting businesses and people to move to the area. Thus, the negative effect on the extractive industries may be offset by the positive impact on other sectors of the economy. Within the main empirical model of simultaneous population and employment growth, the authors found that the wilderness variable, percent of federal land that has wilderness status, was not statistically significant in either the population or employment equation. As noted in Section 3, in order to determine whether the potential negative impact of the wilderness designation on the extractive industry is offset by a positive effect on other sectors of the economy, the authors additionally sub-divided employment into the resource and non-resource sectors. The results indicated that the wilderness variable

is not negatively related with resource employment or positively related with non-resource employment.

In a similar study, Lewis *et al.* (2002) used the growth equilibrium framework to examine the impact of public conservation lands on economic growth in the northern forest region in the US. The results showed that public conservation lands do not adversely impact employment growth. However, it was demonstrated that counties with more conservation land have the effect of attracting new residents or retaining current residents. Since net migration and employment growth are positively related, an increase in conservation land indirectly affects employment growth through its affect on net migration. Note, however, the indirect effects are relatively small.

The above studies are US based. A recent study by Park *et al.* (2008) evaluated the impact of environmental quality on sustainable rural development using a regional growth model for England. Following Deller *et al.* (2001), principal components analysis was used to reduce the number of variables representing environmental quality. The variables representing environmental quality were selected to reflect the potential drivers of economic development in England. Nine groups were identified (figures in parenthesis refer to the number of variables in each group): air pollution (7), traffic volume (7), river water quality (5), wildlife density (4), habitat/land cover type (4), designated areas (5), historic features (3), climate (6) and amenity (9). Principal components analysis was performed for each of the above groups. Rather than use the principal components in the growth model as in Deller *et al.* (2001), Park *et al.* (2008) used the variable from each group with the greatest loading in the first axis. Additionally, the variable with the greatest loading on the second axis was also used for two groupings because of orthogonality in the data, with both the first and second axis describing recognisable trends in the data. Primary variables, rather than derived ones (principal components), were used to make interpreting the outputs of the growth model easier. On the basis of the principal components analysis the environmental variables used within the regional growth model are listed below (grouping in parenthesis):

- Level of NO_2 in the air (air pollution);
- Percentage of river length rated 'good' against chemical water quality (river water quality);
- Percentage of river length rated 'good' against nitrate levels (river water quality);
- Mean number of woodland indicator bird species per 10km square (wildlife diversity);
- Percentage of area covered by semi-natural habitats (land cover and landscape quality);
- Density of grade 1 listed buildings (historic features);
- Density of scheduled ancient monuments (historic features);
- Mean July temperature, 30 year average (climate); and
- Percentage of household delivery points within 4km of a supermarket (amenity).

The results indicated that while some environmental factors are statistically significant, the proportion of the variance is small, implying that other factors not included in the model are important drivers of economic growth. As acknowledged by the author this study includes a small set of non-environmental variables. The authors recommended incorporating factors related to business infrastructures, aspects of the interrelationships between urban and rural areas regarding journey to work and

regional-level employment prospects. Also, the authors noted that it would be desirable to include socio-cultural resources (e.g. clubs, cinemas, museums etc.), developed sport facilities (e.g. sports field, leisure centres and swimming pools), natural and built leisure and tourism attractions (e.g. designated open access land, rights of way, country parks, health farms etc.). It was also not possible to include quality of life measures such as sense of place and community spirit.

Related to quality of life, a number of studies have included measures of crime to explain regional economic growth. For example, Nzaku and Bukenya (2005) found that the variable crime rate had a negative impact on population, employment and income growth, although it was only significant within the income equation. The results within the study by Clark and Murphy indicated that crime rates served as a deterrent for employment growth for firms in the manufacturing, service and trade sectors.

Potential amenity variables within NI study

- Developed amenities. Location of developed amenities available from NINIS website, e.g. outdoor bowling, golf courses cricket pitches, swimming pools, tennis courts and watersports. Could use this to compute number of amenities in ward or distance to nearest amenity. Also, explore further whether proximity to services data is available from the 2005 deprivation index.
- Natural amenities e.g. air pollution, river water quality, wildlife density, habitat cover, designated area, climatic conditions etc. Possible to compute some e.g. land cover and climatic conditions using GIS. Plant diversity and bird diversity data available but difficulties of obtaining data at correct spatial scale.
- Various crime variables available from NINIS.

4.11. Economic Structure

Adelaja *et al*. (2009) considered the following four variables to explore whether the existing economic structure influences economic growth:

- % of total employment in manufacturing
- % of total employment in agriculture
- % of total employment in general services
- % of total employment in financial services

The results demonstrated that the presence of high levels of financial service jobs contribute the most to population growth, followed by general services and manufacturing. In contrast, agricultural share did not significantly affect population growth. In terms of employment, the past percentages of employment in the financial services sector, general services sector, manufacturing sector and agricultural sector did not affect employment growth. It is inferred that while population growth is affected by the structure legacy of the economy, employment growth potentials are not constrained. Similarly, Nzaku and Bukenya (2005) found that the proportion of jobs in manufacturing, services and agriculture each impacted population growth, only

jobs in the services sector was statistically significant in the population change equation. In the population change equation, the results indicated that the share of employment in manufacturing and services positively impact population growth, but the share of employment in agriculture negatively affects population growth. In contrast, Gebremeskel *et al*. (2007) found that the existing economic structure affected employment growth but not population related growth[5]. The estimated coefficients within the employment growth equation were higher for share of people employed within services than that for manufacturing, indicating that industrial restructuring might have helped the service sector to grow faster than manufacturing.

Also related to existing economic structure, Deller and Lledlo (2007) included state/local government employment per 10,000 population as an explanatory variable. The results indicated that greater dependency on the public sector for employment had a negative impact on population and employment growth. Similarly, Duffy-Deno (1997) found that the government sector share of total employment was negatively related to non-resource employment.

Potential economic structure variables within NI study

- Economic structure variables available from 2001 census.

5) Conclusions

The preceding review outlines the multitude of factors that have been taken into consideration to explain spatial variations in population and economic growth. It is apparent that the impact of individual factors varies across study areas and thus, it is difficult to draw conclusions about the potential impact in Northern Ireland. This must be tested empirically. In addition, while some factors are universal other potential explanatory variables need to be modified for the application to the UK. For example, following Park *et al*. (2008) the amenity variables incorporated within the analysis need to reflect the nature of environmental quality in the UK.

Furthermore, the review highlights the limitations of single equation approaches. Failure to account for interdependencies may lead to inappropriate conclusions. The growth equilibrium model provides a systematic framework to account for the complicated interactions of determinants within a spatial context. The growth equilibrium framework has been applied to a variety of study areas, including cities, states, nationwide. The literature indicates that empirical studies based on small units of analysis are particularly prone to spatial effects due to commuting which occurs across regional units. These spatial effects need to be taken into account in applying the modelling system to Northern Ireland.

[5] Note this study uses in-migration and out-migration rather than population.

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