ESPON

EUROPEAN SPATIAL PLANNING OBSERVATION NETWORK

ESPON Project 1.4.4

Preparatory Study on Feasibility of Flows Analysis

Final Report

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The partnership behind the ESPON programme consists of the EU Commission and the Member States of the EU25, plus Norway and Switzerland. Each country and the Commission are represented in the ESPON Monitoring Committee.

This report does not necessarily reflect the opinion of the members of the Monitoring Committee.

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Foreword

The ESPON project 1.4.4 "Preparatory Study on Feasibility of Flows Analysis" was one of the last projects in the ESPON 2006 Programme. The project belongs to the ESPON Studies and Scientific Support Projects. The main task of the study was not to provide a full spatial analysis of flows but to serve as a feasibility study for this theme preparing for more in-depth research on flows in ESPON 2013.

The project commenced in Spring 2006 and was finalised in March 2007 with the submission of this Final Report. The Transnational Project Group consisted of three partners:

- Spiekermann & Wegener, Urban and Regional Research (S&W), Dortmund, Germany acted as Lead Partner; Klaus Spiekermann, Michael Wegener and Katharina Günther contributed to the project.
- The Institute of Geography and Spatial Organization of the Polish Academy of Sciences (IGIPZ PAN), Warszawa, Poland was one of the two project partners; Tomasz Komornicki, Piotr Korcelli and Rafal Wisniewski contributed to the project.
- TRT Trasporti e Territorio, Milano, Italy was the second project partner; Davide Fiorello, Silvia Maffii, Angelo Martino and Loredana Zani contributed to the project.

The project delivered an Interim Report in Summer 2006. It gives an overview on which flows are of interest to be studied by ESPON and an overview on data availability as well as an outlook on the demonstration examples elaborated in the second project phase.

This report is the Final Report of the project. It contains updates of the issues dealt with in the Interim Report, an introduction into methods to generate missing flow data, case studies of flow analyses of selected flows in selected areas, a discussion on which additional findings can be expected from more intense flows analysis and recommendations for future ESPON research with respect to flows.

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1 Executive summary

> *"Our societies are constructed around flows: flows of capital, flows of information, flows of technology, flows of organizational interactions, flows of images, sounds and symbols ... they are the expression of the processes dominating our economic, political, and symbolic life. Thus, I propose the idea that there is a new spatial form characteristic of social practices that dominate and shape the network society: the space of flows.*
>
> (Castells, 1996, 412)

The 'space of flows' metaphor by Manual Castells has stimulated the imagination of theorists and practitioners of spatial development. The vision of a 'network society' in which locations become irrelevant and the flows of information, innovations, products, capital and people are what really matters is fascinating but also misleading. While it is true that in quantitative terms the volume of flows between locations has exploded, people still need places to settle down, work, rest, feel at home and meet other people.

Flows are closely linked to European spatial policy and its objectives of competitiveness, territorial cohesion and environmental sustainability. Nowhere are the goal conflicts between the three goals so clearly manifest than in the dichotomy of flows and places. Promoting international trade and transport flows may bring economic benefit to some regions and disadvantage others and endanger the environment of all. Access to high-speed information and communication technology concentrated on corridors between the largest cities may enhance their position in the global market but also reduce the prospects of smaller cities and run counter to polycentricity.

These few examples demonstrate why awareness and understanding of flows and how they affect places are important for spatial policy. Monitoring and forecasting of trans-national and interregional flows and their impacts on spatial development should therefore be a central field of data compilation and research in ESPON.

The study "Preparatory Study on Feasibility of Flows Analysis" was designed as a feasibility and pilot study. Its main objectives were, building on existing work in ESPON, to give an overview on existing research, analytical concepts, indicators and data sets which are relevant for flows analysis in ESPON, to demonstrate suitable research methods for flows analysis and to elaborate proposals for future applied spatial research covering the theme of flows analysis.

The general objectives of the study were

- to built and expound upon the existing ESPON research framework and policy objectives within ESDP and other recent and related documents with regard to balanced, sustainable development and territorial cohesion.
- to lay down a scientific research basis, i.e. give an overview on existing research works and policies in the field, definitions of appropriate concepts, proposals for indicators, datasets which are relevant in the scope of a future applied research project, and measure and display trends and disparities within and between EU25+2+2 regions.
- to elaborate a proposal for a future applied research in ESPON covering the theme of flows analysis.

The project particularly addressed the following research questions and provides information and guidance on these issues:

- *Which flows can be integrated into the ESPON analysis?* A wide range of different flow types were considered and analysed under the viewpoint of which flows are of interest for ESPON research and relevant for territorial policies and whether it is possible to integrate an analysis of such flows into ESPON research. In this line, conceptual and methodological issues were investigated, and the problem of data availability and methods for estimating missing data were addressed.
- *What are the implications of the integration of flows analysis?* A feasibility check was made to get more insight on how flows analysis might work in practice and what problems might arise. For this purpose selected types of flows were analysed within selected geographical areas in a set of demonstration examples.
- *What should ESPON focus on in the future?* The findings of this preparatory study resulted in proposals for future policy-relevant research regarding flows in territorial analysis in ESPON 2013.

1.1 Key messages and findings

Based on the review of the state of the art of flows analysis, existing data sources and relevant application fields, the main results of the project can be summarised as follows:

- The project identified nine types of flows as of particular importance for ESPON: trade flows, financial flows, migration flows, transport flows, commuter flows, tourist flows, cultural exchange, information flows and environmental flows. It was found that these types of flows are indispensable ingredients of a holistic analysis of spatial development and of di-

rect relevance for EU policies, such as economic policy, regional policy, transport policy, agricultural policy, technology policy and environmental policy.

- These types of flows have significant importance for the main goals of the European Union, economic competitiveness, territorial cohesion and environmental sustainability. Financial, trade, tourist and transport flows have direct impacts on the economic performance of regions, migration flows, information flows and cultural exchange flows play a significant role for the economic and social cohesion between regions and countries, and transport flows and environmental flows in the form of air and water pollution are relevant for the achievement of sustainability objectives.
- The project reviewed the state of the art with respect to each of these types of flows and found that there exist theoretical concepts and feasible analytical methods for monitoring, analysing, assessing and forecasting them at all spatial scales from the European to the local level.
- However, because of the complexity of the forecasting models required, not all types of flows are suitable for establishing a forecasting capability in ESPON. This is the case for transport and environmental flows and may be true for other types of flows.
- Because of this it will be necessary to use the results of existing models and efficient forms of co-operation with other research institutions and European agencies. For other types of flows, where no expertise exists, original innovative work by ESPON is required.
- Data on spatial flows are in general incomplete or entirely lacking. Data on flows between NUTS-2 or NUTS-3 regions, the main levels of interest of ESPON, exist mostly only within one country. Where trans-national flow data are available, they suffer from insufficient spatial resolution or lack of standardisation.
- Methods of bridging data gaps or generating synthetic interregional flow data from spatially more aggregate flows or even origin and destination data are therefore major challenges of flows analysis.

Based on these conclusions, proposals were made for future projects on flows analysis in ESPON 2013. Considering the complexity and high degree of specialisation of the different types of spatial flows and application fields, the research team decided not to propose one single future ESPON project on flows analysis. Instead it was decided to propose six projects in which flows analysis plays a major role: three projects on specific flow types and three projects on the integration of flows analysis into spatial analysis. The six projects are presented in Section 1.3 below.

1.2 Key results from the analysis

In this section the results of the analysis are summarised for each of the nine flow types addressed in the study with respect to political relevance, data availability and, if applicable, the associated demonstration example. The analytical framework and data generation methods used for each of the nine flow types are summarised in Chapter 2 of Part I, the Scientific Summary. The review of flows analysis in other ESPON projects is summarised in Chapter 3 of Part I, the Report on Networking.

Trade flows

Political relevance. The enlargement of the European Union in 2004 brought an abrupt increase of trade between the old and new member states. This necessitates a dynamic spatial analysis, which identifies regions which were the beneficiaries of the first months and years of enlargement and areas where no positive economic impulses occurred after 2004.

Data availability. Trade exchange at the country level is characterised by good accessibility of data encompassing the entire ESPON area. However, information on trade at the NUTS-2 and lower levels is most often fragmentary or are just estimates. Moreover, even when they are available, they do not give a complete picture of the flows of goods, since, by definition, they do not include the flows between the regions within one country. Data of Eurostat contain basic information for the EU member states. Eurostat maintains the COMEXT database based on figures collected by the member states. The data on external trade of the EU are collected by using information from customs declarations.

Demonstration example. The demonstration example dealt with Polish foreign trade. Trade exchange with Poland constitutes around fifty percent of the whole exchange between the old and new EU member states. In the demonstration example the regional distribution of trade was analysed before and after Poland became a member of the European Union using data from the years 2000 and 2005. Particular attention was paid to changes in trade with three neighbouring countries: Germany, the Czech Republic and Ukraine. Due to the key economic role and availability of trade data, trade remains one of the best indicators of international economic connections. The regional analysis gives insight into the directions of trade interactions in individual countries. The observed interactions can be associated with the demand for transport infrastructure. The analysis of trade linkages at an international and interregional level should be an important component of studies aiming at monitoring and evaluating the effectiveness of cohesion policies in the EU – not only between the old and new EU member states but

also between the new member states. When coupled with freight transport analysis, a study of spatial trade patterns is of direct relevance for a possible reformulation of the EU transport policy.

Financial flows

Political relevance. Foreign direct investments (FDI) play an important role in the economy of every country. Foreign companies which introduce new technologies, new forms of management and organisation of production, contribute to modernisation of enterprises and increase employment. Foreign direct investments are particularly important for economic development in the new EU member states. The scale and spatial distribution of these new phenomena have not been addressed by the ESPON projects to date. Along with the decreasing share of investments linked with privatisation of existing companies, the analysis of location factors of new investment projects has become possible and purposeful. It is important to be able to determine the actual scale and spatial dimension of this phenomenon.

Data availability. Among the data on financial flows, data on foreign direct investment (FDI), the EU structural funds as well as transfers carried out by natural persons are particularly important. In the first two cases data availability is satisfactory only at the NUTS-0 level, while in the third case information is completely lacking. Statistical data showing the flow of foreign investments are collected by the United Nations Conference on Trade and Development (UNCTAD) on the basis of information transmitted by national agencies dealing with foreign investments. Eurostat provides also data on financial flows at country level for the majority of EU countries. These data are not always complete. FDI data at the country level for most of EU countries are collected also by the Organisation for Economic Co-operation and Development (OECD). The European Bank for Reconstruction and Development (EBRD) provides data for the years 1991-2005 on direct investments in the new member states, candidate countries and third countries. The European Commission provides data on financing in the Structural and Cohesion Fund programmes.

