NIRSA Working Paper Series No 52 – September 2009

NIRSA
National Institute For Regional and Spatial Analysis
An Institiúid Náisiúnta um Anailís Réigiúnach agus Spásúil

NUI MAYNOOTH
Ollscoil na hÉireann Má Nuad

Cross-Border Population Accessibility and Regional Growth: An Irish Border Region Case-Study

Declan Curran

Justin Gleeson

John Hume Building, National University of Ireland, Maynooth,
Maynooth, Co Kildare, Ireland.
Áras John Hume, Ollscoil na hÉireann, Má Nuad,
Má Nuad, Co Chill Dara, Éire.
Tel: + 353 (0) 1 708 3350 Fax: + 353 (0) 1 7086456
Email: nirsa@nuim.ie Web: http://www.nuim.ie/nirsa

HEA
Higher Education Authority
An tÚdarás um Ard-Oideachas
Funded under the
Programme for Research
in Third Level Institutions (PRTLI),
administered by the HEA

NDP
NATIONAL DEVELOPMENT PLAN

Cross-Border Population Accessibility and Regional Growth: An Irish Border Region Case-Study

Declan Curran[1]

Justin Gleeson

National Institute for Regional and Spatial Analysis

National University of Ireland Maynooth

Maynooth

Co. Kildare

IRELAND

Declan.G.Curran@nuim.ie

Justin.Gleeson@nuim.ie

September 2009

Abstract

This paper calculates and maps relative population accessibility indices at a national and regional level for the island of Ireland over the period 1991-2002 and assesses whether the changing nature of the border between the Republic and Northern Ireland as it becomes more porous has impacted on the growth of the Irish border region over that time period. A spatial econometric analysis is the undertaken to assess the economic consequences of increased economic integration between Northern Ireland and the Republic. Neoclassical β-convergence regression analysis is employed, with the population accessibility indices used to capture the changing nature of the Irish border.

[1] The authors wish to acknowledge the support of the Irish Social Sciences Platform (ISSP), the International Centre for Cross Border Studies (ICLRD), and the All-Island Research Observatory (AIRO). The authors also wish to thank Morton O'Kelly for helpful comments on an earlier version of this paper and Peter Foley for his excellent research assistance.

1. Introduction

It is well known that many existing national borders have been shaped by the conflicts and post-war negotiations experienced throughout the 20th century and earlier. There is no shortage of instances where national borders owe their origins more to geo-politics than underlying cultural or demographic factors and are the product of an arbitrariness that does not reflect the realities "on the ground". Countries have dealt with the legacy of the imposition of such national boundaries in difference ways. In recent decades there have been numerous cases where domestic and/or international political developments or upheaval have either altered the ways in which national boundaries are now regarded or led to changes in the boundaries themselves: German reunification serves as a vivid example of an existing border being swept away, while cross-border co-operation is illustrated in the relationship between the Republic of Ireland and Northern Ireland. On the other hand, there is no lack of cases such as Israel and Palestine or North and South Korea where relations have only began to thaw in recent years, while the former Soviet bloc hosts a myriad of complex cross-border scenarios experiencing various degrees of hostility. At the heart of many of these conflicts lies the use of partition as a supposed conflict resolution mechanism; Anderson (2008). As O'Leary (2006) notes, partition – where a new border is imposed that cuts through at least one community's national territory and creates at least two separate entities – has a dismal record in resolving conflicts and indeed tends to exacerbate conflicts rather than solve them. Again numerous examples abound, with India and Pakistan being oft-cited.

While the issue of cross border regions has been embedded in Europe since the aftermath of World War I, it has taken on a renewed significance in light of the enlargement of the European Union. Beck (2008) notes that border regions cover 40% of the European Union's territory and are home to 30% of Europe's population. What is more, as of 2006, 197 border regions were receiving financial support from the European Union.[2] The Irish Centre for Cross Border Studies provides an interesting insight into the sheer scale of this financial support and the designated areas: [3]

"The large region containing Lithuania, Latvia, and north-eastern Poland, together with their immediate cross-border neighbours in the Russian salient of Kaliningrad and eastern Belarus – a region with a population of over 10 million people – received just €57 million from the EU INTERREG and TACIS programmes in the period 2004-2006. In stark comparison tiny Northern Ireland, along with the Southern Irish border region, with a combined population of a little over two million, received a colossal €1160 million during the years 2000-2006 from Peace II and INTERREG."

[2] Irish Centre for Cross Border Studies, „A Note from the Next Door Neighbours" December 2006. See http://www.crossborder.ie/home/ndn/ndn0612.html.

[3] ibid

Economic challenges such as labour immobility, low levels of cross-border trade, poor infrastructure, and a dependence on agricultural employment have presented obstacles to sustainable cross-border economic development; Bacsi and Kovacs (2006). However, ICLRD (2008) note that in recent times some business sectors have come to recognise the business opportunities that can emerge in border areas; Perkmann (2007) and IDELE (2005). Perkmann (2006) distinguishes between market-driven and policy-driven integration, with market-driven integration being based on the proliferation and/or reactivation of social or economic relationships. Such processes of cross-borderisation, Perkmann (2006) notes, can often be found to predominate in case of persisting borders where highly accentuated cross-border differentials stimulate strong cross-border activity, for instance in terms of factor costs such as labour. Examples include "Greater China" or the US-Mexican border and in each of these cases market-driven integration processes were induced by the declaration of Special Economic Zones. In contrast to this, Perkmann (2006) characterises policy-driven integration as being based on the building of co-operative relationships between public and other bodies that share certain interests, such as coping with environmental interdependencies or creating cross-border economic spaces.

This paper focuses on one particular aspect of long-run cross-border regional development: population accessibility. The Irish border region is used as a case-study area and its economic growth over the period 1991-2002 is empirically analysed. Population accessibility has long been regarded as a critical ingredient in locational and regional development studies; Harris (1954). Measures of population accessibility offer a useful way for estimating the relative potential of a given location at a national scale. Such measures paint a vivid picture of the impact of population dynamics and redistribution on aggregate levels of access, and how these developments can create economic opportunities for given locations over time; O'Kelly and Horner (2003). However, the manner in which these economic benefits will manifest themselves is a still a source of debate. New Economic Geography models hypothesise that while border regions are expected to benefit from economic integration in the medium and long term due to intensified cross-border interaction, in the short run border regions may face significant adjustment pressure due to increased competition in product and on labour markets; [Krugman and Venables (1993), Brülhart et al. (2004), Niebuhr (2008)]. On the other hand, conventional neoclassical theory predicts that the reduction of barriers to trade associated with economic integration will lead to a step increase in allocative efficiency, and hence in income per capita, and growth will accelerate in the transition to a new equilibrium; [Cambridge Econometrics (1996), Martin (2001)]. In this paper, we focus on the impact of cross-border accessibility on the regional economic growth of the regions on either side of Irish North-South border. To analyse Irish border region economic growth empirically, we employ the neoclassical standard β-convergence "growth equation" regression analysis and incorporate the changing nature of the border using the population accessibility measure of O'Kelly and Horner (2003). The suitability or otherwise of this model for the case-study area is then discussed.

This paper is structured as follows: Section 2 presents a short primer on the origins of the Irish cross-border region. Section 3 provides a brief discussion of population accessibility measures. Results of our accessibility measures at national and regional level are presented in Section 4. Data sources and data compatibility issues are also discussed. In Section 5 we utilise spatial regression techniques to assess whether, over the period 1991-2002, economic consequences of increased economic integration between North and South influence the border region's economic development. Section 6 concludes and offers suggestions for future research.

