A New Peripherality Index for the NUTS III Regions of the European Union

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A Report for the European Commission,

Directorate General XVI.A.4

(Regional Policy and Cohesion)

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Contents

TABLES

FIGURES

Terms of Reference

1. Re-estimation of road travel time matrix for NUTS III regions:

(a) the selection of funtional centroids for all NUTS III regions of the EU, some minor enhancements of the ferry network data, re-running the Routeview software, and modification of the spreadsheets used to add rest breaks, border delays, etc.
(b) the methodological changes necessary because of the 25-fold increase in the number of cells in the matrix due to the move from NUTS II to NUTS III

2. Generation of internal distance data;

Derivation of the internal distance data using the “minimum bounding rectangles” approach.

3. Regional variations in speed settings

(a) Changing the road segments to allow simulation of lower speeds for urban, mountainous or less developed regions
(b) Re-estimation of the travel time matrices by Routeview

4. Estimation of Peripherality Indices

Updating of spreadsheets, generation of results tables and maps, for GDP(ECU), GDP(PPS), and labour force based peripherality indices.

5. Final Report

The final report should include a review of recent literature, a detailed account of the methodology, comprehensive results tables and maps (in hard copy and machine readable form).

INTRODUCTION/SUMMARY

This report was commissioned in November 1998, following the submission of a proposal to develop earlier work for the Highlands and Islands European Partnership (Copus 1997), which was presented at a seminar in Brussels in June 1997. The latter was essentially an updated version of David Keeble's (1988) Economic Potential index. This was a synthetic indicator, using a gravity model methodology, intended to simulate the impact which location (relative to large centres) has on potential for economic activity, growth and income generation. The 1997 index was generated using Geographic Information System (GIS) software, and extended to include all EU15 NUTS II regions, together with adjacent EFTA and CEEC countries.

As the terms of reference make clear, the most important change in the current report is the increased geographical resolution associated with the shift from NUTS II to NUTS III regions. This increased detail necessitated some software changes, a relational database being required to manipulate the 1.3 million rows of data. The other main refinement was to take account of speed variations where routes passed through mountains, urban areas, and countries with less well developed transport infrastructure.

Four variations of the peripherality index (each using a different "mass variable" as a measure of the volume of economic activity in each region) are presented in the results section. Although there are of course minor variations in the four resulting maps, the overall pattern is consistent. The core areas remain, as identified by Keeble, along the Rhine from Stuttgart to Rotterdam, and around Antwerp, Brussels Paris and London. At the other extreme, (having excuded the French overseas NUTS III regions, the Azores, Madiera, the Canaries and Tenerife) are the regions of Northern Sweden and Finland, the Scottish Islands and the Islands of the Aegean. Most of southern and western Spain and Portugal, Corsica and the Balearics, Southern Italy, mainland Greece, Northern Scotland, Ireland and southern Scandinavia, are also shown to be relatively peripheral.

REVIEW OF RECENT LITERATURE

A relatively large volume of research has been carried out on the effects of peripherality, and accessibility on regional economic development during the past 15-20 years. However, it is not our intention to provide a comprehensive review of theoretical work relating to the effects of peripherality, but instead to focus on studies which have generated European regional peripherality indicators. The considerable body of work concerned with evaluating the impact of major infrastructural investments such as the Channel Tunnel or the Trans-European Networks (TENs) will be referred to where it satisfies this criterion.

Peripherality indicators fall into two broad types:

The first group utilise gravity model-based methodologies to estimate "economic" or "market" potential. In this case it is assumed that the potential for economic activity at any location is a function both of its proximity to other economic centres and of their economic size or "mass". The analogy with the law of gravity is explicit in that the influence of each centre on the "economic potential" of a location is assumed to be directly proportional to the volume of economic activity at the former, and inversely proportional to the distance separating them. The economic potential of the location is found by summing the influences on it of all other centres in the system.

The second group comprise "travel time/cost" and "daily accessibility" indicators. Although conceptually simpler and more intuitive than the first group, these have become dominant in recent years due to ease of estimation using modern GIS software. Essential these approaches answer one of three questions;

- What is the total cost of travelling from each locality to all the major economic centres in Europe.
- "How many people can be reached with a day trip (3-4 hours each way) from each point on the map?", or
- "What would be the total cost of accessing a total market of n people from each location?"

Gravity Model Indices:

(a) Keeble *et al* 1981 and 1988

The work of Keeble in 1981 and 1988 was a very important milestone in the development of peripherality indicators. Although his Economic Potential model was derived from earlier work, dating back to the 1940s, and a number of writers have subsequently developed it, it is David Keeble's name which is most strongly associated with this sort of analysis.

In 1979 Keeble, was commissioned by DGXVI to carry out an analysis of the influence of centrality and accessibility on recent regional socio-economic trends in the European Community. More specifically the brief set the research team the following task:

> *"assessing whether there exists a significant tendency towards increasing concentration of people and industry in the more central areas of the Community. Three related questions will thus be investigated, namely:*
>
> - *do significant economic differences exist between the central and peripheral regions of the Community;*
> - *are these different categories of regions evolving differently over time;*
> - *how far may observable differences be explained by, or related to, relative location within the Community." (Keeble et al 1981 p212)*

In Keeble's study "centrality" was defined in terms of the "centre of gravity" of economic activity within the Community. It was assumed that the potential for economic activity at any location is at least partly a function of its proximity to other economic centres. The analogy with the law of gravity is explicit in that the influence of each centre on the "economic potential" of a location is assumed to be directly proportional to the volume (or "mass") of economic activity at the former, and inversely proportional to the distance separating them. The economic potential of the location is found by summing the influences of all other centres in the system.

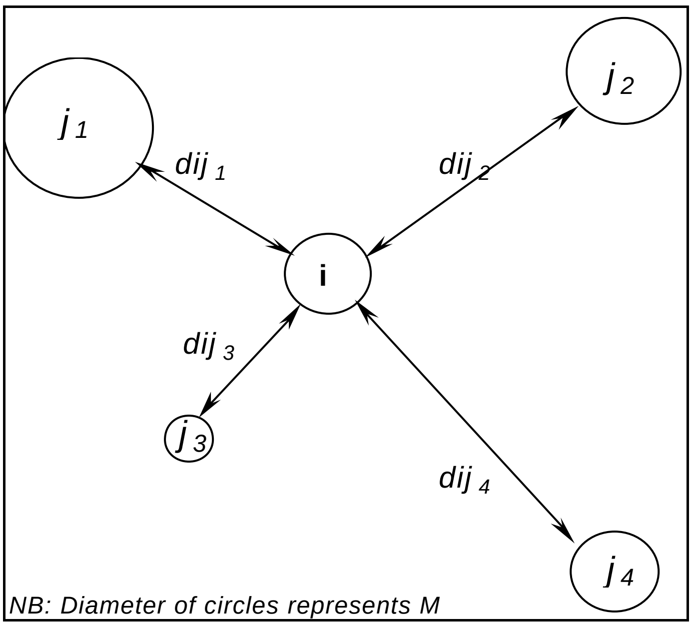

Figure 1: Basic Economic Potential Concepts

Thus in Figure 1 the economic potential of location i is the sum of the economic mass of each other location divided by the distance to i, as shown in formula 1.

1.

$$P_i = \sum_{j=1}^{n} \frac{M_j}{D_{ij}}$$

Where: P_i is the index of peripherality for location i

m is an economic "mass" variable in location j

d_{ij} is the distance between locations i and j

In 1981 Keeble applied the economic potential model to the NUTS I regions of the EU9, (in 1965, 1970 and 1973) and EU12 (1977), using the comparative statics approach to investigate the effects of enlargement, and trends in core-periphery disparities. In 1988 he applied the same procedures to NUTS II regions. The mass variable was regional GDP. Distances were calculated between the regions' "functional centroids" (largest towns or cities), using a simplified model of the major road/ferry network. Tariff barriers were simulated by conversion to road distance equivalents.

The result was a clear core-periphery pattern of economic potential. Keeble describes the core as;

> *"a triangular plateau of high accessibility to Community-wide economic activity with corners on Stuttgart, Hamburg, and Lille. West Berlin, South-East England, and Ille-de-France form outlying peaks of relatively high accessibility around this "golden triangle".*

In his 1988 report the triangle became a "four sided plateau" with the inclusion of the salient extending into the UK as far as Birmingham.

(b) Linneker and Spence (1992)

Linneker and Spence (1992) used a market potential model to estimate the impact of the building of the M25 London orbital motorway on economic activity in 179 zones covering England, Wales and Scotland. Their model is technically more sophisticated than that of Keeble, in that they use a GIS road network to estimate travel times and distance over the fastest route between each pair of regions. These time and distance data are then used to calculate a total cost impedence function incorporating both vehicle running cost and the value of the driver's time. Separate estimates are generated for private cars and for heavy goods vehicles. In the absence of a more direct measure of economic activity at the appropriate regional scale, total employment is used as a mass variable. The overall pattern of economic potential which results from this analysis is very much what might be expected, with peaks in all the major centres of economic activity, and low values in remoter rural areas, such as the Highlands and Islands of Scotland, or Wales and the South West of England.

In a subsequent paper (Frost and Spence 1995) the same model was applied to the 322 travel to work areas (TTWA) of Great Britain. A similar pattern emerged. However the focus of attention in this paper was the role of "self potential", (the effect of the size and level of economic activity of each region on its own peripherality index). It was shown that this was far from trivial, and that the details of the estimation procedure could make a significant difference to the ranking of regions.