Migration flows

Policy relevance. The counterpart of capital flows are international and interregional migration flows. Globalisation and European integration have not only led to intensified flows of trade and capital, but also to growing international labour mobility, despite political forces in the more affluent countries to contain immigration. Migration is one of the two main components of population development. Besides natural population growth or decline caused by changing trends in fertility and growing life expectancy, total

population growth or decline of European countries, regions and cities depends on their migration balance; the net effect of fertility, mortality and migration determines the total population development of a territory. Spatially disaggregate demographic and economic forecasts therefore require reliable forecasts of the prevalent trends in migration flows, not only of international migration but also of interregional migration flows within countries

Data availability. Because of different data sources (e.g. population registers, household surveys and population censuses) and ambiguities of definition of what is a migration, the availability of consistent country-to-country migration data is very low. There are several institutions addressing problems of international migration data. The recently completed EU 6th Framework Project THESIM (Towards Harmonised European Statistics on International Migration) aimed at promoting awareness for the importance of harmonising European migration data. The Organisation for Economic Co-operation and Development (OECD) has done substantial research on international migration between its member countries and on possibilities to arrive at harmonised migration statistics. The ESPON database provides some data of immigrants, but not with specific origin country and mostly for immigrants from non-EU countries. Data on migration between regions within countries are not available from a unified source for all countries of the European Union. Eurostat provides interregional migration data for some countries, but with considerable delay. In addition the same difficulties as with international migration flows exist with respect to the differences between the countries in the definitions of what constitutes a migration. A further problem is the linkage between international and interregional migration. The situation is even less satisfactory with respect to disaggregation of interregional migrants by age, gender, occupation or nationality. In conclusion, the establishment of a Europe-wide database of interregional migration flows would be a major effort that could only be conducted by a permanent institution in co-operation with national statistical offices.

Demonstration example. The demonstration example on migration flows differs from the other demonstration examples in that it does not generate or analyse spatial flow data but forecasts migration flows from other observed data or modelled projections, such as population, employment, GDP per capita and quality of life and political, cultural and language barriers and physical distance between origin and destination regions. Migration data are needed only for the validation and re-calibration of the model, and because of the lack of consistent and comparable data on interregional and international migration in Europe, validation of such a model takes place at higher spatial levels, such as NUTS-2, NUTS-1 or whole countries. However, once

such a model exists, it can be used to provide the information on interregional and international migration flows indispensable for regional demographic or demo-economic analyses or projections usually not available in most existing models. Such a model is of central importance for a holistic view of European spatial development in the face of gradually disappearance of political barriers to personal movement and exchange of labour – a move to another country will not be more difficult than one within one's own country, though cultural and language barriers will continue to exist.

Transport flows

Policy relevance. Transport flows are among the most apparent evidence of the inherent spatial nature of most social and economic activities. The growing integration of markets has given rise to an intensification of flows of passengers and especially freight, making transport one of the major inputs for economic activity. In the last years, transport has therefore received special attention in the political agenda of the European Commission. In addition, the contribution of the transport sector to energy consumption and greenhouses emissions is significant. The knowledge of transport flows is essential to provide policy makers with a correct and detailed knowledge of the transport sector. Analysis and forecasting of transport flows and their spatial and environmental impacts are therefore central for ESPON and intimately connected to rational solutions to the goal conflicts between competitiveness, territorial cohesion and sustainability.

Data availability. In the field of transport there are both existing EU-wide harmonised databases and well-established methods for the generation of such databases. Transport is one of the few thematic fields for which Europe-wide harmonised databases exist, even if this is especially true for freight transport rather than for passenger transport. Some of these databases are built and maintained by official sources like Eurostat, while others are the results of research applications or surveys. For transport flow data in the form of origin-destination matrices at the European level there are two main sources: The first is ETIS-BASE (2005), which is the database recently developed within the European Transport Policy Information System (ETIS). The second major source is the Eurostat database "Intra- and extra-EU Trade". This database, also known as COMEXT, is not primarily a transport database, but a specific section is devoted to trade data in volume and value by mode of transport. Several modelling applications, often developed in projects awarded by the European Commission in the last years in the RTD Framework Programmes have estimated matrices: SCENES, NEAC, VACLAV, TEN-STAC and TRANS-TOOLS.

Demonstration example: Freight flows. The objective of the demonstration example on trade flows was to provide a range of different indicators and to highlight the informative potential of freight flow data rather than to analyse a specific aspect of freight flows. Several output variables from existing models were manipulated by combining data from different sources to compute indicators. The indicators derived are represented in maps to provide an overall view of the EU regions. In addition, loads on road links were extracted and represented graphically. This kind of information on freight transport flows can make a significant contribution to the ESPON objectives. Transport flows are one of the main ways regions interact with each other; if trade links regions to each other in economic terms, freight flows are the physical translation of these linkages. The analysis of such physical linkages is also of great importance for assessing the sustainability of trade. At the same time, transport can be regarded as one production factor the role of which has become more and more relevant as its cost has decreased. Monitoring the size of freight flows in comparison to other indicators, like the stock of infrastructure, can help to identify regions where infrastructure bottlenecks endanger regional competitiveness.

Demonstration example: Passenger flows. The demonstration example on passenger travel aimed at showing how passenger flow data can be used to compute different indicators and how they can be interpreted to identify regional specialisations. This demonstration example focused on long-distance mobility of passengers. Available data sources were selected to compute several indicators in order to derive meaningful indicators. Indicators are represented in maps to provide a view of the EU regions. A graphical representation was adopted to show loads on road links. This kind of information makes a significant contribution to the ESPON objectives, just like information on freight flows. If freight flows are the physical translation of trade, passenger flows are the concrete result of business, tourism, etc. Studying passenger flows means monitoring the relationships between the activities of European citizens and space. For personal mobility the prominent role of metropolitan areas is higher than for freight. This implies that the study of polycentricity needs to take passenger flows into account. Furthermore, the rapid development of new modes of transport, like low-cost airlines, can dramatically change the accessibility of peripheral regions. Monitoring the impacts of accessibility on competitiveness requires the consideration of passenger flows. As freight flows, passenger flows are responsible for environmental impacts reducing sustainability.

Demonstration example: Cross-border flows. This demonstration example looked into the changes in cross-border traffic between the old and new member states and across the external borders of the EU taking Poland as

case study. One of the objectives of the demonstration example was to identify the changes in cross-border traffic at internal and external borders of the European Union after the introduction of Polish visas for east Europeans in 2003 and after the accession of the country to the EU in 2004. A detailed analysis was carried out of two border segments, between Poland and Germany (a new internal border of the EU) and between Poland and Ukraine (a new external border of the EU). The analysis of border traffic is an essential complement for the analysis of flows based on origins and destinations. It may provide verification, especially for studies, in which the data are just estimates or model outputs. The data on border traffic may also be used to verify data on international tourism or migration. In addition, the analysis of cross-border flows provides the opportunity for determining the development potential of border regions. Under a broader perspective, the analysis of the evolving intensity and structure of cross-border flows between the EU member states offers insights into the process of territorial cohesion. Conversely, flows across EU external borders reflect important relations between the EU as a whole and its neighbouring countries.

Commuter flows

Policy relevance. Improved travel connections in and between metropolitan areas have resulted in vastly enlarged commuter sheds, an increase in the number of long-distance commuters, serious peak-hour congestion and environmental problems in cities and loss of open space in suburban areas. One methodological implication for regional analysis is that regional economic indicators, such as GDP per capita, are frequently distorted as income generated in core cities is consumed by households in the much larger commuter shed. The analysis of commuting pattern is of high relevance for spatial development and spatial policies as it potentially enriches the analysis of urban-rural relationships or of different spatial settings of urban systems.

Data availability. Most part of daily commuting happens within agglomerations or between core cities and their surrounding countryside, i.e. commuting takes place mainly below the overall target level NUTS-3 of ESPON research. Consequently, the ideal commuter flow data would be at the municipality level, i.e. LAU-1 or LAU-2. There are huge data gaps regards commuter flow data. In many countries it is unclear whether the data are related only to origin and destination region or whether commuter flow matrices are available. For many more countries such data exist, but access to them might be more difficult than in other countries or they exist only for parts of the country or parts of the work force, or the costs for purchasing such data are very high. The development of a EU-wide commuter flow data base at LAU-2 level would be of enormous value for research in ESPON. However,

the development of such a database would be a very large exercise in terms of data mining, data generation and data harmonisation.

Demonstration example. The focus of the demonstration example on commuter flows was on the spatial pattern of commuter flows in the light of spatially relevant issues, such as polycentricity, urban-rural relationships and dynamics over time. For this purpose, commuter flows between municipalities were analysed for the state of North-Rhine Westphalia and for selected agglomerations in Germany. Spatial patterns of commuter flows by municipality and their dynamics in recent years and spatial interaction patterns were analysed with respect to the spatial organisation of agglomerations. The conclusion for further ESPON research is that more attention should be paid to commuter flow analysis. It would contribute to a deeper understanding of spatial development processes through the inclusion of important issues of spatial interaction. Given the variety of thematic topics which would benefit, commuter flow analysis should not be an isolated theme of one project but an integrated part of several projects dealing with the European urban system, urban-rural relationships, economic and social development etc.. However, reflecting the data situation, a decision has to be made whether to invest in the establishment of a harmonised Europe-wide commuter flow data base with appropriate spatial resolution or whether projects with commuter flows should base their analyses on case studies in countries for which commuter flow data are available.

Tourist flows

Policy relevance. Tourist flows represent a growing component of international travel and have great importance for economic development in particular in the Mediterranean countries and the new EU member states. It is therefore of great interest for ESPON to analyse international tourist flows and in particular tourist flows between the old and new member states. The spatial orientation of ESPON makes it possible to identify the volumes of tourist flows and their structures (nationalities of tourists, numbers of visits, tourists using hotel accommodation, purposes of visits, frequency of visits, etc.). All this is important in the new reality of increased spatial mobility of people, resulting, in particular, from the rapid development of low-cost airlines, the opening of labour markets in the old member states for residents of the new member states, and the vanishing or lowering of the barriers to international migration.

Data availability. Data on tourist visits, overnight stays and accommodation infrastructure at the country level are relatively easily accessible. Problems arise as the level of detail of the data sought increases. It is very difficult to obtain data on tourist visits by country of origin for NUTS-2 and lower levels.

Eurostat conducts detailed statistics for all EU27 countries (and for Switzerland) for NUTS-2 or NUTS-3. The UN World Trade Organisation (WTO) collects data on tourist flows of countries. NUTS-2 and NUTS-3 region data are available from Eurostat, NACE and the ESPON database. Information on tourist visits by country of origin for NUTS-2 regions is available at only some national statistical offices (e.g. those of the Czech Republic, Estonia, Denmark and Poland). There are countries, such as Spain and France, where the available data are partial, i.e. concern visits of tourists from selected countries or groups of countries.

Demonstration example. In the demonstration example on tourist flows, analysis of statistical data made it possible to develop a detailed picture of tourist flows between the old and new EU member states. On the basis of data from Eurostat maps were prepared showing the magnitude and structure of tourist flows between the old and the ten new member states of 2004 and for selected countries. The changes in the numbers of tourists in the years 2000-2005 (for the old member states) and the years 2003-2005 (for the ten new member states of 2004) are presented in maps. The results of the analysis highlight the dramatic increase in tourist visits between the old and new EU member states after the enlargement of the EU in 2004, but also the asymmetry of this growth as more tourists from the old member states visit the ten new member states than in the opposite direction. The analysis of tourist flows should therefore be undertaken within a wider context of international short-term population movement (as opposed to migration). Such an analysis would be extremely relevant for ESPON as it provides direct links to EU integration and territorial cohesion.

Cultural exchange

Policy relevance. One of the greatest assets of Europe is its cultural diversity. The unique historically grown *unity in variety* in cultural traditions, science, education, architecture, theatre, music and the arts is the product of intensive cultural exchange. Modern transport and communication networks facilitate the exchange of experience and innovation in all fields of cultural expression. From the ESPON point of view of spatial planning, cultural exchange is important for several reasons. The "culture industries" are increasingly becoming drivers of regional economic development as they stimulate cultural tourism and so consumption in hotels, restaurants and shops. Cultural exchange also generates sometimes substantial travel flows and so has an environmental dimension. Moreover, cultural exchange flows have a direct relation to polycentricity: they tend to be concentrated on the largest capital cities, and redirecting them also to cities at the lower levels of the urban hierarchy requires planning. In a long-term perspective, cultural ex-

change is important for lowering barriers between countries, and this is important for the development of trade flows, travel and transport, migration and other forms of interaction. However, cultural exchange is also important in its own right as a medium fostering better understanding and trust between countries and so contributes to European integration.