2. Origins of the Irish Border Region

While it is not our intention to provide a comprehensive treatment of the complex political and social issues which have shaped the history of the Irish border area, it is useful to briefly outline the context in which partition occurred.

While the chain of events leading to partition may have been set in motion by sectarian confiscations and plantations of Irish land by successive British monarchs in the sixteenth and seventeenth century, the actual partition of the North and South of Ireland came into being in 1920 with the establishment of two separate Home Rule parliaments in Dublin and Belfast. The gradual political momentum towards Irish Home Rule in the years leading up to World War I was overtaken by the outbreak of the war. British wartime conscription, the abortive nationalist uprising of 1916 and subsequent execution of the uprising leaders, the resounding election victory of the nationalist Sinn Fein party in 1918, and the ongoing military build-up of both nationalists and unionists all brought about a situation where Irish Home Rule was inevitable. It was in this context that the prospect of partition of Unionist areas in Ulster first emerged. As discussed in detail by Anderson (2008), partition was not an outcome that either Irish nationalists or unionists (largely Catholic and Protestant, respectively) wanted, but was imposed by the British government. The geographic distribution of Catholics and Protestants across the island meant that a complete separation of the two communities was not possible and this proved decisive in the location of the border. The six-county Northern Ireland which came into being was designed to secure a 66% to 33% Protestant majority, as this was deemed more secure by the Belfast unionist community than a nine-county Northern Ireland which would have reduced the Protestant majority to 56% to 44%. The population of the six-county Northern Ireland which emerged from partition was approximately 1.3 million, compared to 2.9 million in the 26 counties which were to become the Irish Free State); CSO (2008).[4] By 2006, their populations had grown to 1.74 million and 4.24 million respectively.

The troubles endured by both communities in Northern Ireland from the 1920s through to the early 1990s are well-documented, as is the peace process which culminated in the Good Friday Agreement of 1998. Without describing these developments in depth, suffice it to say this process has lead to the border becoming more porous and has been accompanied by a concerted effort towards cross-border collaboration. These developments are reflected in increased economic interaction between North and South: for example, CSO (2008) notes that manufacturing trade in both directions has increased significantly between 1992 and 2007, with a 47 per cent increase from the Republic of Ireland to Northern Ireland and a 96 per cent increase from Northern Ireland to the Republic of Ireland. In 2005, the value Northern Ireland's manufacturing trade with the Republic of Ireland was 6% (€232 million) of its manufacturing GVA, while the value of Republic's manufacturing trade with Northern Ireland was 0.8% (€274 million) of its manufacturing GVA. These figures suggest that cross-border trade is on the increase, albeit from a very low base.

The border regions themselves have, in terms of economic development, been adversely affected by partition. The presence of custom posts, imposition of tariffs and trade barriers, and lack of adequate infrastructure investment are just three of the obstacles that have hampered the region's development; ICLRD (2008). Added to this was the intensification of security measures and travel restrictions which were implemented in response to the increased levels of violence witnessed from the late 1960s to 1980s. Only since the 1990s has this situation began to change. Ceasefires, demilitarisations, and the removal of checkpoints, the completion of the European single market, increased EU investment, and increased intergovernmental collaboration have all combined to encourage cross-border interaction. It is this enhanced cross-border interaction that presents an opportunity for border regions on either side of the divide to reap the economic benefits of greater population accessibility.

[4] The Constitution of Ireland (Bunreacht na hÉireann), which came into force in 1937, replaced the Constitution of the Irish Free State and officially named the state "Ireland", or, in the Irish language, "Éire". The Republic of Ireland Act 1948, which came into law in April 1949, declared Ireland a republic and thereby terminated Ireland's membership of the British Commonwealth.

3. Potential Population Accessibility

We begin by undertaking an *exploratory spatial data analysis* of population accessibility as per O'Kelly and Horner (2003), where the calculation and visualisation of accessibility indices with GIS helps us to explore spatial population issues. In this way we capture the impact of population dynamics and redistribution on aggregate levels of access, and how these developments can create economic opportunities for given locations over time.[5]

Following O'Kelly and Horner (2003) we measure accessibility as follows:

$$A_i = \sum_j P_j \exp(-\beta d_{ij}) \quad (1)$$

Where:

A_i: accessibility of area i

P_j : population of area j

β : distance decay parameter

d_{ij} : straight-line distances between areas i and j

Equation (1) above posits that distance negatively impacts on accessibility. This is, of course, intuitively appealing: the further away one is from a given location, the more difficult (in terms of travel costs or perhaps opportunity costs) it becomes to travel to that location. In this way, distance acts as an obstacle to accessibility. Naturally, if one resides at that particular location, there is no obstacle to access arising from distance. The exponential form of (1) allows us to handle this "self potential" i.e. each area's own population, as well as the population of surrounding areas. The distance decay parameter, β, which captures the extent to which increased distance becomes prohibitive to accessibility, is estimated as per O'Kelly and Horner (2003). Suppose that at a distance d from area i, we want fraction Q of the j^{th} area's population to be counted into the i^{th} area's accessibility score:

$$\exp(-\beta d_{ij}) = Q \quad (2)$$

Taking the natural logarithm, rearranging terms, and solving for β yields the following expression:

$$\beta = -\frac{\ln(Q)}{d} \quad (3)$$

[5] While the Harris (1954) measure of market potential was initially devised to capture empirical spatial regularities, more recently times New Economic Geography (NEG) models have incorporated these measures into a theoretical framework; Brakman et al. (2001). These NEG models are discussed further in Section 6.

We can then solve for β by fixing *Q* and *d*. This idea is best illustrated with an example: due to distance, only 50% of the population in an area, *j,* which lies 30 kilometres away from area *i* have access to area *i.* In this example, we can calculate the parameter β = - ln(0.5)/30 = 0.0231.

(4) $$A_i^S = \sum_j P_j \exp(-\beta d_{ij}) \qquad \forall j \ni d_{ij} \le S$$

A second, related approach involves imposing a threshold to delimit which areas may count in area *i*'s accessibility statistic [Plane and Rogerson (1994), O'Kelly and Horner (2003)]. This formulation, presented in equation (4), has the effect of curtailing the tails of the distance decay function, as it is posited that population residing in areas beyond a selected threshold cut-off distance, S, are unable to access area *i.* The distance decay parameter, β, can then be calculated as per equations (2) and (3) above. As noted by O'Kelly and Horner (2003), due to the continuous nature of the distance data used, equation (1) will always produce a more generalized map pattern than equation (4), unless one uses a relatively large value for *S* in equation (4).