(c) Owen and Coombes (1993)

D W Owen was a co-author with David Keeble of the EU model described above. This study more or less replicates the methodology for UK Travel to Work Areas (TTWAs). The resulting map is much as might be anticipated, with peak accessibility in London, subsidiary peaks in the Midlands, around Liverpool, Manchester, Newcastle and the Scottish Central Belt, and with the Highlands and Islands at the other extreme. Much of the report is concerned with sensitivity analysis, exploring the effects of including adjacent EU regions, varying the "distance exponent[1]", "route factor[2]" and the mass variable, and thus providing a wealth of information about the behaviour of the gravity model. On the whole the conclusion is that the model is relatively robust, and that there is little theoretical or empirical justification for any deviation from the simple "central case" implementation.

(d) Smith and Gibb (1993)

With the sub-title "a return to Potential Analysis", Smith and Gibb's paper forecasts the impact of the Channel Tunnel on NUTS II regions within the 7 EU member states. A gravity model identical to that of Keeble was applied to freight rail transport. Their distance matrix is based on rail and ferry

[1] The distance exponent effectively increases or decreases the "friction of distance" represented in the model, so that the index has a greater (or smaller) relative range. In terms of isoline maps, a higher distance exponent increases the difference between the peaks and the valleys, and vice versa.

[2] A route factor is a means of adjusting a distance matrix based on air line (crow flies) distances between regional centroids. Clearly it is redundant if GIS software and a digital roadmap are available.

distances and was created from Cook's European Timetable. Three simulations, assuming average (freight train) speeds from 30 to 75 mph, generated results which suggested to the author that the benefits of the Channel Tunnel would be restricted to the South East and adjacent regions, unless rail network improvements allowed faster running.

(e) Bruinsma and Rietveld (1993)

This study used a relatively simple database, comprising road, rail and air travel-times between 42 European cities of over a million people. A gravity model index was estimated for each travel mode, and combined to minimise travel time, using total population as the weighting variable. Particular attention was focussed on the degree of inequality in accessibility of the 42 cities for each transport mode, and a range of future scenarios were evaluated. The greatest inequality was found in the rail only model, with both road and air transport showing a more modest range between the most and least accessible cities. Future road improvements were predicted to have the greatest impact in eastern and southern Europe, and therefore to reduce inequalities. By contrast rail network improvements were expected to benefit the cities of north-west Europe disproportionately and so to increase disparities. Emphasis was also place upon "non-physical barriers" associated with national and EU boundaries, which result in sparser networks and less frequent services. European integration and expansion were therefore anticipated to have substantial effects on accessibility.

(e) Gutierrez and Urbano (1996)

The Gutierrez and Urbano model was developed during the early 1990's to assist the Spanish government in their master plan for transport infrastructure, and was later used to assess the likely impact of the EU Trans European Network (TENS) programme. It therefore focuses on the accessibility of major centres of economic activity (defined as cities of more than 300,000 people) rather than regions. It utilised a variant of the equation (2) which they affirm is "more suitable than those of economic potential to measure the degree of separation between different places throughout the major trans-European routes".

2.

$$A_i = \frac{\sum_{j=1}^{n}\left(I_{ij*}GDP_j\right)}{\sum_{j=1}^{n} GDP_j}$$

Where:

A_i is the accessibility of node i

I_{ij} is the impedence through the network between nodes *i* and *j*, and,

GDP_j is the gross domestic product of the destination node *j* [3].

"Impedences" were travel times calculated for the route between each pair of nodes, using a detailed digital road/ferry network, each class of road having a difference average speed, and changes of mode (road-ferry) and crossing city centres incurring time penalties. Clearly this is a much more sophisticated exercise than that available to Keeble.

The general concentric pattern of accessibility in the resulting map is roughly comparable with that of Keeble. The analysis of the impact of the TENS suggests that although the overall pattern does not change substantially, the greatest increases in accessibility are predicted to take place in the more peripheral areas, particularly Northern Britain, Spain, S. Italy and Greece.

(f) Copus (1997)

During 1997 the Highlands and Islands European Partnership funded a project to re-estimate the economic potential index for all EU15 NUTS II regions, Norway, Switzerland and the CEECS, using the most recent GDP data, and modern GIS software to build a travel-time matrix. The latter used a detailed digital road map of Europe, taking account of different average speeds for different classes of road, realistic ferry crossing and check-in times, EU border crossing delays, and statutory drivers' rest breaks[4].

Figure 2 shows the 1994 EU15 economic potential map generated using GDP (PPS) as the mass variable. The familiar core-periphery pattern emerges, with peaks of economic potential in Brussels, Rotterdam, Amsterdam, Köln, Bonn, Frankfurt, Munich, Paris, London, Hamburg, Berlin, and

[3] This was estimated by applying the GDP per capita for the surrounding region to the population of the city.

[4] It did not however combine travel time costs and vehicle running costs. For simplicity, travel time was used as a surrogate for full cost.

Vienna. Keeble's "Golden Triangle is still identifiable, although its southern apex has become separated from its northern base by a "col" of lower values in the Rheinland Pfalz eastwards into Hessen. The inclusion of Switzerland as a whole clearly "averages out" another peak around Zurich. Within the UK London has the highest economic potential of all NUTS II regions (due to its relatively "tight" boundary), and is located on a ridge of high values stretching from Kent to the West Midlands. Manchester forms an island of high potential.

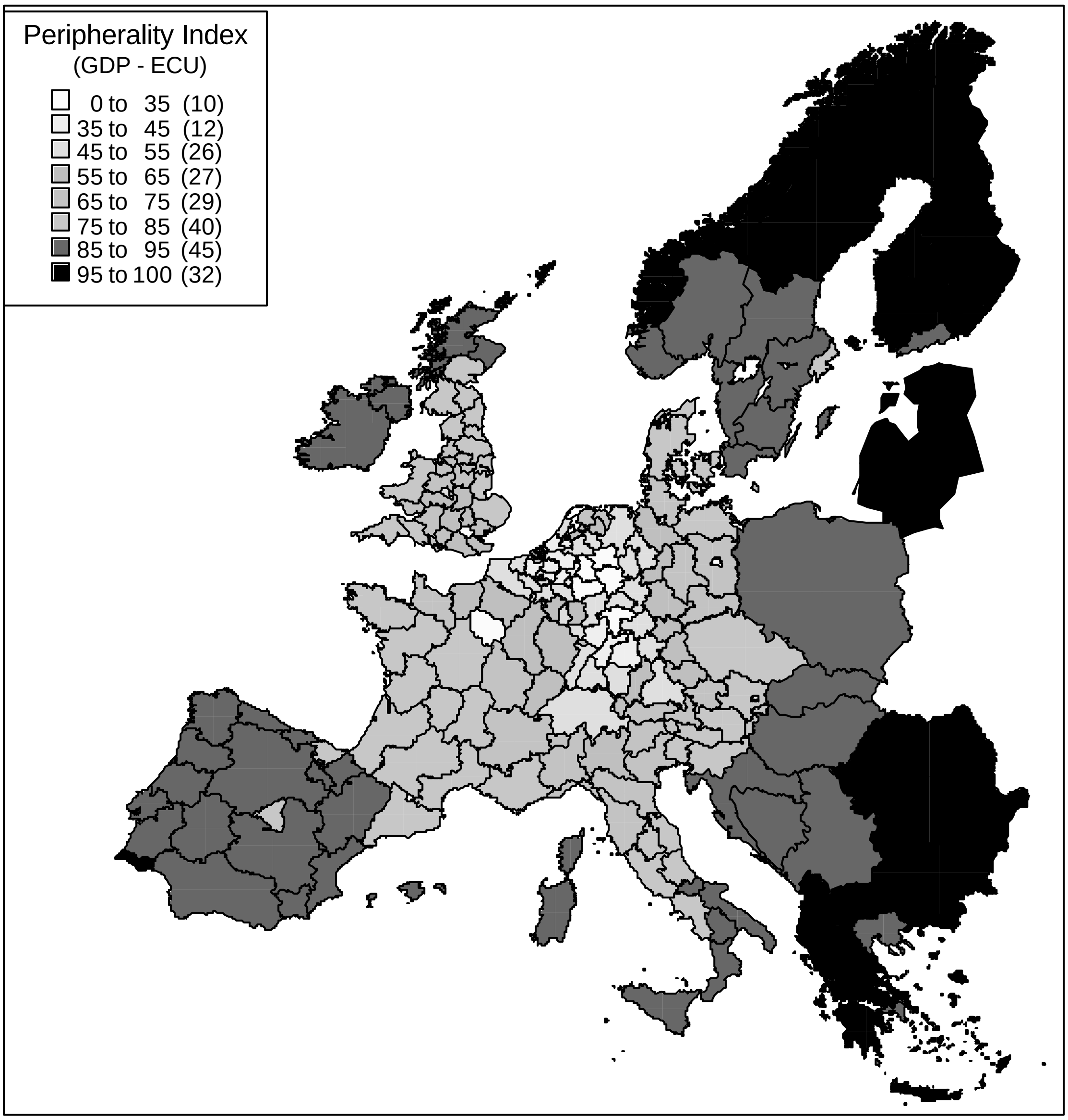

Figure 2: Peripherality Index by NUTS II Region 1994

Source: Copus (1997)

Travel time/cost and Daily Accessibility Models

(a) Lutter et al 1992

The Lutter study developed an unweighted travel time indicator for the regions of the EU12. Average travel times were calculated between each NUTS III region and 194 major cities. These travel times are estimated on the basis of a set of simplified transport networks, not unlike that used by Keeble, but rather more detailed, and multi-modal, allowing the software to select the fastest route, whether by road, rail or air. Although there are some unexpected details[5], the overall pattern which emerges is broadly similar to that of Keeble and other more recent European indices. One disadvantage of this methodology is that the absence of weighting of the 194 cities means that relatively small cities exert the same influence as those at the opposite end of the scale. In addition to the “central case” results - which are reproduced in the Fifth Periodic Report (EU Commission 1994) - the Lutter report contains among its numerous maps, one showing the total population accessible within 3 hours travel time. Two more recent variants appeared in the “Principles for a European Spatial Development Policy” document (Federal German Government 1995). These extended the analysis to the EU15. The first indicator was the average travel time from each NUTS III region to all other regions, by the fastest mode. The second was the average travel time to 41 selected urban agglomerations.