Data availability. As to be expected given the diverse and qualitative nature of cultural exchange, data on cultural exchange flows are generally poor, in particular on flows below the national level. This is why concentration on three kinds of cultural exchange flows is recommended: academic exchange, twinned cities and language education. There is no database of bilateral partnerships between universities in Europe. This information would therefore have to be retrieved from individual universities, and this is likely to be a major effort. There is, however, information on teacher and student exchange in the SOCRATES and ERASMUS programmes. There is a comprehensive but not complete list of twinned cities in Europe on the Internet including also partnerships with cities in other continents. Data on language education in EU member states are scarce.

Information flows

Policy relevance. Information flows are the essence of the knowledge society. The rise of the information society is the result of technological progress. The Internet has brought many-to-many access not only to large corporations but to virtually everybody. The implication for spatial analysis is that space loses part of its importance. Activities that needed to be close together can now be conducted at distant places. Why are there then still large cities? Why do people continue to travel to business meetings, conferences or opera performances? Why is there still a rush hour every morning? It seems that there are additional dimensions to personal face-to-face interaction that cannot (yet) be transported via technical networks. This is why the analysis of information flows is important for ESPON: to disentangle the myths around telecommunications and to test hypotheses about spatial impacts of telecommunications in the context of globalisation, further European integration, urban-rural relationships and the core-periphery dichotomy.

Data availability When, a long time ago, national telecom companies were still public, it was possible to analyse economic complementarity and cooperation between cities as a function of the number of telephone calls between them. Since in most countries telephone companies have been privatised and much telephony occurs by mobile phones, such information has become fragmented and inaccessible because of its commercial value. The situation is even worse for Internet traffic which is, if at all, recorded by transmission line, but not by origin and destination. The analysis of tele-

communication flows is therefore largely constrained to data on the availability of telecommunications infrastructure. There are surveys of information and telecommunications technology in NUTS-2 regions commissioned by the European Commission, which do not yet, however, cover the new EU member states. In addition there are a number of private databases. However, before analyses of the spatial impacts of information flows can be conducted, a substantial amount of data mining and experimentation with the combination of different data sources will be required.

Environmental flows

Policy relevance. Air and water pollution know no boundaries. There is increasing transcontinental transport of air and water pollutants and growing awareness that trans-border air and water pollution are becoming a problem. The Clean Air for Europe (CAFE) Programme of the EC has been set up to develop the Thematic Strategy on Air Pollution under the 6th Environmental Action Programme. For ESPON trans-border flows of air and water pollution are relevant because they influence environmental quality and quality of life in cities and regions. It is therefore important for ESPON to monitor environmental flows between countries and regions and create awareness of the most significant flows and the impact on quality of life and economic development in the regions.

Data availability. Extensive air and water quality data are collected by the European Environment Agency. The French PREV'AIR system since 2003 publishes daily measurements of ozone and PM12 pollution of large parts of western Europe at a fine level of spatial detail. Trans-border flows of air pollutants are by their nature not measurable. A quantification of such flows therefore has to rely on three-dimensional air flow ('wind field') models of air dispersion. As ESPON is not likely to have the capacity to develop its own environmental modelling expertise, it seems advisable to follow a strategy of collaboration with environmental research institutions to obtain output of their models as input to further spatial analyses relating these data to socio-economic variables or using them as input to quality-of-life calculations.

1.3 Recommendations for future ESPON Projects

Considering the complexity and high degree of specialisation of the different types of spatial flows and application fields, the research team decided not to propose one single future ESPON project on flows analysis.

Instead it was decided to propose six projects in which flows analysis plays a major role: three projects on specific flow types and three projects on the integration of flows analysis into spatial analysis:

a. Projects on specific flow types

The first three projects should deal more intensively with specific types of flow than it was possible in this pilot and feasibility study:

Migration flows

The objective of this project is to develop and test a model of interregional and international migration flows in Europe. Such a model is indispensable for a holistic view of regional development and a necessary complement of regional demographic or demo-economic analyses and projections.

The research in the project should include a review of the state of the art of interregional and international migration modelling and of existing national and international migration data, the development of methods to harmonise data from different countries based on different definitions of migration, the development, calibration and validation of the model and its application for a number of policy-relevant scenarios of different immigration policies in EU and non-EU countries. The model should be designed to forecast migration flows between NUTS-3 regions that can be aggregated to higher levels.

Expected results of the project are advances towards a harmonised database of interregional and international migration in Europe, the provision of very important indicators, such as interregional and international migration flows by age, sex and nationality, and the results of exploratory scenarios of the impacts of different immigration policies of different groups of countries for the social and economic development of the regions in Europe.

Freight flows

The objective of this project is to improve the description of mobility of goods by using different types of flow data, such as trade flows, freight flows or cross-border flows. Different types of data which provide alternative points of view on the same activity (freight transport) can be exploited to fill information gaps, correct inconsistencies, validate estimations, etc.

The project should improve existing indicators rather than develop new ones. It should collect, check and harmonise freight flow data, compare data from different sources and produce revised and coherent indicators.

Such indicators would help to monitor the development of patterns over time, i.e. to identify the evolution of linkages between regions and their contribution to the cohesion in the EU space. Comparing the pattern of goods flows with other indicators like environmental or economic performance indicators would be relevant to study the relationship between goods flows and the sustainability (e.g. impacts of goods vehicles traffic on the air quality of

regions) and the competitiveness of EU regions (e.g. correlation between regional development and freight transport growth).

Passenger flows

The objective of this project is to improve the description of mobility of individuals by using different types of passenger flow data – tourist flows, passenger flows, cross-border flows. Different types which provide alternative points of view on personal mobility can be exploited to fill information gaps, correct inconsistencies, validate estimations, etc.

The project should improve existing indicators rather than develop new ones. It should collect, check and harmonise passenger flow data, compare data from different sources and produce revised and coherent indicators.

The enhanced set of indicators would allow to gain a deeper knowledge of the pattern of passenger flows at the regional level in the EU. In particular, different regional specialisations could be studied in more detail: in geographical terms (preferred destinations and origins), in economic terms (tourist, business, etc.) and in transport terms (modes). The indicators would help to monitor the development of patterns over time, i.e. identifying the evolution of linkages between regions and their contribution to the cohesion in the EU. Furthermore, comparing the pattern of passenger flows with other indicators like environmental, economic or infrastructure indicators would be relevant to study the relationship between different types of passenger flows and the sustainability (e.g. impacts of mass tourism on regional environment) and competitiveness of regions (e.g. contribution of tourism to regional development).

b. Projects on flows and spatial development

The second group of projects should pick up again project themes addressed already in ESPON 2006, review their results in the light of flows analysis and extend and enhance their results by bringing in the dimension of flows which was largely neglected in them.

Polycentricity

The objective of this project is to review and extend the results of ESPON 1.1.1 (2004) and ESPON 1.4.3 (2006) with respect to the dimension of flows. In both projects it was not possible to adequately deal with interactions between cities in space because of lack of data. However, interactions between cities, such as information flows, service flows or networks of cooperation etc. are central for the theoretical foundation of polycentricity.

The project should devise innovative methods of data collection on tangible and intangible flows in the "space of flows" (Castells) linking individuals, companies, cities and regions. The tasks of the project will include the development and test of extended indicators of polycentricity at the European, national and regional level taking better account of interactions and networks between cities and regions and analyse the historical and scenarios of future development of polycentric urban systems in Europe.

The expected results of the project are a better understanding of the meaning and added value of polycentricity of regional, national and European urban systems for EU goals, such as competitiveness, spatial cohesion and environmental sustainability.

Urban-rural relationships

The objective of this project is to review and extend the results of ESPON 1.1.2 (2006) with respect to the dimension of flows. In the project it was not possible to adequately deal with interactions between city and countryside because of lack of data. However, interactions between city and countryside, such as commuter flows, information flows and service flows are central for sustainable urban and rural development.

The project should devise innovative methods of data collection on tangible and intangible flows linking cities with their hinterland. The tasks of the project should include the development and test of extended indicators of urban and rural relationships, such as functional urban regions, commuter catchment or retail service areas, with special emphasis on intangible flows, such as telework and e-commerce, and analyse the historical and scenarios of future development of selected urban systems.

The expected results of the project are a better understanding of the relationship between cities and their hinterlands and their added value for EU goals, such as competitiveness, cohesion and sustainability.

Enlargement and beyond

The objective of this project is to review and extend the results of ESPON 1.1.3 (2006) with respect to the dimension of flows. In the project it was not possible to adequately deal with interactions between cities and regions in the new member states and between the new and old member states because of lack of data.

The project should devise innovative methods of data collection and analysis on tangible and intangible flows in the new member states and between the old and new member states. The tasks of the project would include the development and test of extended indicators of polycentricity and cohesion in

the new member states compared with the old member states and analyse their historical development and scenarios of their future development. Particular attention should be paid to the analysis of flows across two different types of borders, i.e. the borders between the old and the new member states and the new external borders of the EU, particularly the eastern borders of Estonia, Latvia, Lithuania, Poland, Slovakia, Hungary, Romania and Bulgaria. For both border types a dynamic analysis comparing flow dimensions before and after enlargements of 2004 and 2007 shall be carried out.

The anticipated removal of border control on borders between the new and old EU member states when joining the Schengen Treaty in 2008 provides a compelling argument for undertaking this study because the year 2007 might be the last year for which it is possible to carry out analysis based on a complete data base gathered by border services.

The expected results of the project are a better understanding of the meaning and added value of polycentricity for overcoming the gap in economic development, spatial cohesion and environmental sustainability between the old and new member states. The project would be the first study investigating the new flow patterns, spatial and functional linkages as well as cohesion effects as a consequence of the EU enlargements in 2004 and 2007. In addition, the results of the flow analysis between old and new member states as well as across the external EU borders may throw a new light on the current investment priorities in road, rail, air and telecommunication infrastructure. Therefore, the project could become the base for other ESPON projects focusing on development of transport networks and linkages in the field of new technologies. Seen from a broader perspective, the project would stimulate the necessary discussion about the feasible and desirable degree of closure or openness of the EU as an economic, political and social system.

2 Scientific summary

There is a long tradition of scientific analysis of movement in space. Most theories start from observed regularities of certain parameters of human mobility, such as trip distance and travel time, and from these try to infer those trip origins and destinations that best reproduce the observed frequency distributions. From these basic principles, a great variety of approaches to measure, analyse and forecast spatial flows have grown.

In scientific terms the main task of this pilot study was to review existing indicators, analysis methods and modelling techniques with a view to their application in the past and their potential applicability in future ESPON studies. One result of the review was that, as many of the flows of interest are not recorded in official statistics, techniques to generate synthetic flow data from available information are of particular importance.

In this chapter the analytical methods to measure, analyse and forecast the nine types of flows identified as potentially relevant for ESPON are summarised. Where relevant, also methods to generate synthetic flow data are indicated. These methodological considerations have to be seen in context with the availability of flow data discussed in the Executive Summary.