4. Population Accessibility Results

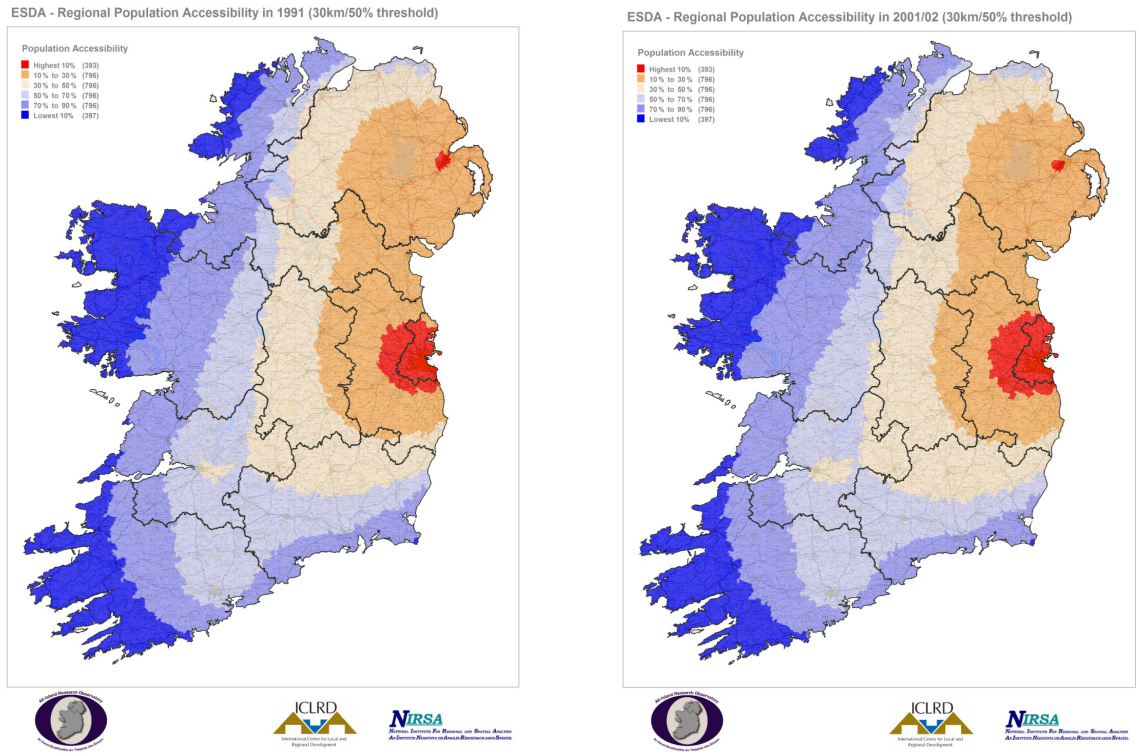
The results of our *exploratory spatial data analysis* of Irish population accessibility are now presented. Population data for 3,414 District Electoral Divisions (DEDs) in the Republic of Ireland and 566 Wards in Northern Ireland, and a matrix of the bilateral distances in kilometres between each of these DEDs and Wards, are used to construct population accessibility indices for 1991 and 2002 (2001 in the Northern Irish case). Republic of Ireland and Northern Ireland population data are available from the Central Statistics Office (CSO) and the Northern Ireland Statistics and Research Agency (NISRA), respectively. A number of important data compatibility issues arise, some of which have been addressed by adjusting the data. These are now briefly discussed. A detailed treatment can be found in Gleeson et al. (2008).

The spatial scale of the DEDs and Wards varies considerably, with the average size and population of DED being 20.4 km^2 and 1,062 compared to 24 km^2 and 2,895 for Wards. This creates a modifiable areal unit problem (MAUP), whereby the difference in scales influences the patterns and statistical relationships found when using the data; Fotheringham and Wong (1991). What is more, variations exist between the spatial boundaries in 1991 and 2002. This has been relatively minor in the DEDs, where the boundaries have remained unchanged but due to confidentiality issues a small number of DEDs have been merged and standardised over the 1991-2002 period. In Northern Ireland, however, the Ward boundaries have changed considerably. In order to make the data comparable over time, the

2001 Ward population has been re-assigned to the 1984 Ward boundaries. This involves using the Northern Ireland Grid Square Product to facilitate a proportioning of 2001 population across grid squares. The 1984 Ward boundaries overlaid on the grid squares and the grid squared values are aggregated to the 1984 Ward boundaries. The result is a matching set of Wards (566) between 1991 and 2001.

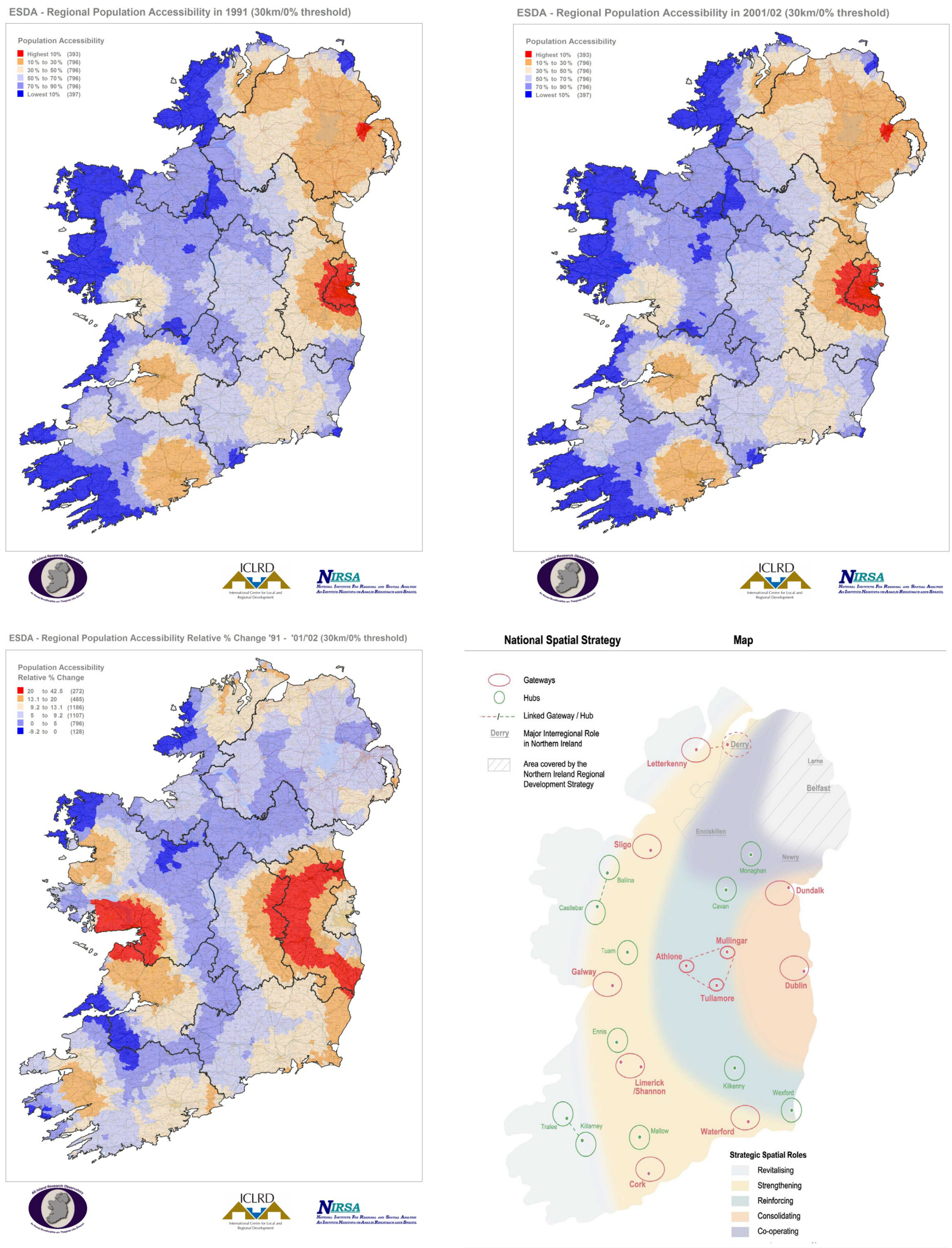
The accessibility indices, illustrated in Figures 1 and 2 below, are calculated as per equation (1) above. As outlined in the previous section, we set the distance decay parameter, β, as follows: due to distance, only 50% of the population in an area, *j,* which lies 30 kilometres away from area *i* have access to area *i.* This allows us to solve equation (3) and calculate the parameter $\beta = -\ln(0.5)/30 = 0.0231$. The accessibility indices presented in Figure (2) are calculated as per equation (4) and we impose the restriction that the population residing in areas beyond a selected threshold cut-off distance, $S = 30$ km, are unable to access area *i.* Figures 3 and 4 illustrate scenarios where the border is initially closed and eventually opened, retaining these values for β and *S*. These scenarios are presented separately for the Republic of Ireland and Northern Ireland, and the changes in the resulting accessibility indices are then discussed.