(b) Chatelus and Ulied (1995)

The UTS (Union Territorial Strategy) project was a DGVII commissioned study into the impact of the Trans European Networks(TENS). It was carried out by G Chatelus of Institut National de Recherche sur les Transports et leur Sécurité (INRETS -Paris) and Andreu Ulied of Multi-Criteria Consulting (MCRIT) of Barcelona. The study addressed three main questions, relating to the ability of the TENS to;
(a) solve trans-national bottlenecks;
(b) change the “accessibility gap” between central and peripheral regions of Europe, and;
(c) encourage more environmentally friendly transport patterns (ie greater use of rail).

A two-fold approach was used. The first element, and the one of most interest here, was the creation of a GIS modelling system, (the UTS system), comprising a large volume of transport

[5] Such as Grampian being shown as less accessible than the Highlands and Islands, and SW Ireland being more accessible than SE Ireland.

network data, socio-economic information, and two transport models which generated different accessibility/peripherality indices.The second main element of the UTS study was a set of case studies which assessed the impact of various infrastructural improvements funded by the TENS programme.

The first of the two accessibility indicators (known as CON(T)) is a Daily Accessibility model. The authors argue that “daily round trips opportunities for last minute business travellers... is the most relevant accessibility measure to indicate the transport system effectiveness serving the most demanding trips.” (P12) The CON(T) model therefore measures, for any city or town in the UTS system, the total population which may be reached within three hours, by the fastest combination of road rail and air transport.

The second model relates to the cost of accessing a market with freight. It has two manifestations; “FreR(M)” estimates (again for each major town or city) the cost of accessing a market of a certain population size; whereas “FreC(T)” estimates the total market which can be accessed within a given time.

The results of the CON(T) model indicate that the cohesion benefits of the TENS are likely to be “lightly positive”. The greatest increases in accessibility are predicted to derive from high speed rail improvements connecting major cities in the heart of Europe, smaller peripheral centres will generally gain only a marginal improvement from improve radial motorway connections.

The freight models led to similar conclusions: “Globally there is little doubt that road networks don’t induce a big change in the geographical hierarchy of the European space. The centre of Europe remains in Germany whatever the new TERN looks like, and the highway network can’t change the level of perphericity of the areas. Moreover, peripheral regions depend for their accessibility to the whole continent on the use they can make of the central areas network.” (p45)

More recently a map produced by an updated version of the freight model has been incorporated in the European Spatial Development Perspective (EU Commission 1998)

(c) Spiekermann and Wegener 1996

Spiekermann and Wegener use a sophisticated Daily Accessibility methodology to assess the effect of the TENS on core-periphery differences in Europe. A 10 kilometre grid raster data file provides population data, which is combined with a simplified rail network. Journey times between grid cells were simulated firstly by connecting the origin to the nearest mainline railway station with a straight line, along which a uniform speed of 30 km per hour was assumed. The rail travel time was then derived from timetables, and another “airline” segment added to connect to the destination grid square. This was repeated for each pair within the 70,000 grid squares in Europe. From the resulting travel-time matrix it was possible to estimate for each cell the total population accessible within a five hour journey. The effects of improvements to the rail system could then be simulated. The authors concluded that “the trans-European networks, in contrast to the claims of the Maastricht Treaty, may widen rather than narrow the differences between central and peripheral regions in Europe (Spiekermann and Wegener 1996 p41).

In a later paper (Vickerman, Spiekerman and Wegener, 1999), an accessibility surface derived from a gravity model is added. A broadly similar (but flatter) pattern is displayed, and again the results of an analysis of changes between 1993 and 2010 call into question the cohesion benefits of the TENs.

Some general themes and conclusions:

Having described the main features of recent studies and indicators it is now possible to draw out some implications for the design and implementation of the peripherality index presented below:

Implied concepts of peripherality:

Each of the peripherality indicators described above is based upon a set of concepts relating to the nature of peripherality, and to the way in which it affects regional economic and social development. Some authors state these concepts more explicitly than others do. It is helpful to review these concepts and to assess the degree to which the indicators adequately represent them. This will help to explain some of the decisions made in the design and implementation of the index presented below.

One of the alternative names for the gravity model indices “market potential” suggests that this group of indicators are essentially concerned with demand side, rather than supply side processes. However, Keeble *et al* (1988) make it clear that their concept of “distance costs” was rather more complex, ranging from the additional cost of assembling raw materials and distributing products, through communication and information gathering costs, organizational and administration costs (the need for a higher levels of stockholding, or a dispersed warehouse system perhaps), to costs of production dislocation and uncertainty (adjusting to unreliable transport of either raw material or output). They further point to the importance of *perceived* (not necessarily real) distance costs, as a disincentive to investment in non-central locations. Furthermore central areas will tend to accumulate *derived* advantages, such as an entrepreneurial culture, superior access to information, proximity to research and development activity and so on. When introducing their index, Keeble *et al* are at pains to stress that the mass variable represents "a broad surrogate indicator of possible markets for traded goods and services, of input sources and opportunities for component linkages, of the availability of commercial information and business services, ... *the index should seek to measure regional accessibility to economic activity in terms of distance costs of all kinds*... rather than narrowly or simply as transport costs of the type implied by traditional Weberian industrial location theory...." (Keeble *et al* 1988 p12 - current authors italics).

None of the subsequent gravity model analyses provides such a detailed account of their concept of peripherality. Owen and Coombes (1983) give a summary of the arguments presented by Keeble *et al*. Linneker and Spence (1992) put forward a rather narrower view focussing on the cost of access to markets. Bruinsma and Rietwald (1993) are mainly concerned with the relative competitiveness of cities in a Europe where traditional national protection measures are no longer tenable. Smith and Gibb (1993) are perhaps a little harsh in stating that "economic potential analysis considers only demand-side factors, ignoring important supply-side considerations such as labour skills, entrepreneurship, supply of capital, and non-transport infrastructure" (p184). As the discussion above has shown, Keeble and his colleagues had a much broader concept in mind, encompassing both demand, and supply - side factors.

Lutter *et al* argue that their unweighted travel time indicator is more appropriate than the Keeble approach because it more exactly represents the key determinants of economic success in a post-Fordist world. Freight costs, they argue are less important than opportunities for rapid executive passenger travel, allowing regions to participate in the expansion of the service sector, R and D dependent high technology manufacturing, or the "knowledge-based economy".

Chatelus and Ulied (1995) generally take the economic development benefits of improved accessibility as given, although, interestingly, they point out that improved transport infrastructure, although necessary, is not sufficient. "Needless to say, the intensity and characteristics of economic development will depend on the willingness of social and economic actors to take advantage of the new accessibility endowment. Empirical evidence even suggests that some places with low accessibility endowment can have higher development than others ... With a long-term view, however, hardly a place without convenient transport endowment can sustain and diversify economic growth." (p10)

Spiekermann and Wegener (1996) like Lutter, acknowledge that the role of transport infrastructure in economic development is far from a simple cost of raw materials/product distribution determinance. They acknowledge the importance of service quality, reliability and speed, the low proportion of production costs accounted for by transport in many modern industries, the various impacts of information and communications technology, and the increasing role of other factors (quality of life, access to information and specialist business services and so on) in industrial location decision making. They stress the fact that infrastuctural improvements often work to the disadvantage of peripheral areas, especially if they link central cities together, or even if they link the core with the periphery. Their accessibility indices are apparently an attempt to represent what they term in a later paper (Vickerman, Spiekermann and Wegener 1999) "generalised transport costs", ie the net outcome of a range of often conflicting effects.

Measuring Centrality

The literature review highlights several considerations relating to the way in which "centrality" or "mass" is measured or represented in the models. The first relates to whether economic activity is represented as being focussed at a limited number of points (as in Bruisma and Rietwald 1993, Lutter *et al* 1995, or Guttierrez and Urbano 1996) or as a continuous surface of varying intensity (as in Spiekermann and Wegenr (1996). The Keeble model takes an intermediate position, representing each region by its "functional centroid". To a large extent the choice of approach here depends on the overall objective of the analysis, so that evaluations of changes in the transport network will be primarily concerned with impacts on its nodes. In the case of the analysis presented in this report, attention is focussed on the relative peripherality of regions as an aid to policy targeting. The Keeble approach therefore seems most appropriate.

The second issue relates to whether centres of economic activity are weighted or not. It might be argued, of course, that beyond a certain threshold size, all centres have a similar impact on their local area. This seems to be the implication, for instance, of the Lutter *et al* methodology. However, most of the indicators (including, indirectly those based on "daily accessibilty" measurements) take the varying size of centres into account, at least in simple population terms. However, only true gravity model indices successfully take into account the relative size of centres, in wealth terms as well as population numbers, and simultaneously incorporate a distance decay function on their influence. The need to take account of relative wealth points to the use of GDP as the mass variable. If the GDP data is expressed in Purchasing Power Standard (PPS) terms it is possible to take account of variations in prices between member states[6].