Trade flows

Analytical framework. In economic geography the theories of gravity and potential are used to describe flows of goods and capital. In the analysis of gravitational interaction an important role is played by the distance decay function expressing the effort or friction of overcoming distance. The usefulness of models based on the gravity paradigm is now sometimes questioned because of the drastically decreasing role, under conditions of globalisation, of physical distance as the barrier to interactions in space and the factors shaping transport costs. One of the fundamental principles explaining spatial interactions is "Ullman's triad", referred to also as the "theory of mutual interactions". It assumes that the connections taking place between regions are the effect of three basic elements: complementarity, intervening opportunity and transferability.

Financial flows

Analytical framework. Financial flows are partly an element of the same interactions as international trade flows. It is assumed that movement of capital accompanies most often the movement of goods, but in the opposite direction. Yet, while flows of goods are conditioned by the existence of transport infrastructure and thus have a definite spatio-temporal dimension, financial flows, today based on telecommunication infrastructure, cannot be

described in practice in similar geographic categories and in this respect have become similar to information flows. The analysis of foreign direct investments must therefore account for the limitations mentioned. The spatial pattern of foreign direct investments differs depending on the object of analysis: the spatial distribution of firms with foreign capital, the magnitude of investments done by foreign investors, or the distribution of the largest enterprises with dominant foreign capital.

Migration flows

Analytical framework. In 2005 the European Commission proposed a definition of what constitutes an international migration as a basis for a harmonised system of European migration statistics. However, these definitions are by no means used in all EU member states. Definitions of international migration vary significantly not only between countries but also within countries over time. Another source of uncertainty is that immigration in most countries is restricted by political constraints, and that these constrains tend to become more rigorous over time. This implies that international migration is largely politically determined and so difficult to forecast. Migration flows between regions or cities are conceptually easier to model and forecast. Within most European countries there are no restrictions on mobility of persons or households between regions or cities except the cost of movement and the opportunities for making a living and finding affordable housing at the destination. Interregional migration flows are to a large part determined by work or education opportunities. In contrast intraregional migration is largely determined by housing factors.

Data generation methods. Given the absence or poor quality of migration data, many efforts have been made to improve the quality of existing migration data or create synthetic migration data with data generation methods. There are two basic approaches for this: to estimate missing cells in a migration matrix by statistical techniques (biproportional adjustment) or to induce migration balances as the residual of natural population growth or decline (natural movement). A third, more ambitious approach is to estimate an interregional migration model based on negative attributes of the origin region (push factors) and positive attributes of the destination region (pull factors) and some measure of 'distance' between the two regions including non-spatial political, social or cultural barriers to migration.

Transport flows

Analytical framework. Transport flows indicators are needed to obtain a quantitative picture of mobility from different perspectives. Aggregate transport indicators, e.g. total trips generated, do not inform about the main fea-

tures of transport activity, i.e. its different development over space. Taking into account the spatial dimension, four main types of transport flows indicators can be identified: nodes-related indicators, links-related indicators, service-related indicators and origin-destination indicators. They can be applied at the *macro* level (flows between countries), at the *meso* level (flows between regions) or at the *micro* level (flows between municipalities).

Data generation methods. Transport flows, especially origin-destination matrices, are often modelled rather than observed data, especially when the spatial detail required is high given the limited availability of spatially disaggregate data. In addition to full transport models, also numerical methods, such as biproportional adjustment, are used to estimate synthetic trip matrices. Travel demand models estimate the flow between two regions as a positive function of the trip generation of the origin region and trip attraction of the destination region and a negative function of the 'distance' between the two regions. In integrated land-use transport models the transport matrix can be derived as result of location and trade choices. The basic concept of the input-output approach is that the production of some economic activity, output, consumes a range of other types of economic activities as input. This concept is made spatial by applying rules for the distribution of the required amount of input from alternative regions of production.

Commuter flows

Analytical framework. The analysis of commuter flows focuses on indicators based on statistical data and existing models. A commuter is a person who travels between a permanent place of residence and a place of work. Commuters can be categorised by several features: purpose, education or skill, frequency of commuting (daily, non-daily, weekly), travel mode or distance. Commuters are counted as out-commuters (at place of residence), in-commuters (at place of work) or as commuter flows, i.e. movements of persons between place of residence and place of work.

Tourist flows

Analytical framework. The analysis of tourist flows is not limited to the analysis of the actual tourist traffic. According to the most frequently used definition, a tourist is a person who is out of own will temporarily outside of the place of permanent residence and the environment associated with the everyday life rhythm. In the opinion of some authors tourism encompasses all trips except commuting. The World Tourist Organisation adopted as the notion corresponding to 'tourist' the higher-level term of 'visitor', denoting a person, whose visit lasts at least one night, and whose proper purpose of travelling can be classified into one of three groups: leisure and holidaymak-

ing, business and professional affairs and other tourist objectives. The category of tourists may include also day visitors, that is persons who do not make use of the accommodation facilities. In practice, however, statistics count as tourists most often only persons having made use of accommodation facilities. Thus, persons on business trips are included in the category of tourists. In case of international tourism an additional source of information are the data collected at state borders. Flows of people referred to as tourist flows may therefore be treated as an object of inquiry and as an indicator of intensity of the more broadly understood socio-economic interactions between the regions of origin and destination.

Cultural exchange

Analytical framework. The range of activities occurring in the field of cultural exchange is so diverse that it is impossible to capture them with any chance of being exhaustive. Therefore the following kinds of cultural exchange may be most successfully explored with priority: academic exchange, twinned cities and language education. Unlike for other types of flows, there exist only few theoretical approaches to measure, analyse or forecast cultural exchanges. Yet it would be interesting to analyse whether there exist statistical correlations between demographic, economic or other variables at the national or regional level and the magnitude and directions of student exchange flows. If it is possible to collect information on the development of student exchange flows over time, cautious forecasts of student exchanges can be made. Similar attempts could be undertaken for the interactions between twinned cities or the origins and destinations of students of language courses.

Information flows

Analytical framework. The theory and methods of the analysis of information flows are in no way different from those of the analysis of material flows. The traditional building blocks of travel analysis, trip generation, destination choice, modal split and assignment, can be applied to information flows as well. The theory behind these steps is also the same: Senders and receivers are perceived as intentionally rational agents who try to maximise their benefit under uncertainty and other constraints. However, what is called impedance in travel analysis, i.e. the time, cost and effort to get from origin to destination, is incomparably less in telecommunications, and if the sender has a flat-fare access to the network, even perceived as zero. The problem with the analysis of information flows is that they are invisible and to a large proportion unobserved. This constrains the analysis of information flows to an analysis of origins and destinations, e.g. Internet access or market penetration of mobile phones, and none of this information tends to be available

at a disaggregate regional level. Moreover, the rate of change in the technology and use of telecommunications is more rapid than probably in any other field of spatial interaction. This makes the analysis of information flows in Europe and the forecasting of their future development and their likely implications for spatial development, i.e. the competition between regions and territorial cohesion and polycentricity a highly ambitious endeavour requiring ingenuity and innovation.

Environmental flows

Analytical framework. Environmental flows, i.e. the analysis and prediction of the spatial distribution of water contamination, air pollutants or industrial or traffic noise are an established field of scientific analysis and modelling. There are modelling tools to identify strategies to protect the local, regional and global atmosphere while imposing least burden on the economic development. It is characteristic for environmental models that they work with high-resolution raster cell models of space. This is a practical barrier to the integration of environmental models with region-based models used in regional economic models, demographic models and migration models. An important methodological challenge is therefore to transfer information from raster-cell models to region-based models and vice versa.

3 Report on networking

Because the ESPON project 1.4.4 was one of the last projects of the EPSON 2006 Programme and most of the other ESPON projects were already finished during its lifetime, the opportunities for networking were rather restricted. However, the few opportunities for networking with the ESPON community were used. These are in particular the last Lead Partner Meeting which took place in Brussels in April 2006 and the final ESPON Seminar in Espoo, Finland in November 2006. The project benefited very much from the discussions and comments received at these occasions.

The major form of interaction with other ESPON projects was, however, the analysis of all final reports with respect to flows analysis. Each ESPON final report of completed projects and the interim reports of ongoing projects were scanned to find out whether the analysis of flows was part of the project, how it was done, what results were obtained and what were the limitations.

Most of the ESPON projects used to some degree concepts of flows for their analysis. However, with very few exceptions, flows analysis did not have prominent role in the analysis. Europe-wide flows analysis, again with very few exceptions, is nearly lacking; most flows analysis was done in case studies for limited areas. As it is demonstrated in Part 2, Chapter 4 of this report, in many ESPON projects flow data would have improved the analysis. However, as such data hardly exist in a harmonised database covering the ESPON space, the projects had to look for second-best data, mostly static data or potential indicators, to overcome the data gaps. Or, the projects ignored flows analysis altogether, which was in some cases surprising. A remarkable consequence is that in projects which tried to combine indicators from different fields into synthetic comprehensive indicators, flow indicators were almost completely missing.

The findings of this one-directional networking activity with other ESPON projects are reported in detail in Part 2, Chapter 4 of this report.

Part 2

Results

1 Introduction

"Our societies are constructed around flows: flows of capital, flows of information, flows of technology, flows of organizational interactions, flows of images, sounds and symbols. Flows are not just one element of social organization: they are the expression of the processes dominating our economic, political, and symbolic life. ...
Thus, I propose the idea that there is a new spatial form characteristic of social practices that dominate and shape the network society: the space of flows. The space of flows is the material organization of time-sharing social practices that work through flows. By flows I understand purposeful, repetitive, programmable sequences of exchange and interaction between physically disjointed positions held by social actors."

(Castells, 1996, 412)

The Oxford English Dictionary defines a flow as "a steady, continuous stream" (http://www.askoxford.com), the Cambridge Dictionary adds that a flow is "a regular and quite large number of something" (http://dictionary.cambridge.org). These supplementary definitions are thus referring to more than one item of the same type moving once or often in small or large numbers in a certain direction.

The ESPON Project 1.4.4 "Preparatory Study on Feasibility of Flows Analysis" deals with the question of flows within territorial analyses. However, the main task of the study was not to provide a full spatial analysis of flows but to serve as a feasibility study for this theme preparing for more in-depth research on flows in ESPON 2013. The general objectives of this preparatory study were

- to built and expound upon the existing ESPON research framework and policy objectives within ESDP and other recent and related documents with regard to balanced, sustainable development and territorial cohesion.
- to lay down a scientific research basis, i.e. give an overview on existing research works and policies in the field, definitions of appropriate concepts, proposals for indicators, datasets which are relevant in the scope of a future applied research project, and measure and display trends and disparities within and between EU25+2+2 regions.

- to elaborate a proposal for a future applied research in ESPON covering the theme of flows analysis.

The project particularly addressed the following research questions and provides information and guidance on these issues:

- *Which flows can be integrated into the ESPON analysis?* A wide range of different flow types were considered and analysed under the viewpoint of which flows are of interest for ESPON research and relevant for territorial policies and whether it is possible to integrate an analysis of such flows into ESPON research. In this line, conceptual and methodological issues were investigated, and the problem of data availability and methods for estimating missing data were addressed.
- *What are the implications of the integration of flows analysis?* A feasibility check was made to get more insight on how flows analysis might work in practice and what problems might arise. For this purpose selected types of flows were analysed within selected geographical areas in a set of demonstration examples.
- *What should ESPON focus on in the future?* The findings of this preparatory study resulted in proposals for future policy-relevant research regarding flows in territorial analysis in ESPON 2013.