Figure 1: Population Accessibility Indices, 1991 (left) and 2002 (right)



As illustrated in Figure 1 above, the accessibility indices provide a "broad brushstroke" view of accessibility at a national scale. Salient features emerging from Figure 1 are the presence of a strong eastern corridor, the notable accessibility hotspots of Dublin and Belfast, and the relatively lower accessibility of the whole western seaboard. However, the general impression created by Figure 1 appears to be an unrealistic one. The failure of large urban centres, apart from Belfast and Dublin, to feature on the map suggests that the accessibility indices are "oversmoothed". Following O'Kelly and Horner (2003), we adjust the accessibility indices to incorporate the restriction that population residing in areas beyond a selected threshold cut-off distance, S = 30 km, are unable to access area *i*. This ensures that accessibility is limited to a 30 km zone around each ED. In this way, the accessibility indices presented in Figure 1 can be adjusted for the continuous nature of the distance data. Results of this restricted version of the accessibility index are presented in Figure 2. As an aid to interpretation we also include in Figure 2 (bottom right) a map of the National Spatial Strategy's (NSS) Gateway and Hub towns, complete with NSS colour-coded "spatial roles".

Figure 2: Population Accessibility with 30 km Threshold Distance, 1991-2002 (top left and right); % Accessibility Change and NSS Gateways/Hubs (bottom left and right)



While the accessibility indices presented in Figure 2 adhere to the broad trends illustrated in Figure 1, they capture a more plausible pattern as the largest Irish urban centres are now clearly visible. The accessibility indices of Cork, Galway, Limerick and Waterford are now all discernable, as are those for the Letterkenny/Derry area. What is more, distinct changes in the accessibility indices over the period 1991-2002 can also be identified. The most notable changes (Figure 2, bottom left) include the increased accessibility of the greater Dublin and east coast areas. There are also noticeable accessibility increases on the west coast, Galway, Limerick, and Tralee/Killarney all being clearly visible. This spatial pattern of accessibility increases is particularly interesting in the context of the Gateway and Hub towns designated in the National Spatial Strategy (2002). While the National Development Plan 2000-2006 identified Dublin, Cork, Limerick/Shannon, Galway and Waterford as existing gateways, the NSS designated four new national level gateways - the towns of Dundalk and Sligo and the linked gateways of Letterkenny/(Derry) and the Midland towns of Athlone/Tullamore/Mullingar. In addition, the NSS identified nine, strategically located, medium-sized "hubs" which, it is envisaged, will support, and be supported by, the gateways and will link out to wider rural areas. The hubs identified are Cavan, Ennis, Kilkenny, Mallow, Monaghan, Tuam and Wexford, along with the linked hubs of Ballina/Castlebar and Tralee/Killarney. One feature of note in Figure 3 is the relatively low population accessibility indices in the mid-west and border region (south of the border) – a finding which may provide useful insights for future debate on the NSS and gateway/hub choices.

Another relevant issue is the extent to which cross-border accessibility can have differing impacts on either side of the border. Figure 3 (left) illustrates the accessibility indices for the Republic of Ireland in 1991 where we treat the Northern Ireland as being inaccessible. In this instance we are trying to characterise a situation where cross-border travel and trade are restricted and we refer to this scenario as "closed border". In contrast, Figure 3 (right) illustrates the accessibility indices for the Republic of Ireland in 2002 where we treat Northern Ireland as being accessible and we refer to this scenario as "open border". In this way, we can identify which regions in the Republic and Northern Ireland stand to benefit in terms of enhanced population accessibility from the border becoming more porous over time. From Figure 3 it is clear that in the Republic the areas around Letterkenny in the Northwest, Dundalk in the East, and Cavan and Monaghan show the greatest changes in accessibility over the period 1991-2002. This stands to reason, given Letterkenny's proximity to the Northern Irish city of Derry and Dundalk's proximity to the Northern Irish town of Newry.

Figure 3: ROI Population Accessibility with 30 km Threshold Distance, 1991 with Border Closed (left) and 2002 with Border Opened (right)

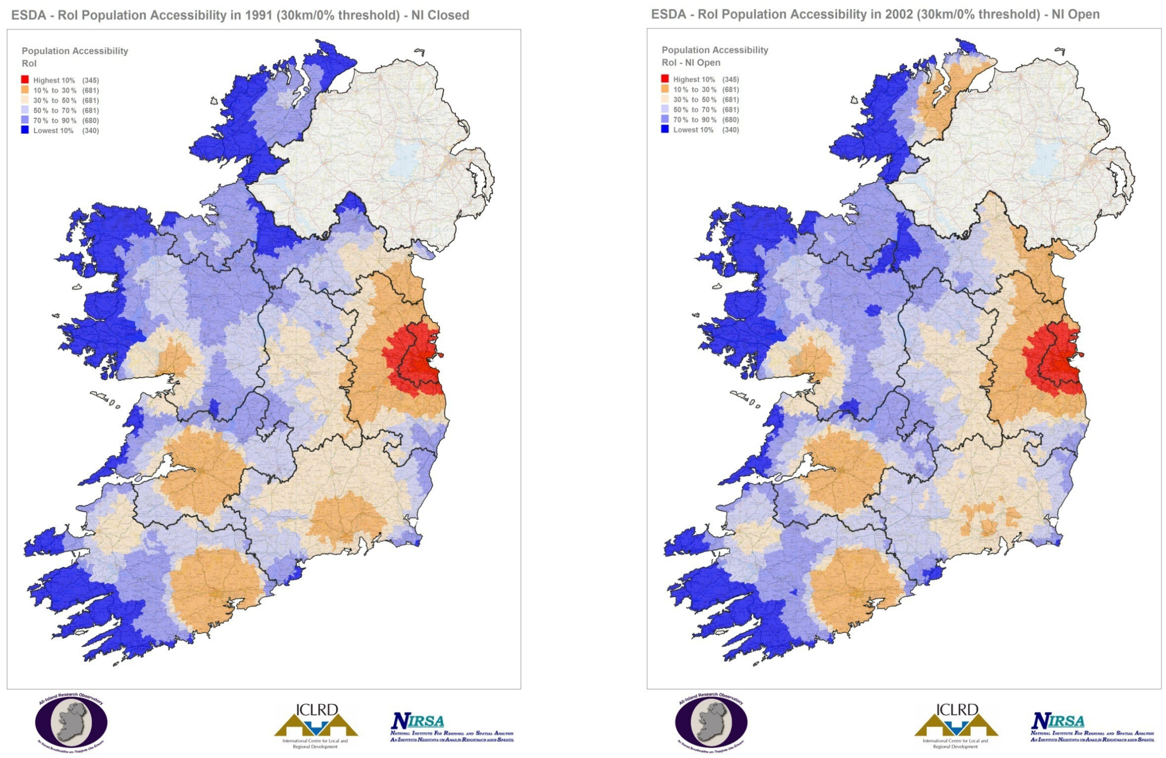
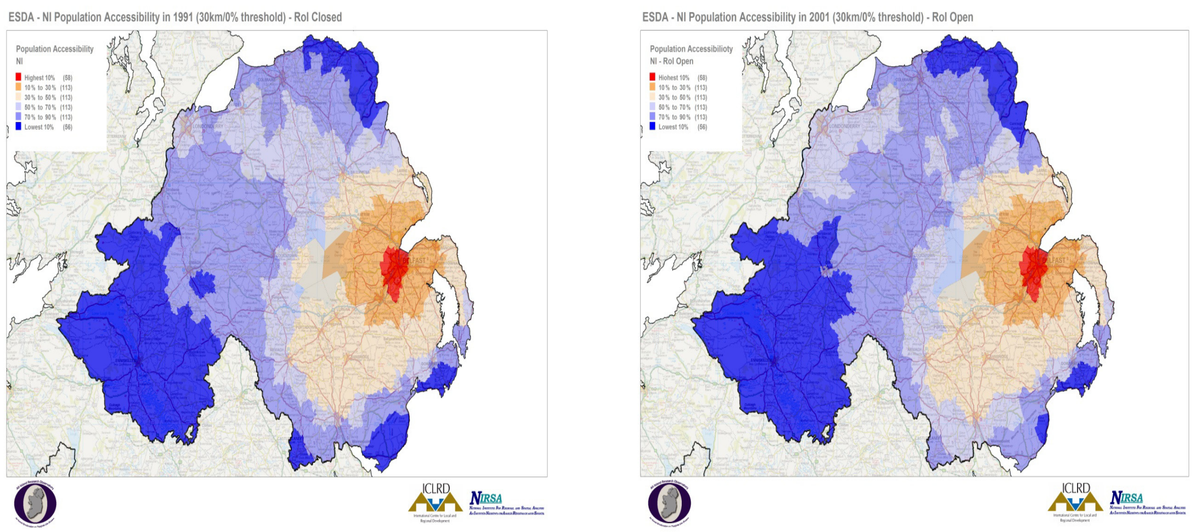