[6] Keeble argued that the most appropriate "mass" variable was GDP in current price ECU, since it was, in his view "the best available summary index of the economic activity which is present and the output of goods and services by

Simulating Generalised Distance Costs

Here a number of choices need to be made in the light of the concept of peripherality underlying the analysis. For instance the distance variable may be expressed in terms of kilometres or in terms of travel time, and either of these may be estimated in terms of road rail or air transport, or a combination of all three. The choice should take account of sectoral and geographical differences in modal shares, and the assumed form of development. Thus traditional manufacturing industries might be more sensitive to the cost of road or rail freight transport, while high technology activities or services might be more influenced by accessibility in terms of executive air or high speed rail transport. In many peripheral areas rail transport is not really an option, since the network is too sparse, whilst air travel is relatively expensive. Here road transport is generally the best option for freight transport, and the car the most common means of travel for both personal and non-executive business travel.

However, having said all this, it is important to remember that actual freight or travel costs have a relatively minor role in production costs, even in peripheral areas (Vickerman 1991, PIEDA 1984, PIEDA 1997, Burns 1996, Chisholm 1987), and it is, generally speaking, the *perceived* cost, quality and convenience of accessing centres of economic activity which influences both inward investment decisions and endogenous growth rates. The choice of distance variable should therefore perhaps take account of the likely lag between actual travel time reductions and popular perceptions of relative accessibility, both of the local populations and potential inward investors or migrants.

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organisations and individuals in each region." (Keeble *et al* 1981). In the 1988 report Keeble showed that a switch to PPS data slightly reduced the range of the index but left the spatial pattern virtually unchanged (Keeble *et al* 1988)

THE METHODOLOGY

To a large extent the methodology used to generate the NUTS III peripherality index presented below follows that of the earlier study for the Highlands and Islands European Partnership, (Copus 1997). However there are a number of significant changes, some dictated by the very much larger volume of data associated with the shift from NUTS II to NUTS III regions, and some which were enhancements requested by the client.

The Regional Framework

The regional framework for this analysis was the 1,115 1998 NUTS III regions of the EU, (minus the French overseas Departements, the Azores, Madiera, Ceuta and Melilla, the Canary Islands and Tenerife[7]), plus five Norwegian regions, Switzerland, and 17 countries of Central and Eastern Europe[8]. The latter were included because their economic activity clearly impacts upon the relative peripherality of the adjacent EU regions. This regional framework is illustrated in Figure 3. A list of regions is also presented in Appendix 1. For each of the NUTS III regions a centroid was established. For the great majority functional centroids (the largest city or town) were identified. In a relatively small number of cases (mostly predominantly rural, but a few being almost continuously built up) it was not possible to identify a functional centroid, and in these cases the geometric centre of the region was substituted.

The Travel Time Matrix

Routeview software was used to generate a travel time database, containing over 1.3 million rows of data, representing the total number of possible combinations of the 1,105 regions/countries included in the analysis. As in the 1997 index, (and for the reasons given above) it was assumed that road freight transport travel times are the most practicable indicator of the real or perceived "generalised distance cost" disadvantages of peripheral regions.

[7] These were excluded either because the travel time matrix assumed road transport, and sea transport dominated the routes between these regions and the rest of the EU or because GDP data was not available.

[8] The full list of these is; Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Slovenia, Bosnia Herzogovena, Croatia, Yugoslavia, Albania, Macedonia, Bulgaria, Romania, Hungary and Turkey.

Figure 3: The Regional Framework

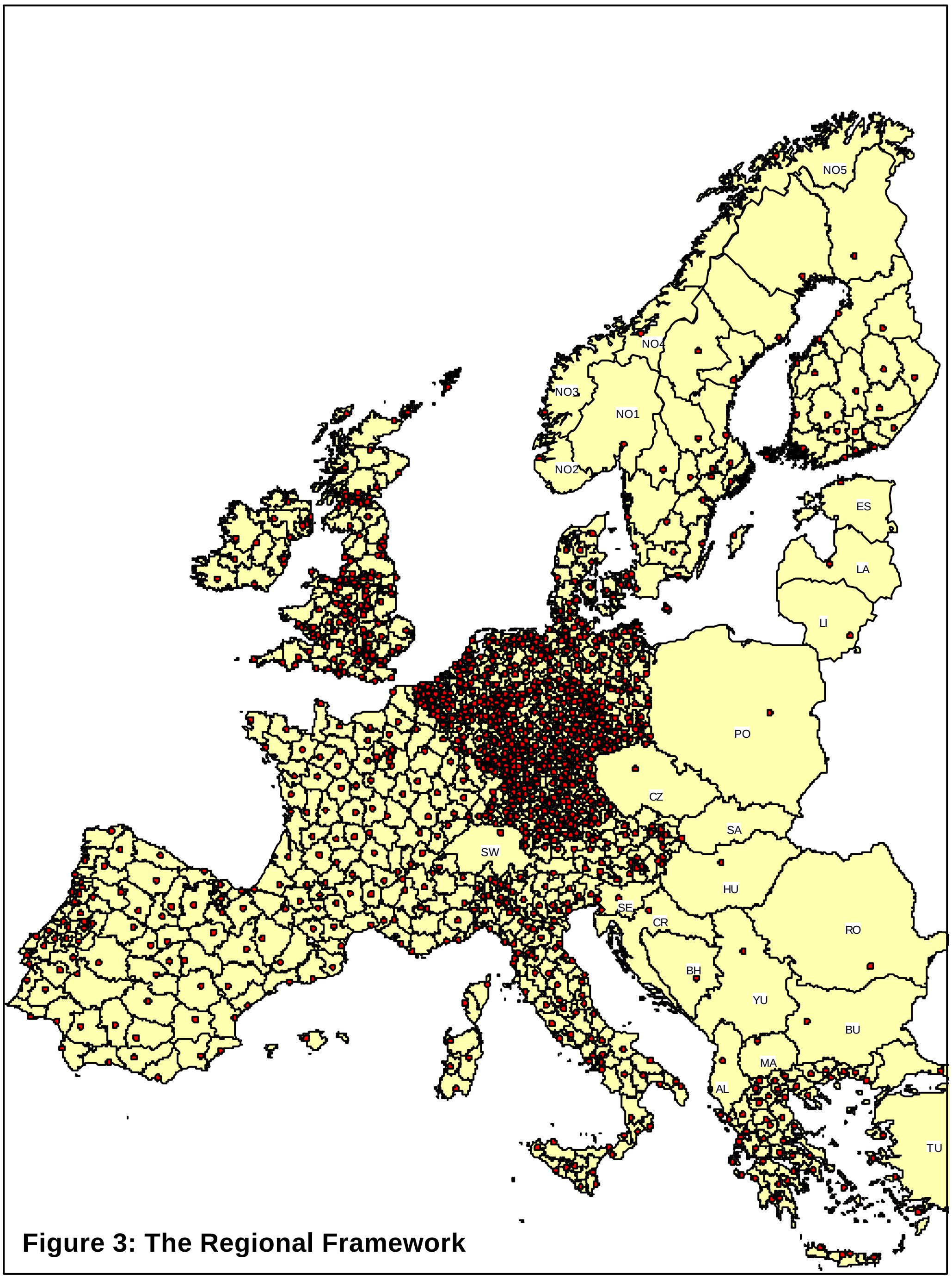


Figure 3: The Regional Framework

The road speed settings (Table 1), (which relate to heavy goods vehicles), were based on advice given by the Research Department of the Freight Transport Association. The ferry and Channel Tunnel setting require further explanation. In the case of the Channel Tunnel, the time absorbed at each end of the crossing by queuing, checking in, unloading and so on, was assumed to total 2 hours[9]. This was incorporated by the insertion of 2 kilometre long links connecting each end of the tunnel to the road network, and assigning these a speed of 2KPH. The tunnel link itself was assigned a speed appropriate for simulating the 40 minute journey time.

Table 1: Road and Ferry Speed Settings used in the Travel Time Matrix Calculation

Road/Ferry/Tunnel Type	KPH	MPH
Motorway	80	49
Dual carriageways	70	43
Major single carriageway routes	55	34
Local routes	40	24
Channel Tunnel	88	54
Ferry 1	35	21
Ferry 2	27	17
Ferry 3	19	12
Ferry 4	2	1
Motorway (Mountain zone)	70	43
National (Mountain zone)	60	37
Regional (Mountain Zone	50	31
Local (Mountain Zone	35	21
Motorway (Urban Zone)	70	43
National (Urban Zone)	55	34
Regional (Urban Zone	45	28
Local (Urban Zone	35	21
Motorway (CEEC)	70	43
National (CEEC)	65	40
Regional (CEEC	50	31
Local (CEEC	35	21
Motorway (CEEC Mountain Zone)	70	43
National (CEEC Mountain Zone)	60	37
Regional (CEEC Mountain Zone	50	31
Local (CEEC Mountain Zone	35	21
Motorway (CEEC Urban Zone)	70	43
National (CEEC Urban Zone)	55	34
Regional (CEEC Urban Zone	45	28
Local (CEEC Urban Zone	35	21

Over 100 major ferry links (defined as year round freight services with at least one service per week) were incorporated in the network, together with numerous short crossings. The short crossings were allocated an average speed of 17 MPH. The network links representing the major

[9] 35 minutes are required for checking in, waiting time and unloading time were assume to total 1 hour 25 minutes. This is based on a current frequency of over 50 trains per day.

crossings were measured and the average speed required to simulate actual passage times given in the Thomas Cook European Timetable were calculated. Check in, waiting and unloading time were also incorporated as follows:

- Check in time was assumed to be 1 hour for ferrries with a passage time of 3 hours or more, 45 minutes for those with passage times of between 1 and 3 hours, and 15 minutes for shorter ferries.
- Waiting time was estimated as half the average interval[10] between sailings, up to a maximum of 2 hours (including check in time).