The project was organised in six closely linked work packages (Figure 1). The project commenced with an examination of the ESPON needs for flows analysis (WP 1). Based on this, the issues of data availability (WP 2) and methods for the generation of missing data (WP 3) were analysed. Several demonstration examples with flows analysis were conducted (WP 4) and, together with the results of the other work packages, led to recommendations for further ESPON research on flows (WP 5). A co-ordination work package (WP 6) took care of project development and communication with the ESPON community.

This Final Report gives an overview on which flows are of interest to be studied by ESPON. For this, the political relevance of flows analysis is discussed (Chapter 2) and an analytical framework is developed (Chapter 3). Chapter 4 summarises to what extent flows played already a role in previous ESPON projects. Data availability for flows analysis is indicated in Chapter 5. Basic methods for the estimation of missing flow data are presented in Chapter 6. Seven demonstration examples for flows analysis were elaborated and are presented in Chapter 7. The report ends with conclusions on the feasibility of flows analysis in ESPON research and makes suggestions for flows analysis in ESPON 2013 (Chapter 8).

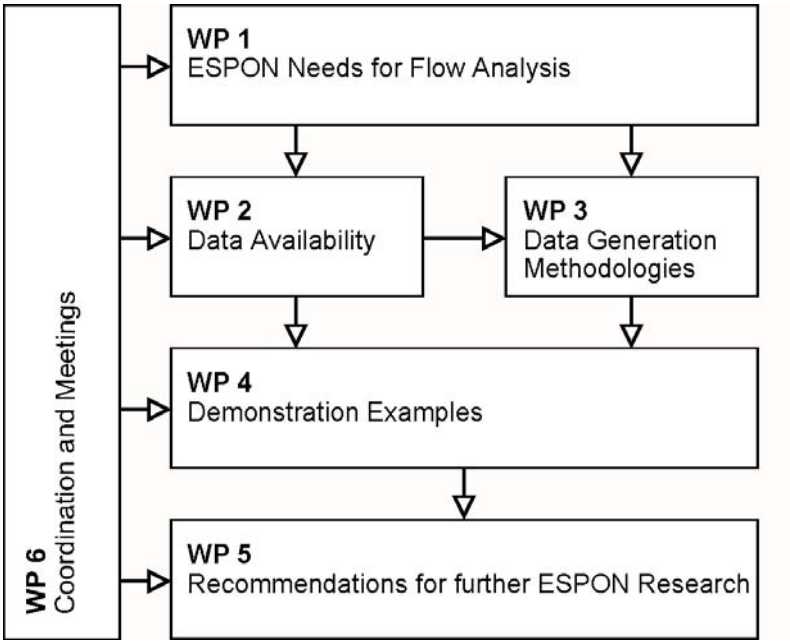


Figure 1 Project structure

2 Political relevance of flows analysis for ESPON

The 'space of flows' metaphor by Manual Castells quoted at the beginning of the introduction has stimulated the imagination of theorists and practitioners of spatial development. The vision of a 'network society' in which locations become irrelevant and the flows of information, innovations, products, capital and people are what really matters is fascinating but also misleading. While it is true that in quantitative terms the volume of flows between locations has exploded, people still need places to settle down, work, rest, feel at home and meet other people. That space matters is also behind the metaphor of the ecological footprint which suggests that the earth has a finite carrying capacity expressed in territorial units.

European policy – not only spatial policy – has to find its way through the often conflicting demands and impacts of spaces and flows. Economic policy has to deal with international flows of capital and goods in globalised markets but has also to help local economies to survive against their competition. Social policy has to find a balance between open borders and the capacity of societies to accommodate immigrants. Transport policy has to find a trade-off between the benefits of unconstrained mobility and its environmental impacts in cities and regions. Energy policy has to find the right mix between local energy production and long-distance energy imports. Environmental policy has to protect settlements and sensitive landscapes against cross-border flows of water and air pollution.

All these are elements of European spatial policy and closely linked to its objectives of competitiveness, territorial cohesion and environmental sustainability. Nowhere are the goal conflicts between the three goals so clearly manifest than in the dichotomy of flows and places. Promoting international trade and transport flows may bring economic benefit to some regions and disadvantage others and endanger the environment of all. Access to high-speed information and communication technology concentrated on corridors between the largest cities may enhance their position in the global market but also reduce the prospects of smaller cities and so run counter to the polycentricity objective.

These few examples demonstrate why awareness and understanding of flows and how they affect places are important for spatial policy. Monitoring and forecasting of trans-national and interregional flows and their impacts on spatial development should therefore be a central field of data compilation and research in ESPON.

With the close linkage between trans-national and interregional flows for spatial development in mind, the political relevance of flows analysis for ESPON are discussed in this chapter. Because some types of flows are relevant for several fields of European policy making, the discussion is organised by types of flows: trade flows, financial flows, migration flows, transport flows, commuter flows, tourist flows, cultural exchange, information flows and environmental flows.

In the following chapter the same types of flows are examined with respect to existing and potential theoretical and empirical approaches to dealing with them scientifically. In Chapter 5 the same types of flows are assessed with respect to the availability of data for their analysis.

Trade flows

The ESPON projects to date have encompassed the present European Union of 27 member states plus Norway and Switzerland. Several of these projects analysed also flows between countries and regions (ESPON 1.2.1 , ESPON 1.1.1 and ESPON 1.1.3). Many of these analyses were, however, based on data collected before the enlargement of the European Union. The quality of the data was often different for the old and the new member states. Moreover, part of the information was not based on data but on models, in which not always up-to-date economic data were used.

The enlargement of the European Union in 2004 brought an abrupt increase of trade between the old and new member states. This necessitates a dynamic spatial analysis, which identifies regions which were beneficiaries of the first months and years of enlargement and areas where no positive economic impulses occurred after 2004.

Financial flows

Foreign direct investments (FDI) play an important role in the economy of every country. Foreign companies, which introduce new technologies, new forms of management and organisation of production, contribute to modernisation of enterprises and increase employment. There are practically no longer important obstacles that hamper investing and location of enterprises in any region of the integrated Europe. Yet despite this, numerous less developed regions are still being overlooked by the investors, which deepens the polarisation between the regions in the new member states and between the old and new member states.

Foreign direct investments are particularly important for economic development in the new EU member states. Just before the accession of the ten new member states, i.e. in the years 2002-2003, the value of foreign direct investments in the accession states suddenly declined. This was most probably the effect of the termination of the privatisation processes in countries such as the Czech Republic, Slovakia and first of all Hungary. The data from the years 2004-2005 show a reversal of this trend. There has also been a significant change in the character of investments. Foreign direct investments associated with the privatisation processes largely went into greenfield type projects. The manufacturing sector, which dominated before, gave way to investment in services. Competition for the acquisition of foreign investment emerged between the countries and regions of the new member states (particularly so in the automotive industry between the Czech Republic, Poland, Slovakia and Hungary).

The scale and spatial distribution of these new phenomena have not been addressed by the ESPON projects to date. Besides, along with the decreasing share of investments linked with privatisation of existing companies, the analysis of location factors of new investment projects has become possible and purposeful. The media made outsourcing and the related transfer of jobs from the old to the new member states a constant cover story. It is important to be able to determine the actual scale and spatial dimension of this phenomenon – in practice, the numbers of jobs transferred to the new member states remains many times smaller than the number of jobs transferred to East Asia.

Migration flows

The counterpart of capital flows are international and interregional migration flows. Globalisation and European integration have not only led to intensified flows of trade and capital, but also to growing international labour mobility, despite political forces in the more affluent countries to contain immigration. Because of their ageing populations, the economies of the richer countries critically depend on labour immigration, in particular for low-wage jobs in manufacturing and services. Also within countries there are important shifts in migration flows: with economic development rural-to-urban migration declines and is replaced by movements of households from the central areas to the suburban periphery of metropolitan areas resulting in ever longer commuting distances.

Migration is one of the two main components of population development. Besides natural population growth or decline caused by changing trends in fertility and growing life expectancy, total population growth or decline of

European countries, regions and cities depends on their migration balance; the net effect of fertility, mortality and migration determines the total population development of a territory. Moreover, migrants are different in age, income, education and culture than the native population, so that in the long run migration affects the composition of the population and labour force in both the sending and receiving countries. Spatially disaggregate demographic and economic forecasts therefore require reliable forecasts of the prevalent trends in migration flows, not only of international migration but also of interregional migration flows within countries

Reliable forecasts of population development, however, are of critical importance for policy making in various policy fields including social policy, education policy, economic policy, transport policy and housing policy. Depending on the policy field, population forecasts for different spatial units are needed. Social and economic policy require forecasts of international immigration and outmigration by age, nationality, education and skill. Education policy, transport policy and housing policy require spatially disaggregate forecasts of migration flows between regions or even municipalities.

These are the reasons why the analysis and prediction of migration flows at all spatial levels from the municipal to the European level are of great scientific and political relevance for ESPON.

Transport flows

Transport flows are among the most apparent evidence of the inherent spatial nature of most social and economic activities. It is hard to imagine the life on a large continent like Europe without individuals and goods moving across the territory, both locally and over longer distances. Indeed, the growing integration of markets has given rise to an intensification of flows of passengers and especially freight, making transport one of the major inputs for economic activity.

In the last years, transport has therefore received special attention in the political agenda of the European Commission. In 2001 the *White Paper on Transport* proposed sixty measures to overhaul the transport policy of the EU. In the foreword it is written (European Commission, 2001, 3):

"Transport is crucial for our economic competitiveness and commercial, economic and cultural exchanges. This sector of the economy accounts for some 1,000 billion, or over 10 % of the EU's gross domestic product, and employs 10 million people. Transport also helps to bring Europe's citizens closer together".

The political relevance of transport is not only due to the key role played by transport itself, but especially due to the awareness that policy measures are needed, on the one side to meet the requirements of a modern transport system that can actually provide the Community with the basis for its development and, on the other side to deal with the challenges that the growth of transport raises on the energy supply and environmental side. The White Paper states:

"Transport is a key factor in modern economies. However, there is a permanent contradiction between society, which demands ever more mobility, and public opinion, which is becoming increasingly intolerant of chronic delays and the poor quality of some transport services. As demand for transport keeps increasing, the Community's answer cannot be just to build new infrastructure and open up markets. The transport system needs to be optimised to meet the demands of enlargement and sustainable development, as set out in the conclusions of the Gothenburg European Council. A modern transport system must be sustainable from an economic and social as well as an environmental viewpoint" (European Commission, 2001, 11).

The contribution of the transport sector to energy consumption and greenhouses emissions is significant. In the summary of the European Commission *Green Paper on Energy* it is said (European Commission, 2002, 10-11):

"It is indeed fortunate that industry has stabilised its consumption thanks to modernisation investments. Transport, on the other hand, is without doubt the leader in energy demand. All the forecasts predict an explosion in the activity of this largest consumer of oil".

and

"Transport accounts for 67 % of the final demand for oil, on which it is totally *dependent (98 %). Energy intensity increased by 10 % between 1985 and 1998. Growth forecasts from now to 2010 are phenomenal: +16 % for cars, +90 % for aircraft, and 50 % more road traffic. The external cost of transport – from congestion, among other things – is estimated at 2 % of GDP."*

Measuring is often a precondition for understanding and decision making. It is therefore straightforward to see that the knowledge of transport flows is essential to provide policy makers with a correct and detailed knowledge of the transport sector. Furthermore, even if transport is a determinant for the life and development of the whole European Community, most of the key impacts of transport – both positive and negative – take place at the local level. Thus, a set of spatially detailed indicators of transport flows is very relevant.