Figure 4: NI Population Accessibility with 30 km Threshold Distance, 1991 with Border Closed (left) and 2002 with Border Opened (right)



In the Northern Ireland accessibility indices of Figure 4, the Derry region does not feature as prominently as its cross-border neighbour Letterkenny does in Figure 3. Surprisingly, the Northern Irish accessibility indices do not display an increase corresponding to that of Cavan and Monaghan across the border (Figure 3). While this interpretation relies heavily on visual inspection, it does suggest that the border areas in the Republic enjoy greater potential in terms of population accessibility that the border regions on the Northern side. Though not incorporated into the accessibility indices used in this paper, future research might fruitfully be directed towards ascertaining whether the prevailing economic and socio-demographic characteristics on each side of the border (such as urbanisation, economic mass and industry structure, demographic mass and structure) influence the degree to which the benefits of accessibility will be realised over time.

5. Population Accessibility and Regional Growth in the Irish Border Region

Given the enhanced population accessibility and market potential open to the Irish border region areas in light of the border becoming more porous, it is natural to wonder how this development has impacted regional economic growth in the area over time. To analyse this empirically, we employ β-convergence "growth equation" regression analysis and incorporate the measures of population accessibility constructed as per Sections 3 and 4.

5.1 Convergence and the Modelling of Regional Growth

While a variety of distinct convergence concepts have emanated from the economic growth literature, one form of convergence which has received particular attention over the last two decades has been that of β-convergence; [Baumol (1986), Barro and Sala-I-Martin (1992), and Mankiw et al. (1992)]. This form of convergence occurs when poor regions grow faster than richer regions, resulting in a catching-up process where the poor regions close the economic gap that exists between their richer counterparts. This approach originates from neoclassical growth model developed in the 1950s and 1960s [Solow (1956), Swan (1956), Cass (1965), Koopmans (1965)]. Neoclassical growth theory predicts a tendency for poorer regions to show faster growth than richer regions under certain simplifying assumptions, as both are considered to be converging toward the same level of per capita income. Under weaker assumptions, regions may be converging on different equilibrium levels of per capita income, and their growth rate is inversely related to the difference between their present per capita income and their equilibrium level. The theory predicts that the reduction of barriers to trade associated with economic integration will lead to a step increase in allocative efficiency (due to a reallocation of resources from low-productivity to high-productivity uses) and hence in income per capita; [Cambridge Econometrics (1996), Martin (2001)]. Growth will accelerate in the transition to a new equilibrium. Sustained long-run growth in the model is driven by exogenous technical progress, so does the theory does not identify any contribution from economic integration to a higher long-run growth rate.

Endogenous growth models, which have emerged since the late 1980s, have sought to provide a theoretical framework within which per capita income does not tend to converge on an equilibrium value driven by exogenous technological progress. In these models, the long-run growth rate is determined within the model, be it through the inclusion of knowledge spillovers and human capital, research and development and imperfect competition, or the explicit modelling of technology diffusion; [Romer (1986), Lucas (1988), Rebelo (1991), Aghion and Howitt (1992)]. This opens up the possibility that economic integration can contribute to a higher long-run growth rate by stimulating the accumulation of those forms of capital to which returns are not diminishing. However, the same feature makes it uncertain whether poorer regions will tend to show faster growth than richer regions, and allows the possibility of a cumulative causation process that could widen regional disparities; Cambridge Econometrics (1996). Empirical evidence has shown that some regions managed to sustain high per capita income over a long time span while other regions seemed to be trapped in a low income growth path. These persistent differences in per capita income are at odds with the standard neoclassical growth model. Despite these conflicting findings, β-convergence analysis has retained its popularity as an empirical test for convergence (or lack of), not least because it can easily be augmented to include newly developed spatial econometric analytical techniques.

5.2 Estimating Regional Growth using Spatial Econometric Techniques

The now-standard specification of β-convergence can be expressed in vector form as follows:

(5) $$\mathbf{ln}\left(\frac{y_{t+k}}{y_t}\right) = \alpha + \mathbf{(}1 - e^{-\lambda k}\mathbf{)}\,\mathbf{ln(}y_t\mathbf{)} + \varepsilon_t$$

where $y_{i,t}$ is per capita income of state i in year t; α represents the intercept term, and $(1\text{-}e^{-\lambda k})$ is the convergence coefficient, which is usually reparametrized as $\beta = (1\text{-}e^{-\lambda k})$. The β coefficient is then estimated using Ordinary Least Squares (OLS), and the speed of convergence, λ, can then be calculated. A negative estimate for β indicates that growth rates of per capita income over the k years is negatively correlated with initial incomes or employment – a finding which is interpreted as a support for the hypothesis of convergence. It is assumed that the error terms from different regions are independent:

(6) $$E[\varepsilon_t \varepsilon_t'] = \sigma_t^2 I\,.$$

This unconditional β-convergence specification can then be augmented, as per Barro and Sala-I-Martin (1992), to include a range of control variables (such as differences in human capital accumulation, infrastructure disparities, industrial structure, as well as dummy variables reflecting different regional characteristics) which may capture differences in the paths of steady-state income per capita.

Equations (5) and (6) can be augmented to capture interactions across space, a refinement which reflects more accurately the realities of the growth process across regions. As Henley (2006) notes, this spatial dimension can exert its influence on regional growth through numerous channels: adjustment costs and barriers to labour and capital mobility, spatial patterns in technological diffusion, the ability of regions to pursue independent regional growth policies, and the extent to which neighbouring regions interact and benefit from spillover effects. Any analysis which ignores the influence of spatial location on the growth process runs the risk of producing biased results. Following from Anselin (1988), spatial dependence has been incorporated into the β-convergence specification in two ways: it can be included as an explanatory variable in the specification or it can be modelled as operating through the error process.[6] The former, known as a Spatial Autoregressive Model (SAR), depicts a region's growth as being directly affected by growth in neighbouring regions. This direct spatial effect is independent of the exogenous variables and is captured by including a spatial autoregressive parameter, ρ, and a spatial weight matrix, *W*, in the specification:

(7) $$\ln\left(\frac{y_{t+k}}{y_t}\right) = \alpha + (1 - e^{-\lambda k})\ln(y_t) + \rho W \ln\left(\frac{y_{t+k}}{y_t}\right) + \varepsilon_t$$

It may be the case that, rather being directly affected by the growth rate of its neighbours, a region's growth rate may be influenced by a complex set of random, unexpected shocks transmitted across space. Such unexpected shocks take the form of spillovers associated with technology or consumer tastes. In this SEM case, the spatial influence does not enter the systematic component of the specification. Instead, it is captured in an error term which contains a spatial error coefficient, ζ, and an idiosyncratic component, *u*, where $u \sim N(0, \sigma^2 I)$.