These calculations allowed the ferries to be grouped into four classes, according to the average speed required to cover the network link distance within the total transit time (passage+check-in+waiting+unloading). Each ferry link was then coded, enabling an appropriate speed setting to be associated with it.

Further refinements were added by depressing average speeds in mountainous and urban areas. The extent of the mountain areas is shown in Figure 4. In Central and Southern Europe these areas were defined by the 7,000 foot contour, whilst in Britain and Scandinavia, (where latitute increases the effect of altitude) the 3,000 foot contour was selected. The urban areas (Figure 5) were derived from those included in the 1994 Edition of the Digital Chart of the World. Finally, average speeds were also adjusted downwards within the CEECs to reflect the generally lower quality of the infrastructure there.

As in the earlier NUTS II analysis, travel times were adjusted to take account of statutory drivers' rest time (assuming that drivers would not exceed the 9 hours per day limit) and for border delays[11] both at the external borders of the EU, and on the boundaries between non-EU states.

[10] Calculated as number of daily sailings divided by 12 (assuming that most non pre-booked journeys will be daytime ones.

[11] Assumed to average 1 hour.

Figure 4: Mountain Areas used to Adjust Average Speeds

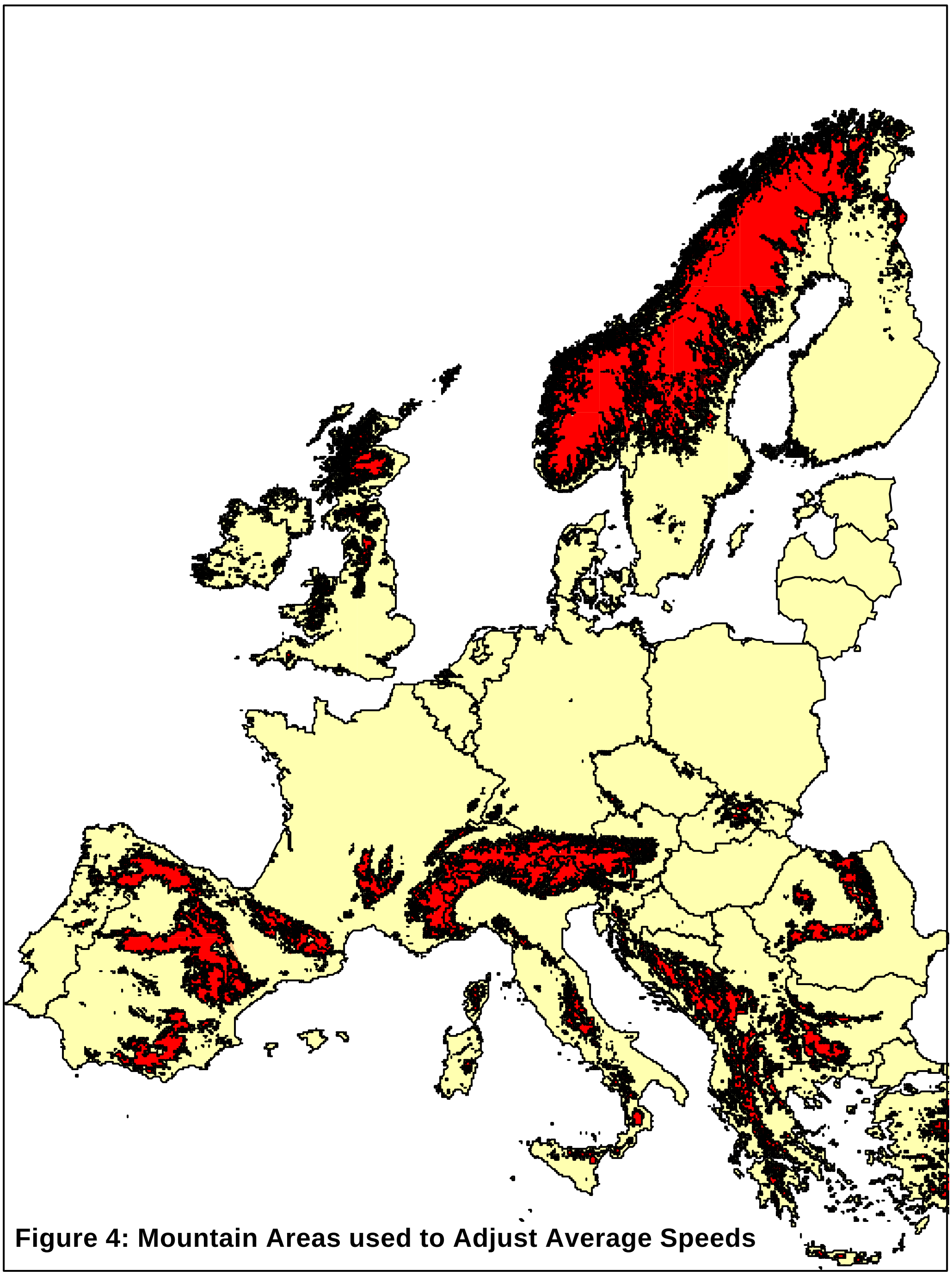


Figure 4: Mountain Areas used to Adjust Average Speeds

Figure 5: Urban Areas used to Adjust Average Speeds

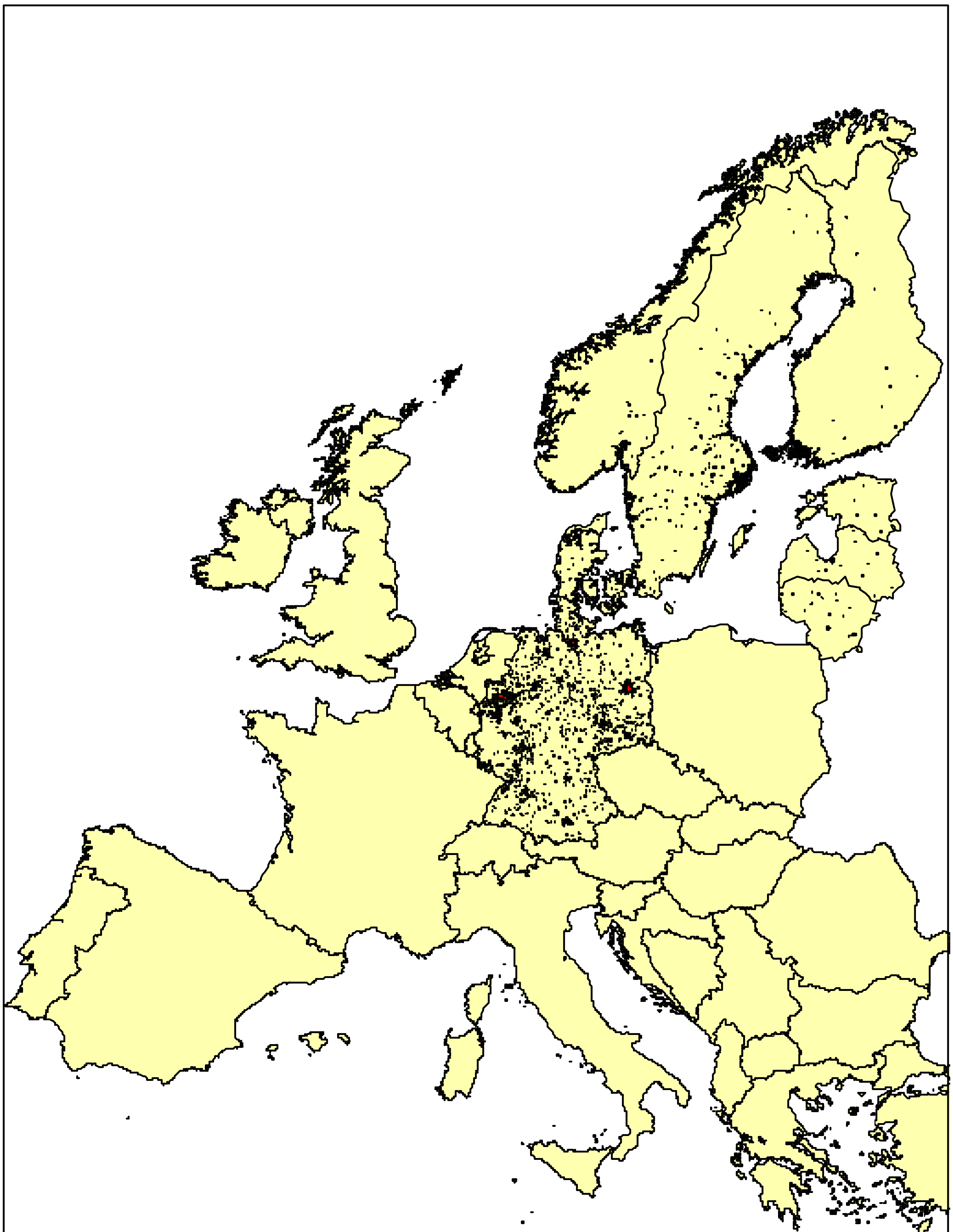


Figure 5: Urban Areas used to Adjust Average Speeds

The Minimum Bounding Rectangle Internal Distance Estimation

Internal distance, (the distance used in the “self potential” calculation) was represented, as in the 1997 NUTS II analysis by one third of the major axis of each region’s “minimum bounding rectangle” (Figure 6). This is a more appropriate measure than that derived from the region’s area, used by most previous gravity model analyses, since it makes allowance for the effects of the elongation of regions, and better reflects the increased travel costs within regions composed of a number of islands.