Analysis and forecasting of transport flows and their spatial and environmental impacts are therefore central for ESPON and intimately connected to rational solutions to the goal conflicts between competitiveness, territorial cohesion and sustainability.

Commuter flows

Improved travel connections in and between metropolitan areas have resulted in vastly enlarged commuter sheds, an increase in the number of long-distance commuters, serious peak-hour congestion and environmental problems in cities and loss of open space in suburban areas. One methodological implication for regional analysis is that regional economic indicators, such as GDP per capita, are frequently distorted as income generated in core cities is consumed by households in the much larger commuter shed.

The analysis of commuting pattern is of high relevance for spatial development and spatial policies as it potentially enriches the analysis of urban-rural relationships or of different spatial settings of urban systems (e.g. Sinz and Blach, 1994; Spiekermann, 1997; Bade and Spiekermann, 2000):

- In monocentric urban regions commuter flows are radial from the surrounding area to the city centre. The core city has a positive commuter balance, the suburban municipalities a negative balance. However, if the core city has grown already beyond its municipal boundaries, municipalities at their border might have also a positive commuter balance.
- In polycentric urban regions, commuter flows are running not only to a core city but also to other destinations with higher concentrations of jobs. In such agglomerations there are intense commuter linkages between these secondary centres, and, as an overlaying pattern, all centres might have established their own systems of commuter catchment areas.
- In urban regions that are spatially organised in a more dispersed way, the commuter pattern is network-like. There is no dominant centre and no dominant orientation of commuter flows. Larger cities in such regions do not necessarily have a positive commuter balance.

In all these spatial settings the importance of reverse commuter traffic, i.e. flows going from the core cites to the outskirts, and tangential commuter traffic is growing at the expense of flows to the centres.

Tourist flows

In a unifying Europe it is essential to recognise and analyse in detail the magnitude and structure of tourist flows. Tourist flows represent a growing component of international travel and have great importance for economic development in particular in the Mediterranean countries and the new EU member states. It is therefore of great interest for ESPON to analyse international tourist flows and in particular tourist flows between the old and new member states and, equally important, also neighbouring countries, such as Croatia, Macedonia and Turkey.

The analysis of statistical data allows to answer the question whether and how the accession of the ten new member states of 2004 had an impact on the general trends in tourism. Did tourist flows increase after the EU enlargement? What are their main directions? How did they change? Did the new member states manage to attract a greater number of tourists than before the accession? The spatial orientation of ESPON makes it possible to identify the volumes of tourist flows and their structures (nationalities of tourists, numbers of visits, tourists using hotel accommodation, purposes of visits, frequency of visits, etc.). All this is important in the new reality of increased spatial mobility of people, resulting, in particular, from the rapid development of low-cost airlines, the opening of labour markets in the old member states for residents of the new member states, and the vanishing or lowering of the barriers to international migration.

After the EU enlargement in 2004 the number and length of border segments between the EU and third countries increased abruptly. Until then such a situation had existed only in the thinly populated areas of Scandinavia. Now the boundary of the EU with Russia, Belarus, Ukraine, Romania (until its membership), Serbia and Croatia crosses the entire continent from the Baltic Sea to the Adriatic Sea. This brings about a polarisation of the European border regimes. To an increasing degree the weakly formalised borders (or the practically nonexistent ones) start to dominate inside the EU and the highly formalised ones (with visa requirement for the direct neighbours being the rule) on the outer borders of the European Union.

Under these conditions it is necessary to include in the analysis of flows also those from and to the outer neighbours of the EU. This concerns not only the candidate countries (Croatia, Macedonia and Turkey), but also to the remaining Balkan countries (Serbia, Montenegro, Bosnia and Herzegovina and Albania) and the countries of eastern Europe Ukraine, Belarus, Russia and Moldavia. Because of the length of the present outer borders, the omission of traffic crossing these borders would distort the analysis of existing interactions in the new member states.

Cultural exchange

One of the greatest assets of Europe is its cultural diversity. There is a unique historically grown *unity in variety* in cultural traditions, science, education, architecture, theatre, music and the arts. This unity in variety is the product of intensive cultural exchange.

Cultural exchange is not a new phenomenon. Already in the middle ages existed strong trans-European networks of cultural exchange between monasteries as centres of scholarship. Cultural exchange became more intense with the foundation of universities and the growing interest in classical culture at the absolutist courts in the Renaissance and Baroque periods. Scholars, such as Erasmus of Rotterdam, or artists, such as Wolfgang Amadeus Mozart, were "travel pioneers" in cultural exchange with impressive itineraries all over the continent (Foucher, 1993).

Modern transport and communication networks facilitate the exchange of experience and innovation in all fields of cultural expression:

- Art museums exchange their works of art for exhibition events commemorating great artists or artistic schools. Large-scale exhibition events are becoming tourist attractions of economic importance. More and more the exhibitions themselves travel between countries to reach wider audiences.
- Theatres, opera houses and concert halls exchange productions to save costs and reach wider audiences. Actors, singers and conductors perform at different places all over the world . The number of variety of summer festivals attracting international cultural tourist is growing at an impressive rate.
- Universities are increasingly linked by international networks. Every university has bilateral partnerships with universities in other countries. To spend at least one year at a university abroad is almost standard experience for most students. Many countries have set up programmes to fund exchange of university teachers and students; at the European scale the ERASMUS programme facilitates the exchange of students between universities in all EU member states.

Partnerships between cities (‘town twinning') has become a powerful movement, Most cities in Europe are linked with one or more cities abroad by twinning agreements promoting visits, youth exchange and joint cultural activities. Twinning between European cities has been supported by the European Union since 1989. In 2003 an annual budget of about 12 million € was allocated to about 1,300 projects.

- Teaching of foreign languages at schools tends to be asymmetrical: in large countries the languages of smaller neighbours are rarely taught, whereas more languages are taught and spoken in smaller countries.
- More and more governments recognise the importance of international cultural relations and support cultural institutions, such as the Maison de France or the Goethe-Institut, offering cultural events and language courses in other countries.

From the ESPON point of view of spatial planning, cultural exchange is important for several reasons. The "culture industries" are increasingly becoming drivers of regional economic development as they stimulate cultural tourism and so consumption in hotels, restaurants and shops. Cultural exchange also generates sometimes substantial travel flows and so has an environmental dimension. Moreover, cultural exchange flows have a direct relation to polycentricity: they tend to be concentrated on the largest capital cities, and redirecting them also to cities at the lower levels of the urban hierarchy requires planning. In a long-term perspective, cultural exchange is important for lowering cultural and language barriers between countries, and these are important for the development of trade flows, travel and transport, migration and other forms of interaction. However, cultural exchange is also important in its own right as a medium fostering better understanding and trust between countries and so contributes to European integration.

Information flows

Information flows are the essence of the knowledge society. They constitute the Castell's 'space of flows' which, as some analysts believe, is gradually replacing the space of fixed locations separate by physical space.

The rise of the information society is the result of technological progress. In the 1950s the first transatlantic cable carried 36 simultaneous telephone conversations. Transatlantic cables today carry millions of simultaneous messages, and much more are carried by satellite connections. The Internet has brought many-to-many access not only to large corporations but to virtually everybody. High-speed networks are rapidly eliminating existing bandwidth restrictions and so open new perspectives for the transmission of images and television programmes.

The implication for spatial analysis is that space loses part of its importance. Activities that needed to be close together can now be conducted at distant places. A customer calling a hotline may without knowing talk to a call centre agent nearby or in India or Ireland. Once you have access to the Internet, it no longer matters where you are. You may even work at home.

Why are there then still large cities? Why do people continue to travel to business meetings, conferences or opera performances? Why is there still a rush hour every morning? It seems that there are additional dimensions to personal face-to-face interaction that cannot (yet) be transported via technical networks. Some researchers even believe that telecommunication even reinforces spatial polarisation, i.e. the dominance of large cities.

This is why the analysis of information flows is important for ESPON. It will be a challenging task to disentangle the myths around telecommunications and to test the hypotheses about spatial impacts of telecommunications in the context of globalisation, further European integration, urban-rural relationships and the core-periphery dichotomy. Important questions that need to be answered are:

- Is there a correlation between immaterial information flows and material flows of person travel and trade?
- Do information flows decline with distance as material flows?
- Are there cultural or language barriers to information flows, just as in travel?
- Are there spatial disparities in the provision of telecommunication access and services and what are their impacts on territorial cohesion?
- Are telecommunication flows reinforcing or destroying polycentric urban systems at the European, national or regional level?
- Will teleconferencing be a substitute for business meetings as air travel becomes more expensive?
- Will telework and e-commerce change urban and rural life styles and make urban transport more sustainable?

Environmental flows

Air and water pollution know no boundaries. There is increasing transcontinental transport of air and water pollutants. There is growing awareness that trans-border air and water pollution are becoming a problem:

- Since 1979 the Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE) has addressed some of the major environmental problems of the UNECE region through scientific collaboration and policy negotiation, exchange of information, consultation, research and monitoring (see Annex Internet Sources).

- The Clean Air for Europe (CAFE) Programme of the EC has been set up to develop the Thematic Strategy on Air Pollution under the 6th Environmental Action Programme.
- The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone sets emission ceilings for 2010 for four pollutants: sulphur, NO_x, VOC and ammonia. Once the Protocol is fully implemented, Europe's sulphur emissions should be cut by at least 63%, its NO_x emissions by 41%, its VOC emissions by 40% and its ammonia emissions by 17% compared to 1990, and the area in Europe with excessive levels of acidification will shrink from 93 million hectares in 1990 to 15 million hectares and that with excessive levels of eutrophication will fall from 165 million hectares in 1990 to 108 million hectares, and the number of days with excessive ozone levels will be halved, resulting in 2.3 million less life-years lost as a result of the chronic effects of ozone exposure in 2010 than in 1990 and approximately 47,500 fewer premature deaths resulting from ozone and particulate matter in the air.

For ESPON trans-border flows of air and water pollution are relevant because they influence environmental quality and quality of life in cities and regions. It is therefore of great importance for ESPON to monitor existing environmental flows between countries and regions and create awareness about the most significant flows and the impact on quality of life and economic development in the regions. However, the main relevance of these flows lies at the intraregional or urban scale and will become important for ESPON to the extent ESPON addresses intraregional and urban problems.

3 Analytical framework for flows analysis in ESPON

There is a long tradition of scientific analysis of movement in space. Most theories start from observed regularities of certain parameters of human mobility, such as trip distance and travel time, and from these try to infer those trip origins and destinations that best reproduce the observed frequency distributions. It had long been observed by Ravenstein (1885) and Zipf (1949) that the frequency of human interactions such as messages, trips or migrations between two locations (cities or regions) is proportional to their size, but inversely proportional to their distance. The analogy to the law of gravitation in physics is obvious.

The gravity model was the first *spatial interaction* (or in short *SIA*) model. Its straightforward physical analogy has later been replaced by better founded formulations derived from statistical mechanics (Wilson, 1967) or information theory (Snickars and Weibull, 1976), yet even after these substitutions the SIA model did not provide any *explanation* for the spatial behaviour modelled. Only later did it become possible (Anas, 1983) to link it via random utility theory (McFadden, 1973) to psychological models of human decision behaviour (Luce, 1959). From the SIA model it is only a small step to its application as a location model. If it is possible to make inferences from the distribution of human activities to the spatial interactions between them, it must also be possible to identify the location of activities giving rise to a certain trip pattern.