(8) $$\ln\left(\frac{y_{t+k}}{y_t}\right) = \alpha + (1 - e^{-\lambda k})\ln(y_t) + \varepsilon_t \qquad \text{where} \quad \varepsilon_t = \zeta W \varepsilon_t + u_t$$

[6] For more detailed treatment of spatial autoregressive and spatial error models, see Bernat (1996), Rey and Montouri (1999), and Fingleton and Lopez-Baso (2006).

It is also possible to incorporate both the spatial autoregressive and spatial error components into one specification, as per equation (9) below. In this case, it is recommended that two distinct spatial weight matrices are used so as to avoid identification problems; LeSage (1998).

(9) $$\ln\left(\frac{y_{t+k}}{y_t}\right) = \alpha + (1 - e^{-\lambda k})\ln(y_t) + \rho W_1 \ln\left(\frac{y_{t+k}}{y_t}\right) + \varepsilon_t \qquad \text{where} \quad \varepsilon_t = \zeta W_2 \varepsilon_t + u_t$$

We now report results for cross-sectional growth equation regressions which test for convergence using the SAR, SEM, and SAC specifications.

5.3. Border Region Growth Equation Results

For the empirical analysis that follows, we employ a rather loose definition of the Irish border region: we count the DEDs of all the Republic of Ireland counties that touch the border and the Wards of all the Northern Irish districts that touch the border as the "border region". While this does not adhere to any administrative definition, there is no reason to believe that an administrative region would be the appropriate economic functional area for this analysis. For this reason, we opt for a relatively broad definition of the border region and leave the issue of border region economic functional areas for future research. For our purposes this border region comprises of the Northern Irish districts of Derry, Down, Dungannon, Armagh, Fermanagh, Newry and Mourne, Strabane, and Omagh and the Republic of Ireland counties of Donegal, Leitrim, Cavan, Monaghan, Louth. Table 1 provides summary statistics of border region DED and Ward manufacturing employment growth for 1991-2002.

Table 1: Summary Statistics, DED and Ward Manufacturing Employment Growth, 1991-2002

	Border Region DEDs - Republic of Ireland	**Border Region Wards - Northern Ireland**
Average Annual Growth91-02	-1.46%	-1.08%
Maximum Growth	22.71% (Kiltyclogher, Leitrim)	7.27% (Creggan, Derry)
Minimum Growth	-14.03% (Knockalla, Donegal)	-7.27% (St. Peters, Derry)
Standard Deviation	4.09	2.33
No. of EDs/Wards with >0% Growth	178	51
Total No. of EDs/Wards	422	185

Note: The"border region" in this analysis refers to DEDs of all Republic of Ireland counties and the Wards of all Northern Irish districts that touch the border

Due to the unavailability of income or GDP data at Ward level, we use the average annual growth (over the period 1991-2002) of manufacturing employment expressed as a percentage of working age population for each DED and Ward as our dependent variable. The log of 1991 manufacturing employment as a percentage of working age population is then used as an explanatory variable representing the initial position of each DED and Ward. While income per capita is the more common indicator of living standards in this line of research, the distribution of employment activity is also used. As Desmet and Fafchamps (2006) note, the employment data can be more informative about where economic activity is located and allows for sectoral disaggregation. The manufacturing employment classification for the Republic of Ireland in both 1991 and 2002 relates to those aged 15+ who are at work in an economic activity classed as (1) Mining, quarrying, and turf production, (2) Manufacturing industries, and (3) Electricity, gas, and water supply. The classification in Northern Ireland for 1991 is based on those aged 16+ (employees and self employed) in (1) Energy and water, (2) Mining, (3) manufacturing metals etc., and (4) Other manufacturing. The 2001 classification for Northern Ireland relates to those 16-74 employed in (1) Mining and quarrying, (2) Manufacturing, and (3) Electricity, gas and water supply. Republic of Ireland and Northern Ireland manufacturing employment data are available from the Central Statistics Office (CSO) and the Northern Ireland Statistics and Research Agency (NISRA), respectively.

We use our accessibility indices as proxies for the border moving a situation of restricted cross-border movement to being quite porous. For the former we use the indices presented in Figures 3 (left) and 4 (left) where, for 1991, the border is assumed to be closed, while for the latter we take the indices presented in Figures 3 (right) and 4 (right) for 2001 which posit an open border. Again, these accessibility indices for 1991 and 2002 are merely intended to serve as proxies reflecting the changing nature of the border, rather than actual measures of the level of cross-border activity. This approach is not unlike that of Redding and Sturm (2008), who use measures of market potential as an explanatory variable. The change in the accessibility index over the 1991-2001 period *(Δ Accessibility Index 1991-2002*) is a relative measure giving a heavier weight to those DEDs and Wards who have greater potential benefitting from a more porous border. Our specification includes one binary dummy variable *(ROI dummy*), which is assigned a value of 1 for DEDs in the Republic of Ireland and 0 for Wards in Northern Ireland. This dummy variable is intended to be a "catch-all" variable, controlling for an array of factors influencing DED and Ward growth due to their being in the Republic or Northern Ireland. Given that the DEDs and Wards utilise different currencies (currently Sterling and Euro, and formerly Sterling and Irish Punt), and that DEDs and Wards are subject to distinct national public investment and financial assistance policies, we acknowledge that it may be asking a lot of one dummy variable to control completely for these influential factors. The SAR, SEM, and SAC specifications include the following spatial weights: the SAR and SEM specifications both characterise W as a first-order binary contiguity matrix, while SAC characterise W_1 as a binary contiguity matrix and W_2 as a nearest neighbour-based spatial weight matrix. In keeping with equations (5)-(9) above, ρ and τ represent the spatial autocorrelation coefficient and spatial error coefficient, respectively.

Table 2: Border Region SAR, SEM, and SAC Growth Equations, 1991-2002

Dependent Variable: Growth of Average Annual Manufacturing Employment (% of pop)*, 1991-2002*			
	SAR	SEM	SAC
Constant	-0.082	-0.084	-0.086
	(0.005)***	(0.010)***	(0.006)***
Log Manufacturing Emp'ment (% of pop) 1991	-0.042	-0.042	-0.041
	(0.003)***	(0.005)***	(0.003)***
Δ Accessibility Index 1991-2002	-0.006	-0.006	-0.006
	(0.002)***	(0.002)***	(0.002)***
ROI Dummy	0.005	0.005	0.006
	(0.003)*	(0.003)*	(0.003)**
ρ (SAR)	0.120		0.279
	(0.010)***		(0.116)**
τ (SEM)		0.050	-0.072
		(0.128)	(0.021)***
Adjusted R^2	0.34	0.34	0.35
Log Likelihood	1,488.61	1,487.09	-
Number of Obs	607	607	607

Note: SAC uses GMM estimation method; SAR and SEM use maximum likelihood method .Standard errors are given in parenthesis. Significance at ***1%, **5%, and *10% level.