Mass Variables and Sources

Three mass variables were specified in the terms of reference; GDP - ECU, GDP - PPS, and Labour Force. A fourth, total population, has also been included. The main source of information was the Eurostat Regio database. GDP and population data is available for all 1998 NUTS III regions except for those of Italy, where GDP is only available at the NUTS II level. In order to create a comprehensive dataset, GDP for the Italian NUTS III regions was estimated by apportioning the NUTS II data according to population shares. Labour force data is available for 1995 NUTS III regions in all EU member states except Greece, Finland and Portugal. These gaps were again filled by appotioning NUTS II or NUTS I data according to population share. Within the UK (where the 1998 revision of NUTS regions affected almost all regions), NUTSII Labour Force Survey data was apportioned by population share. Elsewhere (in Sweden, Finland, Saxony and Thuringia) 1998 boundary revisions were accommodated either by summing 1995 region data (where regions were simply amalgamated) or by apportionment. Data for the EFTA and CEEC countries were derived from a variety of sources, including the World Bank Development Indicators report, the EU Regular Reports on Progress towards Accession, and national statistical services. Full details are provided in the note beneath Table A1.2.

Figure 6: Minimum Bounding Rectangles used in the Internal Distance Estimation

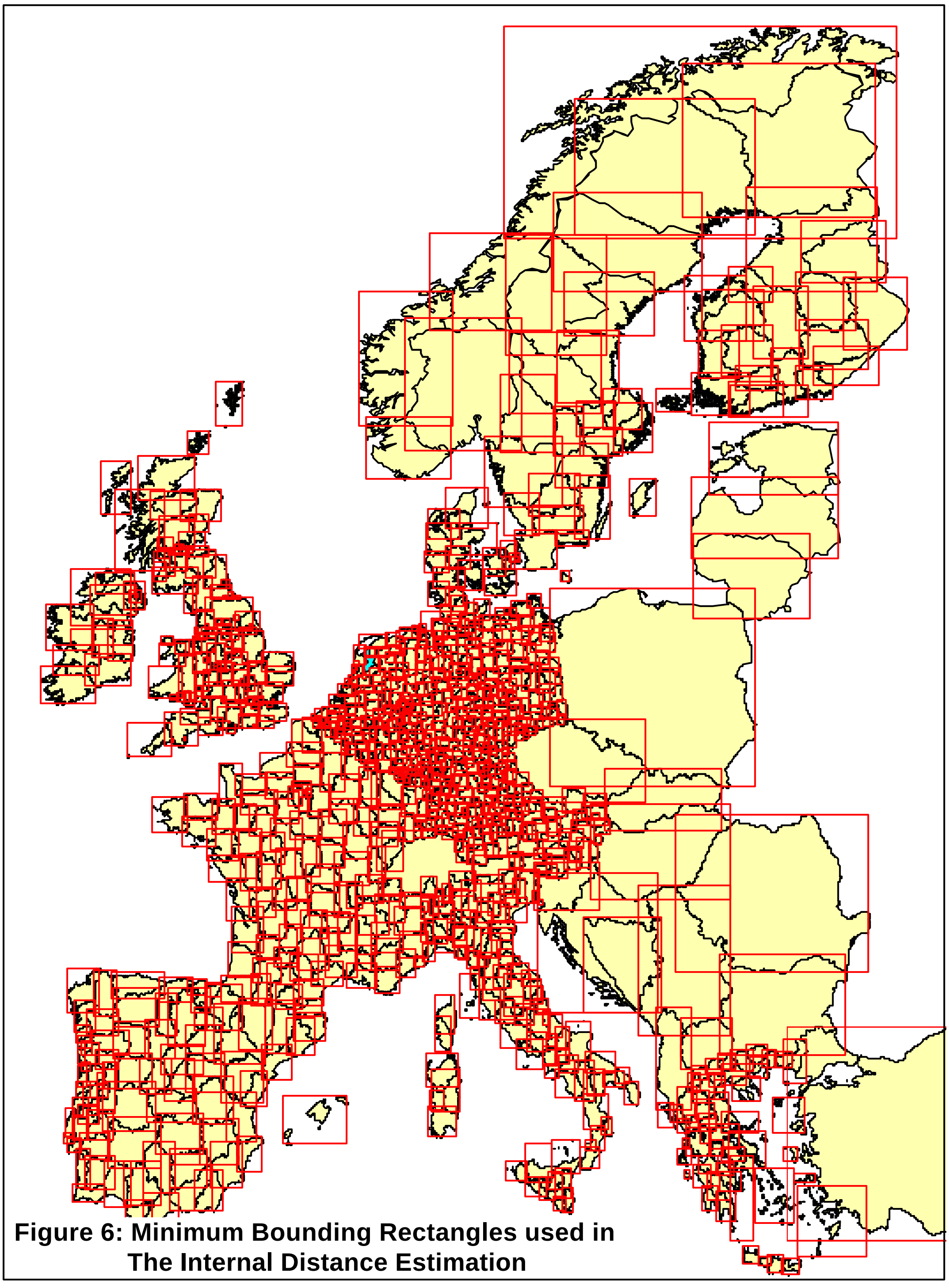


Figure 6: Minimum Bounding Rectangles used in The Internal Distance Estimation

Index Calculation

Travel time and mass variable data were combined (using formula 1) within the Access database, and the results exported to Excel, where the self potential calculation was added. As in the 1997 NUTS II report, the resulting economic potential scores were transformed into peripherality indicators by expressing them as an index ranging from 0 for the most peripheral region to 100 for the most peripheral. In the case of the GDP based indexes, the resulting distribution (Figure 7) was rather skewed. Better discrimination between regions (Figure 8) was achieved by re-estimating the indicator on the basis of the cube root of the economic potential score. The latter adjustment was found not to be necessary in the case of the labour force and population based indexes, where the distribution is already rather flatter. It is perhaps important to note that although (for clarity and convenience) these graphs plot the distribution of peripherality scores in relation to distance from Paris, the index calculation itself reflects the location of each region in relation to all others, weighted according to the mass variable.

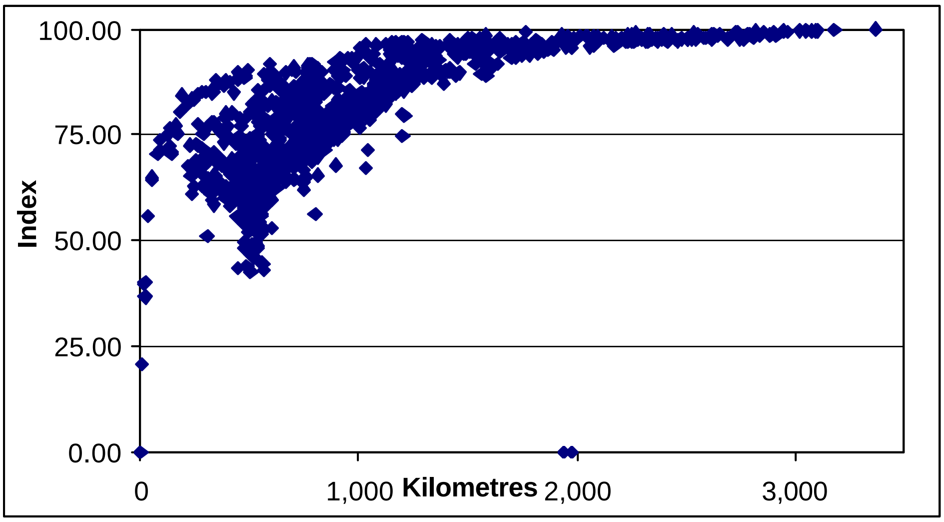


Figure 7: Distribution of GDP-ECU Peripherality Scores (based on unadjusted Economic Potential) by Distance from Paris

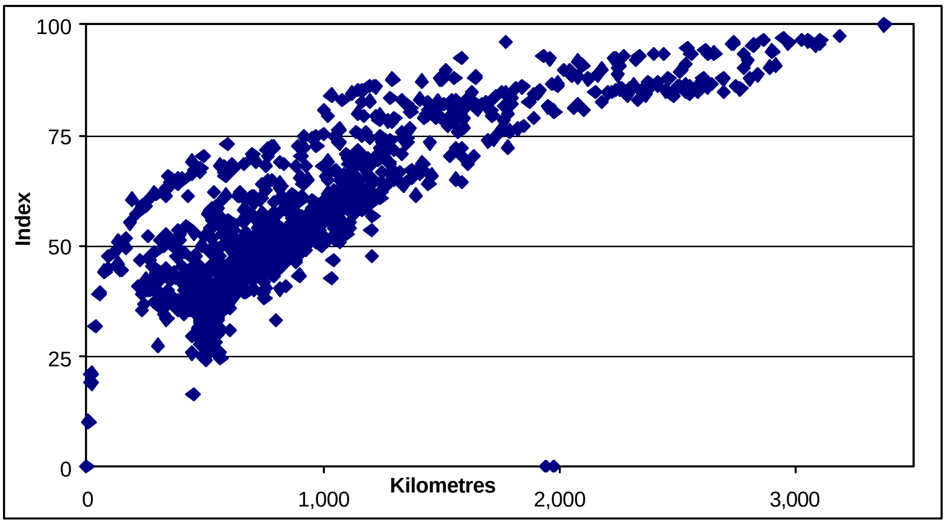


Figure 8: Distribution of GDP-ECU Peripherality Scores (based on adjusted Economic Potential) by Distance from Paris

RESULTS

The resulting indices have been tabulated by member state and by region in Appendix 1. They are also presented in the form of density shading maps in Figures 8 to 11.