A second set of theories focuses on the *economic* foundations of location. In regional economics, the theories of *growth poles* (Perroux, 1955) or *circular cumulative causation* (Myrdal, 1957) predict polarisation between central and peripheral regions because of economies of scale and enhanced possibilities of innovation in the larger industries at the centre. If transport costs are taken into account, a hierarchical pattern of market areas around *central places* emerges (Christaller, 1933; Lösch, 1940). Central places of higher levels have high functions but also all the functions of lower levels, which explains the existence of small and large cities. Manufacturing industries tend to locate close to the locations of raw materials and other inputs or close to their markets depending on the cost of shipping goods of different weight (Weber, 1909); if they also take account of economies of scale or labour cost, agglomeration or dispersal may occur (Isard, 1956). Following Krugman (1991; 1996), a great part of spatial development can be explained by the interplay of two major driving forces, economies of scale and transport cost. All types of land uses experience increasing returns to scale: on the level of the firm *internal* economies of scale through labour savings

through mass production, on the level of cities and regions *external* economies of scale or agglomeration economies through synergies between firms and access to large diversified labour and customer markets. The consequence is a trend to ever larger units of production and distribution. Transport, however, has since the introduction of the railways been characterised by acceleration and decreasing costs. Dematerialisation of production and the transition to a service-based economy have contributed to reducing the importance of physical transport.

Flows of people, goods and information take place by the intermediary of transport and communication networks, and constitute important characteristics of geographical space and of socio-economic systems (Haggett, 1972; Morrill, 1970). Moreover, economic growth of regions depends on their capacity to interact with the environment, both the socio-economic and the natural (Domański, 1996). That is why any regional analysis has to account for the economic linkages with other regions (Isard, 1965).

Some geographical analyses refer to physical analogies and distinguish such interactions as convection (physical movement of goods and people), conduction (not requiring displacement, but ensuring equilibration – like, e.g., financial flows), and radiation (movement of information), see Domański (1996). The totality of international connections of regions is composed of all the three kinds of interactions mentioned.

Wilson (1974) argues that spatial interactions and connections are expressed through transport, financial and information flows (the latter involving personal contacts, correspondence, telephone conversations). Lowe and Moryadas (1975) classify them into those that are the effect of propagation of phenomena (associated with diffusion), and those resulting from the linkages between definite places (or, in other words, flows having definite origins and destinations). In their opinion both kinds of movements are expressed through the motion of persons, goods and information. At the same time, though, they emphasise that precise distinction between the notions of diffusion and flow is not possible.

The interregional connections may be represented in the form of model-based graphical schemes. The simplest graphical scheme for the analysis of international connections at the regional level is the scheme of spatial distribution of bilateral contacts. For analytical purposes international connections between two (or more) countries can be spatially aggregated in three basic ways (Komornicki, 2002): (a) by region (administrative units) in country A; (b) by region (administrative units) in country B; (c) by direction of transport connection (transport of goods and passengers between countries).

In this chapter the nine types of flows identified as potentially relevant for ESPON, trade flows, financial flows, migration flows, transport flows, commuter flows, tourist flows, cultural exchange, information flows and environmental flows are discussed with respect to their suitability to be analysed using one of the theoretical and empirical approaches presented above. The subsequent sections of this chapter give for each type of flows an overview of its the relevance for territorial analysis and present the main analytical concepts and indicators that can be applied to them.

3.1 Trade flows

It is held that the domain which exerts the biggest influence on the advancement of the globalisation process is international trade (Wnorowski, 2002). At the same time, trade connections become less and less persistent in space (Rogacki, 2001). Trade can no longer be analysed in abstraction from other kinds of connections: especially capital interactions (foreign direct investment), but also to some extent social interactions (e.g. migration).

It should be also remembered that international trade has changed its nature through globalisation. Rather than being an exchange of goods between companies located in various countries, it becomes increasingly the multiple exchange of components and semi-products within the networks of multinational corporations across the state borders (Stryjakiewicz, 2002).

In economic geography the theories of gravity and potential are used to describe flows of goods and capital. In the analysis of gravitational interaction an important role is played by the distance decay function expressing the effort or friction of overcoming distance. Interregional interactions are usually taken as inversely proportional to the distance between the regions. It was most often assumed that the distance variable is continuous. This was certainly a correct assumption in the economic conditions of the middle of the 20th century. Currently, this dependence has diminished perceptibly. The usefulness of models based on the gravity paradigm is now sometimes questioned because of the drastically decreasing role, under conditions of globalisation, of physical distance as the barrier to interactions in space and the factors shaping transport costs (Stryjakiewicz, 2002).

The gravity model is also often criticised for the assumption of full functional complementarity between origin and destination regions, a situation very rarely encountered in the real world (Ullman, 1957). Many authors think that the model correctly describes interactions between towns that are not far from each other. Its validity decreases already in the description of inter-

regional connections, and drops decisively in the domain of international interactions (Lowe and Moryadas, 1975). Within countries, administrative boundaries bring about a discontinuity of the distance function. In the case of interactions crossing national borders (even when these borders are highly permeable) the jump-like change of the intensity of interactions is even more drastic. An attempt of using the gravity model in the study of international interactions was undertaken, for instance, in the analysis of business trips with passenger cars in the Netherlands (Rietveld, 1999). All internal relations between the twelve provinces of the country as well as the relations of these provinces with the selected regions of Europe were accounted for. It was demonstrated that the existence of boundaries (despite their significant permeability inside the Schengen area) reduces the number of interactions by approximately 16%.

One of the fundamental principles explaining spatial interactions is "Ullman's triad", referred to also as the "theory of mutual interactions". It assumes that the connections taking place between regions are the effect of three basic elements: complementarity, intervening opportunity and transferability. Complementarity appears when two regions dispose of different resources and is the consequence of geographical differentiation. In order for a connection (here a flow of goods) to arise, there must exist supply of a product in one region and demand for it in another one. Intervening opportunity reflects the absorption of some part of the potential interaction between two regions by a large centre (region) situated between them. Transferability describes the reducing influence of distance (geographical, time-wise or economic) on the intensity of connections. It is assumed that under increasing costs and time of transport a given product is replaced by another one not requiring so high expenditures.

Rogacki (2001) thinks that under conditions of globalisation and saturation of the world market with the majority of goods, the principle of complementarity and the increasing number of intervening opportunities are confirmed by the weakening persistence of trade flows. The number of intervening opportunities increases, in particular, due to the integration process in Europe. At the same time, the globalisation process brought about, inter alia, by decreasing transport costs, causes a significant limitation to the role of transferability in the macro scale. It is even possible to dare the proposition that close to fifty years after the principles of "Ullman's triad" were formulated, the role of complementarity and intervening opportunity in explanation of interregional trade flows has increased, while the role of the factor of transferability has decreased.

3.2 Financial flows

Financial flows are partly an element of the same interactions as international trade flows. It is assumed that movement of capital accompanies most often the movement of goods, but in the opposite direction. Yet, while flows of goods are conditioned by the existence of transport infrastructure and thus have a definite spatio-temporal dimension, financial flows, based nowadays on telecommunication infrastructure, cannot be described in practice in similar geographic categories, in this respect have become similar to information flows.

Thus, spatial studies often concentrate on the effects of capital movements and not on the financial flows themselves. Such effects are constituted by greenfield investments or those realised with funds of the European Union. Significant financial flows accompany also, on the other hand, the so-called portfolio investments (mainly done through the stock exchanges). They can have important impacts on the entire economic systems of particular countries, but are most often devoid of any spatial character. Economic interactions are also expressed through private transfers (especially remittances by seasonal or permanent emigrants). These, however, are usually statistically inaccessible.

The analysis of foreign direct investments (as reflected in the statistical data available) must therefore account for the limitations mentioned. It is also necessary to define precisely what is understood by foreign direct investments. According to the International Monetary Fund direct investment is an activity undertaken in order to gain persistent influence on the functioning of an enterprise in a given country. According to the OECD, direct investment takes place when a single investor controls at least 10% of the shares of a given company. The statistical offices of the particular countries often count as firms with foreign capital all those that have some foreign co-owners (even when their share is below 10%). However, agencies dealing with foreign direct investments most frequently collect data only for larger undertakings (e.g. in Poland exceeding one million US Dollar).

The spatial pattern of foreign direct investments (especially in the new EU member states) differs depending on the object of analysis:

- spatial distribution of firms with foreign capital (concentration in regions with high numbers of small firms, e.g. in border regions),
- magnitude of investments done by foreign investors in total (in the new member states this distribution is most often analogous to that of the entire economy – the consequence of privatisation) or in new (greenfield) establishments,

- distribution of the largest enterprises (according to sales) with dominating foreign capital (usually metropolitan areas, and first of all the one of the capital city).

3.3 Migration flows

In the analysis of migration flows three different kinds of migration have to be distinguished: *international* migration between countries, *interregional* migration within countries and *intraregional* migration within a region.

International migration

In 2005 the European Commission proposed a definition of what constitutes an international migration as a basis for a harmonised system of European migration statistics (European Commission, 2005). According to this proposal, the following definitions are to apply:

- "Immigration" means the action by which a natural person establishes his or her usual residence in the territory of a Member State for a period that is, or is expected to be, of at least twelve months, having previously been usually resident in another Member State or a third country.
- "Emigration" means the action by which a natural person having previously been usually resident in the territory of a Member State, ceases to have his usual residence in that Member State for a period that is, or is expected to be, of at least twelve months.
- "Immigrant" means a natural person undertaking an immigration.
- "Emigrant" means a natural person undertaking an emigration.

These definitions are based on the definition of a long-term migrant given in the United Nations Recommendations on Statistics on International Migration (United Nations, 1998). The concept of usual residence, which forms the basis of definitions of international migration is also based on the UN Recommendations:

- "Usual residence" means the place in which a person normally spends the daily period of rest, regardless of temporary absences for purposes of recreation, holiday, visits to friends and relatives, business, medical treatment or religious pilgrimage.

However, these definitions are by no means used in all EU member states. There is a great lack of uniformity in the definitions of international migration (Nowok and Kupiszewska, 2005). Definitions of international migration

vary significantly not only between countries but also within countries over time. The main sources of variation in the definitions used are the differences in the concepts of place of residence and duration of stay that are applied to determine who is an international migrant.

Residence is a vaguely defined term: it can be interpreted from a legal or actual point of view, and the conditions differ between nationals and non-nationals; and among non-nationals there is a distinction between foreigners with the right to free movement and others. Time is a supplementary concept to that of residence. Some countries assume that a migration has taken place after a residence for a minimum period of time; others take only permanent change of residence into account, without a precise definition of the term permanent. Where a minimum period of residence is required there is a great variation in the minimum time: In some countries there is no minimum time and any change of residence is registered, the minimum time in other countries varies between three months and one year. Moreover, in most countries not actual time is accounted for (which would delay registration of a migration by that period) but intended or expected duration of stay; and this of course implies the risk of change of plans.

Another source of uncertainty is the fact that immigration in most countries is restricted by political constraints, and that these constrains tend to become more rigorous over time. There exist various forms of constraints, such as the authorisation to stay only for a limited period or for a specified purpose such as family reunification or education without the permission to work, or permission to work only in occupations in which there is a need for labour, or specific quotas for immigration from different origin countries.

Moreover, these political constraints are in continuous development. With the enlargement of the European Union in 2004, the restrictions on migration between the old and new member states are gradually being removed (though with different momentum by different old member states), while the restrictions on migration from outside the enlarged EU to the new member states have increased.

A special category are people applying for asylum for political reasons and illegal immigrants.