From Table 2 above it is clear that the variable capturing the changing nature of the Irish border, Δ *Accessibility Index 1991-2002,* exhibits a negative significant coefficient across all specifications. This finding is not indicative of a gain due to allocative efficiency over the period 1991-2002, but may suggest that competitive factors have had a negative impact on border region manufacturing employment. These indications have implications for the choice of theoretical framework used to underpin this research, and are discussed further in Section 6. Either way, it would appear that those areas that have greatest potential to gain from enhanced population accessibility did not reap those benefits over the period 1991-2002 – they actually appear to fare worse in terms of manufacturing employment as a result of enhanced accessibility. The *ROI dummy* exhibits positive coefficients, though these are only significant at 10% level in SAR and SEM specifications and significant at 5% in SAC specification. This indicates that being located in the Republic of Ireland has been beneficial to manufacturing employment over the period 1991-2002.

The coefficient of *Log Manufacturing Emp'ment (% of pop) 1991* is negative significant across all specifications. As discussed above, this negative significant coefficient is taken to be indicative of convergence in empirical "growth equation" regression analysis.[7] What is more, the value of the coefficient points to a convergence speed of approximately 3.7% per annum. Of course, in this instance convergence may not be that positive a finding – manufacturing employment contracted over the period 1991-2002, and the high convergence may be capturing a collapse to the mean figure. The spatial coefficients (ρ and τ) are significant in the SAR and SEM cases, with the spatial autocorrelation coefficient being positive, as one would expect. In SAC specification the spatial autoregressive coefficient is also positive and significant, but the spatial error cofficent has a negative significant coefficient. This is counter-intuitive and could, for example, be due to a spatially correlated omitted variable. The adjusted R^2 statistic is relatively low (34-35%), though this is a common feature of this type of "growth equation" regression analysis.

The findings presented in Table 2 should be tempered by a number of "health warnings". As discussed in Section 4, serious issues arise in relation to the spatial scale and spatial units used in the analysis. What is more, due to the high level of spatial disaggregation of the geographical units, not explicitly controlling for commuter flows is a further potential source of error. A further source of noise arises from the employment data. It is standard in this type of analysis to average the data over 3-5 years. However, as our data only spans 11 years, we do not smooth the data in this fashion. An additional issue may be the risk of endogeneity or reverse causality between accessibility and the dependent variable, annual growth manufacturing employment. One could argue that accessibility prior to the imposition of the border in 1920 has influenced the location of current border region employment and thus the technique of instrumental variables should be used to correct for this. However, as this assumes that accessibility and mobility prior to 1920 is comparable to current day trends, we do not pursue this argument here. We also check for correlation between the explanatory variables themselves, as well as between the explanatory variables and the residuals, and find nothing of concern. While this list of caveats may be a cause for concern, we feel that the statistically significant results across specifications presented in Table 2 are quite robust.

[7] The dispersion of income per capita between regions can also be measured by analysing the change in standard deviation of the income per capita variable over time. This approach is referred to as "sigma convergence"; see Barro and Sala-I-Martin (1992). The standard deviation of border region *Log Manufacturing Emp'ment (% of pop)* decreased from 0.477 to 0.407 over the 1991-2002 period. This narrowing of the standard deviation is indicative of a convergnce process.

5. Conclusion

This paper aims to (i) calculate relative population accessibility indices at a national and regional level for the island of Ireland over the period 1991-2002 and (ii) assess whether the changing nature of the Irish border as it becomes more porous has impacted on the growth of the Irish border region over that time period. The accessibility indices presented above provide a vivid overview of accessibility at a national scale and are now computationally feasible thanks to the emergence of detailed DED- and Ward-level population datasets and suitable statistical and GIS software. These accessibility indices are particularly interesting in the context of the Irish National Spatial Strategy, as the future development of the designated Hub and Gateway towns will no doubt be influenced by the reservoirs of market potential from which they can draw, and how this market potential evolves over time. The focus of this paper is the regional economic growth of the Irish border region. In this context, the enhanced population accessibility afforded to cross-border regions as the Irish border becomes softer is of great interest. The relative population accessibility indices for 1991 and 2002 presented in Section 4 suggest that the border areas in the Republic enjoy greater potential in terms of population accessibility that the border regions on the Northern side. This idea of the Republic and Northern Ireland deriving differing benefits from the changing nature of the border certainly merits further research, and could be analysed in the context of the prevailing economic and socio-demographic characteristics on each side of the border. The empirical spatial regression analysis of Section 5 is based on the neoclassical convergence model and assesses the impact of the changing nature of the Irish border on the annual growth of border region manufacturing employment over the period 1991-2002. The 1991 and 2002 population accessibility indices of Section 4 are utilised as proxies for the border moving from a relatively restricted to a more open status. Key findings include (i) those areas that have greatest potential to gain from enhanced population accessibility did not enjoy enhanced manufacturing employment over the period 1991-2002 – they actually appear to fare worse in terms of manufacturing employment as a result of enhanced accessibility and (ii) the DEDs and Wards of the border region exhibit convergence over the 1991-2002 period, with a convergence speed of 3.7% per annum. However, as border region manufacturing employment contracted over the period 1991-2002, this convergence may reflect a collapse to the mean figure.

The neoclassical growth framework underpinning the empirical analysis of this paper raises a number of problems, not least the fact that its prediction that the reduction of barriers to trade associated with economic integration will lead to a step increase in allocative efficiency and hence in income per capita is not borne out in the border region 1991-2002 manufacturing employment data. A further issue concerns price differentials between the Republic and Northern Ireland. While the neoclasssical growth theory predicts a convergence in real wages, it is debatable whether this fully characterises the Irish border region scenario where cross-border retail prices differ substantially due both to currency exchange rates and tax differentials. These theoretical shortcomings may lead one to consider alternative theoretical frameworks. Two questions arising from the empirical analysis undertaken above point to a class of New Economic Geography (NEG) models as offering additional insights: (i) is there evidence of a "home market effect" where the Republic of Ireland experiences a greater gain from exporting to Northern Ireland than the other way around? and (ii) could it be that, rather than enhanced accessibility bringing initial benefits to the border region, competitive factors may have exerted a negative impact on border region manufacturing employment? NEG models deal with the distribution of economic activities across space which depends on the relative strength of agglomeration and dispersal forces. These agglomeration and dispersal forces are influenced by factors such as the size of a region's home market, scale economies, and transport costs. Brülhart et al. (2004) explicitly incorporate economic integration of regions, and the impact of integration on the spatial dispersion of economic activity, into the NEG framework. Brülhart et al. (2004) characterise economic integration as a decline in cross-border transport costs in a three-region model, comprising of a domestic interior, domestic border region, and foreign region. As Niebuhr (2008) puts it, this decline in cross-border transport costs gives rise to two opposing forces: (i) rising accessibility of the foreign market increases the incentive to locate near foreign consumers for the domestic industry, i.e. to locate in the border region, because the importance of domestic demand declines relative to foreign demand, and (ii) an increased competition by foreign firms, especially in border regions. Domestic centripetal, agglomerating, forces are weakened by (i) as the border region gains in attractiveness, while (ii) reduces the attractiveness of border regions as production sites. The question then is "which force triumphs?" According to Brülhart et al. (2004), the effect of the centrifugal force dominates and the probability that domestic manufacturing concentrates in one region increases due to declining external trade costs. If the border region has better access to foreign demand, its attractiveness relative to the internal domestic region will rise in case of trade liberalisation. While this theory may offer potential for explaining the location of Irish border region economic activity, empirical structural tests can be problematic; Brakman et al. (2002). That said, Sturm and Redding's (2008) empirical analysis of changing market potential due to German division and subsequent re-unification illustrates how specific predictions of NEG models can be empirically tested. Furthermore, NEG models do not allow to draw precise conclusions as integration might not be sufficient to destabilise the existing spatial distribution of economic activity; Niebuhr (2008). In the Brülhart et al. (2004) model, a concentration of manufacturing in the (domestic) interior region is only possible in case a comparatively large number of manufacturing firms were located in that region in the pre-integration period. The potential of NEG models to explain the observed trends in the location of Irish border region economic activity is currently being investigated by the authors.