GDP - ECU Index

Figure 9 clearly identifies the core regions of the EU around the cities of Paris, London, Rotterdam, Antwerp, Brussels, the Ruhr conurbation, Frankfurt, Stuttgart, Munich, Hamburg and Berlin. At the other extreme are the regions of northern Sweden and Finland, the Scottish Islands and the Aegean islands. Large areas in the south west of the Iberian peninsula, Southern Italy, mainland Greece, Ireland and Northern Scotland also achieve relatively high scores.

GDP - PPS Index

The index based on GDP - PPS has a slightly flatter distribution. The most obvious differences between Figure 9 and Figure 10 are in Spain and Portugal, Italy and Ireland, where GDP - PPS is relatively higher than GDP - ECU, and the peripherality scores are consequently reduced. The relative accessibility of the regions around Milan and Barcelona are particularly highlighted by the map. By contrast there differences between the ECU and PPS indexes are relatively minor in Britain, Scandinavia and Greece. It is interesting to note that according to this index, most of Greece (outside Athens and Thessaloniki) is more peripheral than most of the CEEC countries.

Population Index

It is perhaps surprising that given the difference in mass variable, and the slight difference in methodology (see above) a broadly similar pattern emerges with the population index (Figure 11). As explained earlier the distribution is much flatter than that of the GDP indices, due to the fact that the latter compounds population differences with per capita income variation. Nevertheless the changes in the ranking of regions are relatively minor.

Workforce Index

The workforce index largely replicates that using population as its mass variable. There are, however, a few minor differences, including the highlighting of Madrid as an island of accessibility surrounded by more peripheral regions.

Figure 9: Peripherality Index (GDP - ECU)

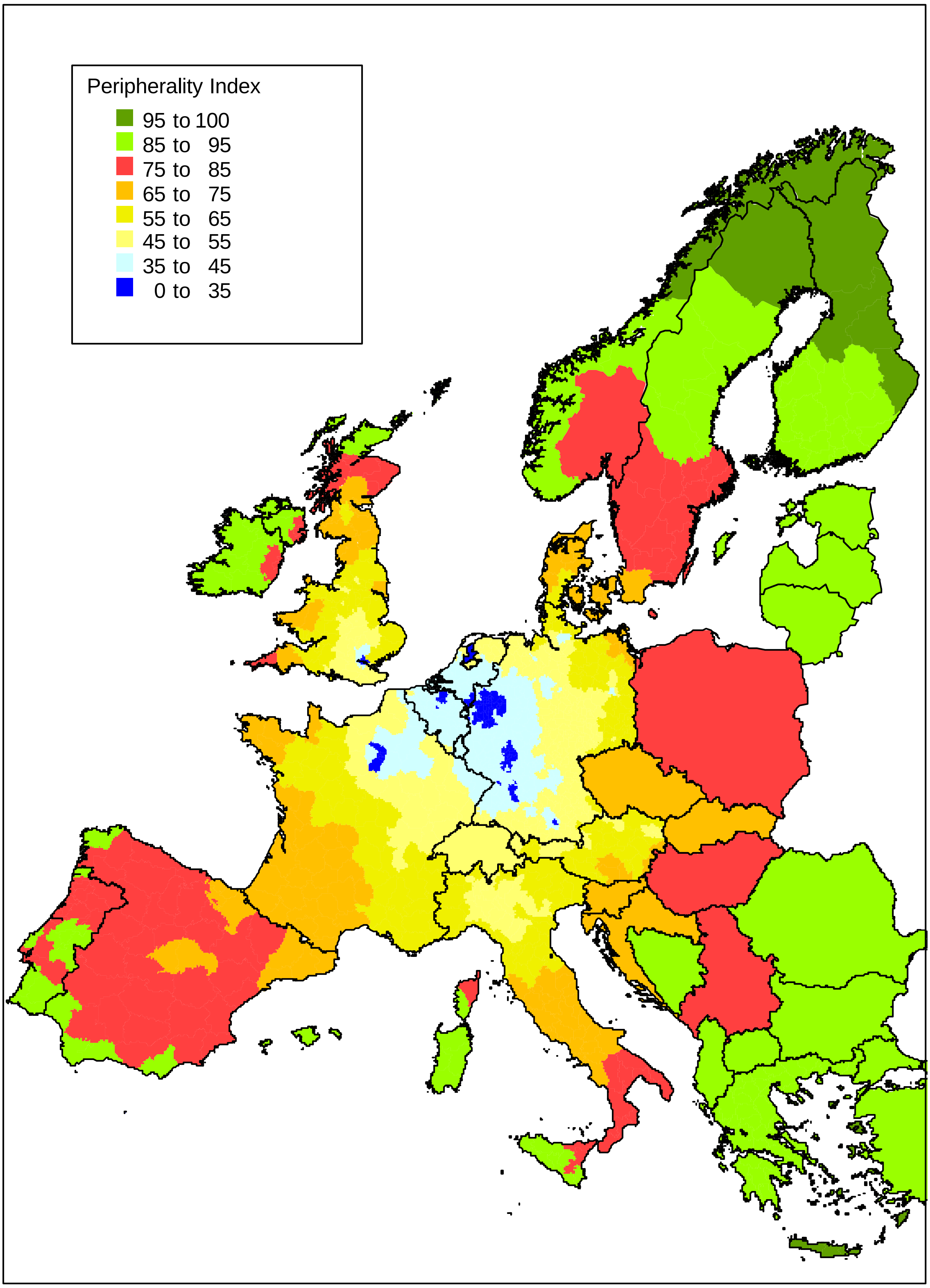


Figure 10: Peripherality Index (GDP - PPS)

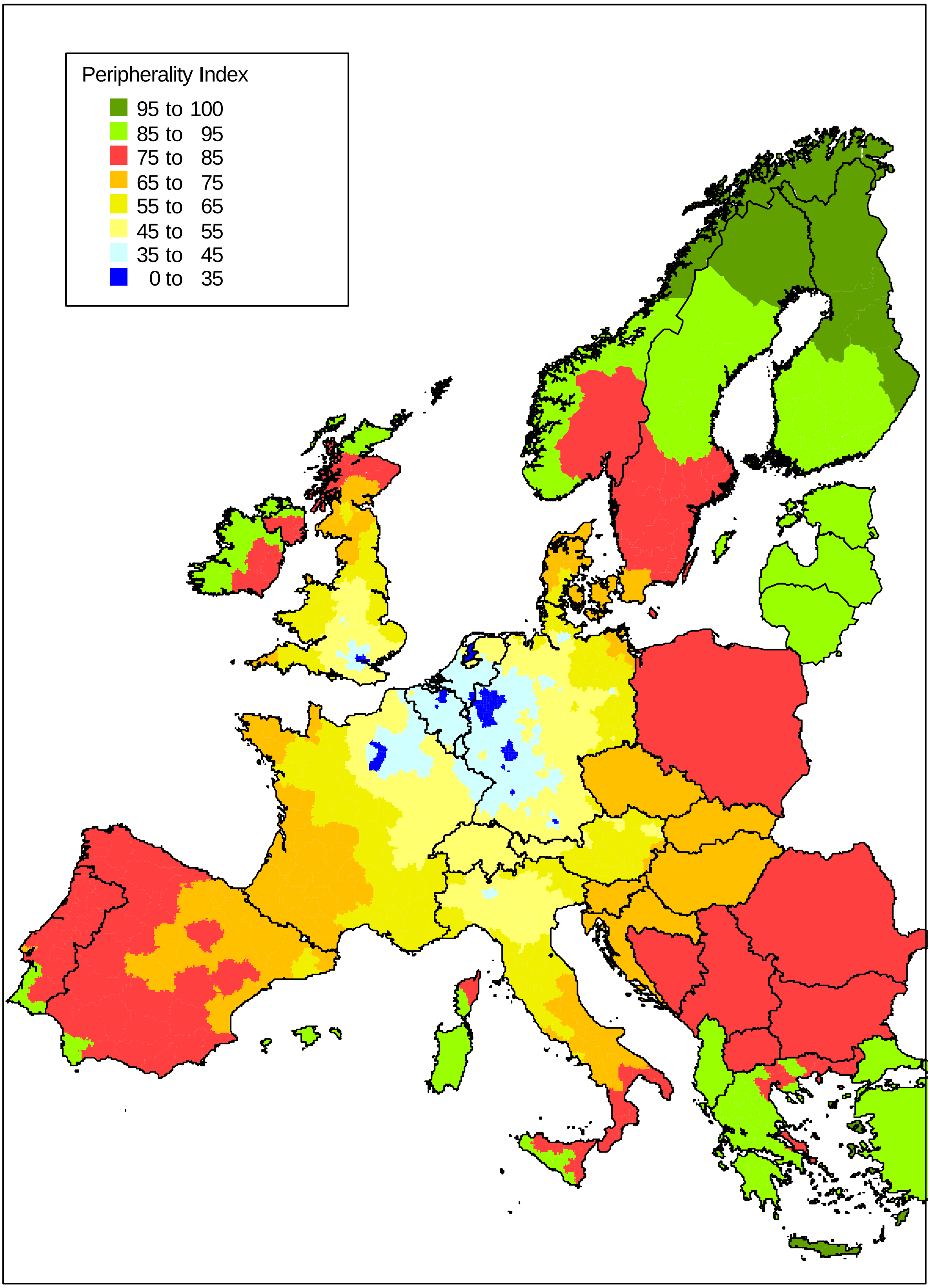


Figure 11: Peripherality Index (Population)