It may well be that this paper raises more questions than it answers. Questions such as “how can areas capitalise on their population accessibility and market potential?” and “how should population accessibility influence policymakers in the area of cross-border cooperation?” have not been tackled head-on here but it is hoped that this paper can be a platform for future research in this sphere. However, this paper does contribute to the on-going discussion on how the economic potential of cross-border regions should be characterised in the broader national context and how this economic potential can evolve over time. We also shed light on the extent to which cross-border accessibility can have differing impacts on each side of the border. Further research should provide insights in to how the prevailing economic and socio-demographic characteristics on each side of the border (such as urbanisation, economic mass and industry structure, demographic mass and structure) can influence the degree to which the benefits of accessibility will be realised. As the population on both sides of border areas gradually move away from the tendency of living “back-to-back” (Busteed, 1992) and as softer borders become the norm, issues such as population accessibility and relative market potential become all the more pertinent for cross-border regions.

References:

Aghion, P., and P. Howitt, (1992) A Model of Growth Through Creative Destruction , *Econometrica* 60 2 323-351.

Anderson, J. (2008) Partition, Consociation, Border-Crossing: Some Lessons From the National Conflict in Ireland/Northern Ireland, Nations and Nationalism 14 (1) 85-104.

Anselin, L. (1988) *Spatial Econometrics: Methods and Models*, Kluwert Academic.

Bacsi, Z. and E. Kovacs (2006) The Role of Cross-Border Cooperation in Rural Development – A New European Perspective, *Proceedings from the First International Conference on Agriculture and Rural Development*, Topuska, Croatia.

Barro, R. and X. Sala-I-Martin, (1992) Convergence, *Journal of Political Economy* 100 223-251.

Baumol, W.J. (1986) Productivity Growth, Convergence, and Welfare: What the Long-run Data Show, *American Economic Review* 76: 1072-1085

Beck, J. (2008) Lessons from an Institute for Cross-Border Cooperation on the Franco-German Border, *Journal of Cross Border Studies*, No.3.

Bernat, A. (1996) Does Manufacturing Matter? A Spatial Econometric View of Kaldor's Laws, *Journal of Regional Science* 36: 463-477.

Busteed, M. (1992) The Irish Border: From Partition and Confrontation to Cooperation? *Boundary Bulletin*, No. 4, 13-17.

Brakman, S., Garretsen, H., and C. van Marrewijk (2001) *An Introduction to Geographical Economics*, Cambridge.

Brülhart, M., Crozet M., and P. Koenig (2004) Enlargement and the EU Periphery: The Impact of Changing Market Potential, *The World Economy*, 27(6) 853-875.

Cambridge Econometrics (Fingleton B., Lewney R. and Pinelli D.), Single Market review 1996: Aggregate and regional impact. Regional growth and convergence. Study for the European Commission 1996.

Cass, D. (1965) Optimum Growth in an Aggregative Model of Capital Accumulation", *Review of Economic Studies*, 32, 233-240.

Central Statistics Office (2008) *Ireland North and South – A Statistical Profile 2008* (Dublin: CSO)

Department of Environment and Local Government (2002) *National Spatial Strategy for Ireland, 2002-2020*. (Dublin: Government Publications Office).

Department of Finance (1999) *National Development Plan, 2000-2006*. (Dublin: Government Publications Office).

Desmet K. and M. Fafchamps (2006) Employment concentration across U.S. counties, *Regional Science and Urban Economics* 36(4): 482-509

European Commission (1996) Economic evaluation of the Internal Market European Economy http://ec.europa.eu/economy_finance/publications/publication7875_en.pdf

Fotheringham, A.S. and D. Wong, (1991) The Modifiable Areal Unit Problem in Multi-Variant Statistical Analysis, *Environment and Planning A*, 23, 1025-44.

Fingleton, B. and E. Lopez-Baso (2006) Empirical Growth Models with Spatial Effects, *Papers in Regional Economic Science* 85(2)

Gleeson, J., Kitchin, R., Bartley, B., Driscoll, J., Foley, R., Fotheringham, A.S., and C. Lloyd (2008) *The Atlas of the Island of Ireland*, AIRO and ICLRD.

Harris, C. (1954) The Market as a Factor in the Localisation of Industry in the US, *Annals of the Association of the American Geographers* 44(4):315-348.

Henley, A. (2005) On Regional Growth Convergence in Great Britain, *Regional Studies* 39, 1245-1260

ICLRD (2008) *Fostering Mutual Benefits in Cross-Border Areas*, International Centre for Cross Border Studies, Armagh.

IDELE (2005) Cross-Border and Transnational Cooperation for Local Employment Development, *Eighth Thematic Report of the IDELE Project*, European Commission.

Koopmans, T. C. (1965) On the Concept of Optimal Growth, in *The Econometric Approach to Development Planning,* Amsterdam, North Holland.

Krugman, P. and Venables A.J. (1993) Integration, Specialization, and Adjustment, NBER Working Paper No. 4559, Cambridge Massachusetts

Krugman, P. and Venables A.J. (1990) Integration and the Competitiveness of Peripheral Industry, in: Bliss C (Ed.), Unity with Diversity in the European Economy: the Community's Southern Frontier, Cambridge University Press, 56-77

LeSage, J.P. (1998) *Spatial Econometrics*, Economics. University of Toledo

Lucas, R. E. (1988) On the Mechanics of Development Planning, *Journal of Monetary Economics*, 22 1 3-42.

Mankiw G, Romer D. and D. Weil (1992) A Contribution to the Empirics of Economic Growth, *Quarterly Journal of Economics* 107: 407-437.

Martin, R. (2001) EMU versus the regions? Regional Convergence and Divergence in Euroland, *Journal of Economic Geography* 1 51-80.

Niebuhr, A. (2008) Spatial Effects of European Integration: Do Border Regions Benefit Above Average?, *International Journal of Public Policy* 3(3).

O'Kelly, M.E. and M.W. Horner (2003) Aggregate Accessibility to Population at the County Level: U.S. 1940-2000, *Journal of Geographic Systems* 5:5-23.

O'Leary, B. (2006) Partition; Definition, Types, Justification, Criticism, Explanation and Assessment. Moving Frontiers, Plotting Pathways Final Conference, Armagh. (www.qub.ac.uk/cibr)

Perkmann, M. (2007) Policy Entrepreneurship and Multi-Level Governance: A Comparative Study of European Cross-Border Regions, *Environment and Planning C*, 24(4).

Plane, D.A. and P.A Rogerson (1994) *The Geographical Analysis of Population with Applications to Planning and Business*, John Wiley and Sons, New York.

Rebelo, S. (1991) Long-Run Policy Analysis and Long-Run Growth, *Journal of Political Economy*, 99 3 500-521.

Redding, S. and D. Sturm (2008) The Costs of Remoteness: Evidence from German Division and Reunification, *American Economic Review*, 98(5): 1766–97.

Rey, S. and B. Montouri (1999) U.S. Regional Income Convergence: A spatial Econometric Perspective, *Regional Studies* 33: 143-156

Romer, P. M. (1986) Increasing Returns and Long-Run Growth, *Journal of Political Economy*, 94 5 1002-1037.

Swan, T. W. (1956) Economic Growth and Capital Accumulation, *Economic Record*, 32 334-361.

Solow, R. (1956) A Contribution to the Theory of Economic Growth, *Quarterly Journal of Economics*, 70 1 65-94.