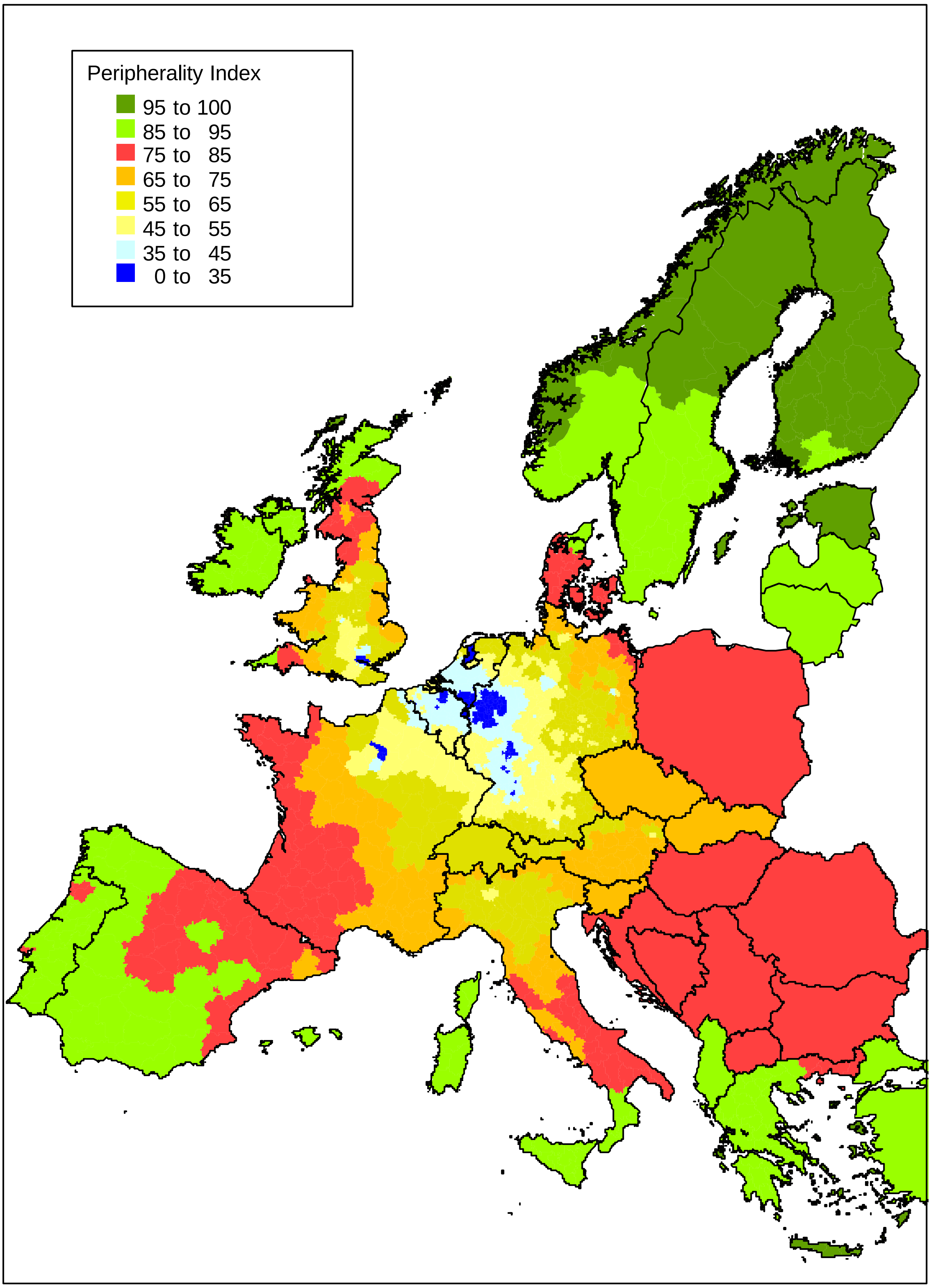
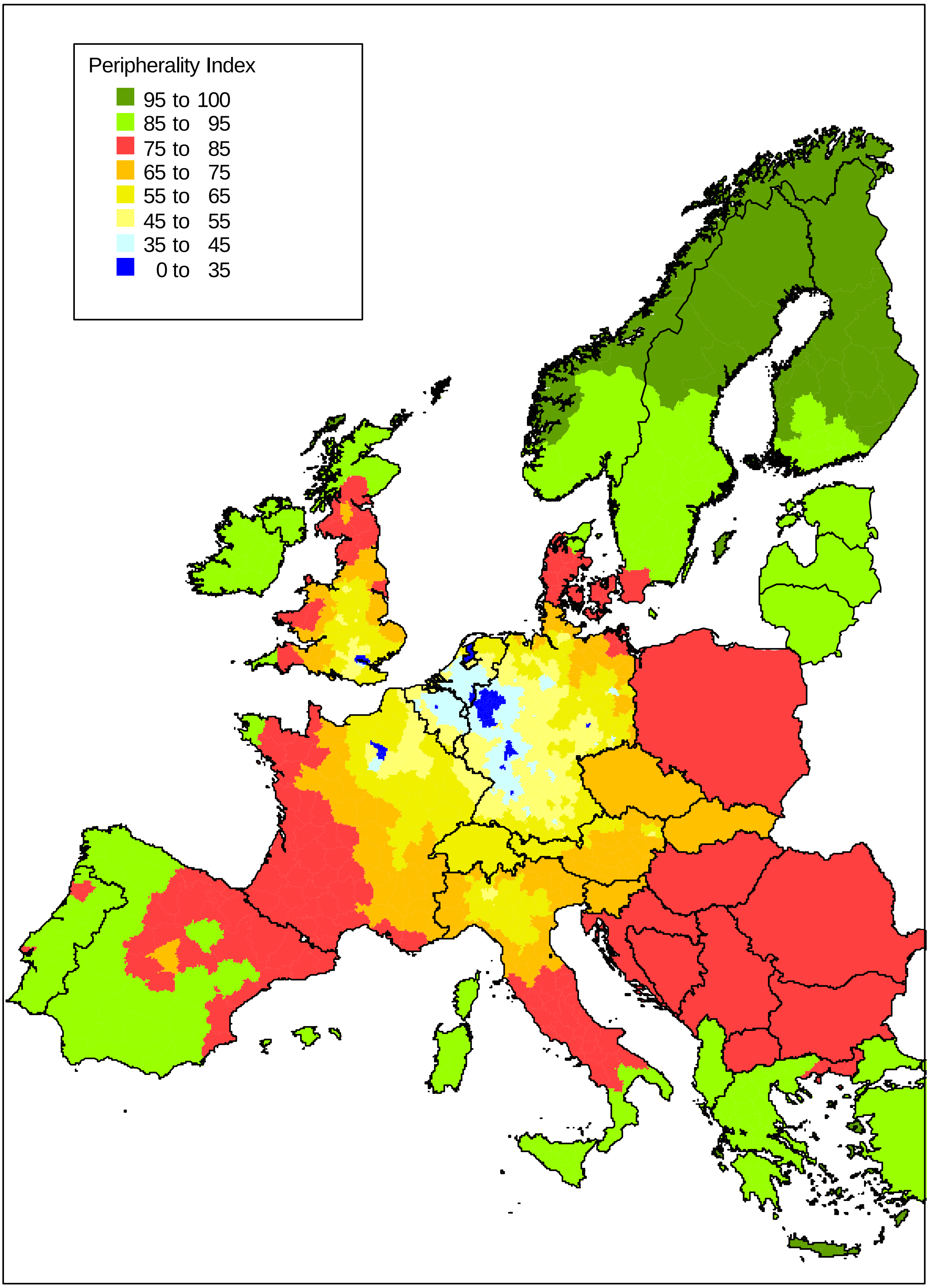


Figure 12: Peripherality Index (Workforce)



CONCLUSIONS

The recent literature suggests that, in the absence of more direct measures of the impact of peripherality upon economic activity and development, gravity model based indices are probably the most useful indicators of the relative positions of regions. This analysis has generated, using a robust methodology, a peripherality index for NUTS III regions of potential usefulness for policy targeting within the EU. The resulting maps suggest that there have been relatively few changes to the overall pattern of peripherality within the EU since Keeble carried out his analysis in the 1980s. Peripherality is still a very important issue for economic development policy in regions around the northern, western, and southern margins of the Union, and the effects are exacerbated in island areas.

There are a number of possibilities for enhancing and developing the model, including a move from travel time measurement to total travel cost, incorporation of other transport modes, (especially air), and extension of the coverage to CEEC regions in order to assess the likely impacts of enlargement.

In the longer term, however, there is a need to re-examine the whole concept of “generalised distance costs”, and the way in which gravity model peripherality indices represent them. Although the subjective perceptions of peripherality which play a powerful part in determining the role of location in economic development probably lag behind changes in real accessibility and economic disadvantage, the latter will increasingly revolutionise regional patterns of economic activity in Europe in the new millenium. New concepts of peripherality, and more direct indicators will be required within this context.

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APPENDIX 1 DATA TABLES