Interregional migration

Migration flows between regions or cities are conceptually easier to model and forecast. Within most European countries there are no restrictions on mobility of persons or households between regions or cities except the cost of movement and the opportunities for making a living and finding affordable

housing at the destination. Interregional migration flows are to a large part determined by work or education opportunities: people move to other regions to take advantage of a (better) job or a place at an educational institution. Increasingly, interregional migration is also motivated by considerations of quality of life, culture or climate, in particular after retirement.

Intraregional migration

Change of residence of persons or households within a region is an important component of regional development and the relationship between urban areas and rural areas and between cities and their suburbs. With growing affluence and cheap transport, moving to the suburbs has become affordable for large parts of the population with the effect that cities have expanded into their surroundings at the expense of open space and ever longer travel distances. Intraregional migration is therefore of great importance for less energy-demanding, sustainable cities. However, because of the European focus of ESPON, intraregional migration flows will not be specifically addressed in this pilot project.

3.4 Transport flows

As no transport modelling capacity has been developed in ESPON, the analysis of transport flows concentrates on transport flow indicators based on statistical data and existing models.

Transport flows indicators are needed to obtain a quantitative picture of mobility from different perspectives. Generally speaking, indicators are used as synthetic measures of phenomena investigated. Therefore, the roots of indicators are the questions to which one looks for responses.

As explained in Chapter 2, the political relevance of transport is due to its positive role in the economic development and in the social life of citizens and its negative role in terms of energy consumption, pollution and other externalities. Hence the policy issues are of the kind:

- Which regions generate the higher amount of transport demand? Are these the same regions where economic activity is better performing?
- Does traffic affect accessibility and competitiveness of regions?
- Which corridors bear the larger environmental burden (congestion, noise, pollution)?
- Are there differences in the mobility pattern of different areas in terms of energy efficiency of transport?

Some of these questions can be answered using aggregate indicators of transport activity (e.g. total trips generated, total vehicle-km travelled). This kind of indicators is already present in the ESPON database. The June 2006 version of the database includes the following transport indicators:

- total trips generated by trip purpose and mode in NUTS-2 regions;
- total trips attracted by trip purpose and mode in NUTS-2 regions;
- average distance of trips per person by trip purpose and mode in NUTS-2 regions;
- total distance travelled by trip purpose and mode in NUTS-2 regions.

However, these indicators do not inform about the main features of transport activity, i.e. its different development over space. Aggregate indicators hide that trips generated are generally unevenly distributed among possible attractions, that a given average distance is the result of a matrix of trips making different use of alternative links (e.g. roads, rail routes) and nodes (e.g. ports, airports).

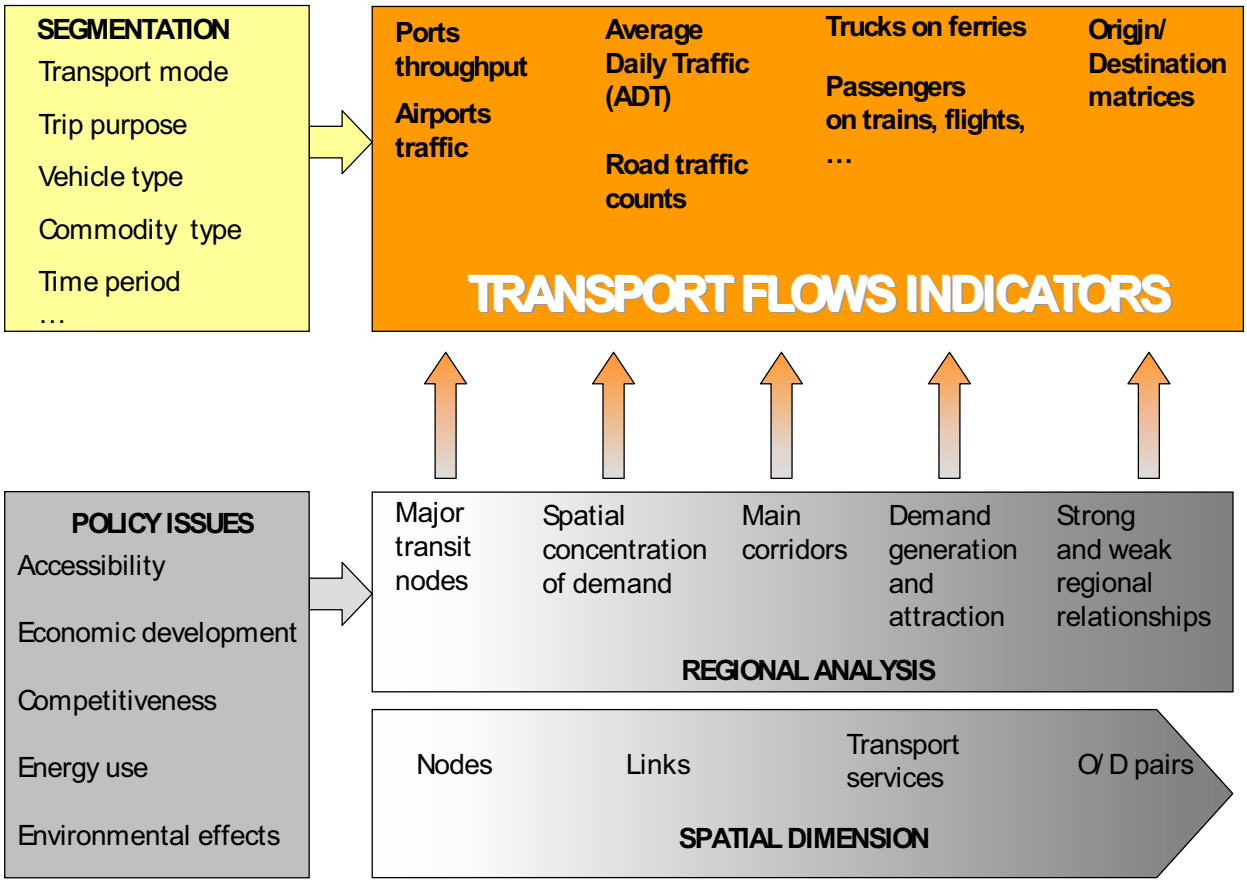


Figure 2 Analytical framework for transport flows indicators

Transport flow indicators help to enlarge the scope of the analysis and take into account the spatial dimension of transport. Figure 2 frames transport flow indicators taking account of:

- the policy issues giving rise to the need for transport indicators,
- the spatial dimension,
- the relevant aspects for a regional analysis of mobility,
- the segmentation of indicators.

Taking into account the spatial dimension, four main types of transport flows indicators can be identified:

- *Nodes-related indicators*. Such indicators concern the amount of transport flows passing through given nodes of the transport network. The main nodes of a transport network are bus stations, rail stations, sea ports, inland ports, airports. Indicators can just make reference to the total amount of passenger and/or freight travelling through the node in a given period of time, but they can also add more information like the direction of the flow (inward or outward).
- *Links-related indicators*. Such indicators provide information about the amount of flows travelling on given roads or rail stretches. The most used indicator in this group is Average Daily Traffic (ADT) which is a total value of vehicles travelling in 24 hours disregarding the direction of travel and without any detail about the different type of vehicles. Traffic counts on given road sections (e.g. on trunk roads or at customs) enrich the description of the flow in terms of the timing profile (e.g. traffic data per hour over 24 hours), the direction of travel, the type of vehicle (e.g. cars, light goods vehicles, heavy goods vehicles, etc.).
- *Service-related indicators*. Passengers can be counted on board of trains, coaches, flights, etc. Also, for coaches and trains, passengers getting on and off at stations and stops can be counted. In both cases a profile of the flow over the service route is available. The indicators can make reference to single trips or to the total trips in a day, etc. Another indicator belonging to this group is the number of vehicles carried on ferries.
- *Origin-destination indicators*. Origin-destination indicators fully describe transport flows including the place where the flow starts and the place where the flow ends. This information is of course of great value as the same node or link flow can be generated by a different mix of short and long-distance demand. So origin-destination data are of help also to interpret other transport flow indicators. Furthermore, in principle from origin-destination data, all other kind of indicators can be deducted (e.g.

given a road flow from two regions, one can estimate which links and nodes of the network are used) while the reverse does not apply in general. An origin-destination matrix is the usual form of this indicator. Each cell of the matrix contains the amount of flow from the origin zone (generally in row) to the destination zone (generally in column) in a given period of time (e.g. peak-hour, day, year). The flow can be expressed in terms of individuals, vehicles, etc. Furthermore, different matrices can be built for different trip purposes (e.g. business trips, tourist trips) or commodity types (e.g. bulk goods, containers).

With reference to the ESPON "three-level approach", transport flows intrinsically concern the *meso* and the *micro* level rather than the macro level. Origin-destination data can be built at the *macro* level (flows between countries), at the *meso* level (flows between regions) as well as at *micro* level (flows between municipalities). Other types of transport flows indicators make generally reference to local circumstances: as explained above flows at nodes can regard airports or stations, link flows report traffic on given roads, etc.

3.5 Commuter flows

The analysis of commuter flows is constrained by the same restriction that to date no transport modelling capacity exists in ESPON. Therefore the analysis of commuter flows focuses on transport flow indicators based on statistical data and existing models.

A commuter is a person who travels between a permanent place of residence and a place of work. The different terms used for commuting in different languages encompass already several features of this activity. The English-language expression "commute" originates from the reduced or "commuted" fare paid for a rail season ticket (Wikipedia, 2006), i.e. reflects the stability of this flow. The German term "pendeln" translates into "to oscillate" or "to shuttle"; thus describing the regular movement between two places. In French, a commuter is called "banlieusard", a person coming from the suburbs to work. In most countries the definition of a commuter implies that the journey to work crosses a municipal boundary, i.e. that place of residence and work are located in different municipalities.

Before the industrialisation the individual places of residence and work were located closely together in walking distance. Only in very few large towns that had already a concentration of manufacturing, trade and administration some workers had to commute from the early suburbs or the rural surroundings to the central city. With increasing industrialisation, commuting became

a growing phenomenon (Ott and Gerlinger, 1992). However, the greatest increase in commuter traffic was caused by the growing spatial separation between the still central industrial or commercial areas and residential suburbs responding to the desire of large parts of the population to live in detached single-family houses in pleasant natural environments. The spatial separation of urban functions was made possible by the development of modern transport means. The first push was induced by the introduction of public transport; tram and underground lines, buses and commuter trains, but also the use of bicycles enabled people to live far from their workplace. The tremendous rise in motorisation that observed in Europe during the last fifty years has allowed to select a place of living nearly without consideration of its distance to the place of work.

Commuter can be categorised by several features. A first differentiation is the purpose of the journey:

- To go for work is the dominant reason for a commuter trip.
- The second purpose is education. More and more university students do not live near their university but elsewhere, mainly at their parents' place, and travel to the university by car or public transport.

A second important differentiation addresses the time and frequency of commuting:

- Daily commuting is the prevalent form of commuting, i.e. leaving home for work in the morning and returning in the afternoon or evening.
- Non-daily commuting of part-time workers or teleworkers is growing due to increasingly flexible labour markets and wide-spread availability of Internet access for connections between home and workplace.
- Weekly commuting or even less frequent commuting is another option chosen by a growing number of commuters. These commuters have a second home or other forms of accommodation near their place of work or university and come home to their main place of residence only for weekends.

Commuter flows are usually described by a set of standard indicators (Leser et al., 1997):

- Commuters are counted as out-commuters at the origin, i.e. the place of residence. The out-commuter rate is the share of out-commuters of the total number of workers living in a municipality.

- Commuters are counted as in-commuters at the destination, i.e. the place of work or education. The in-commuter rate is the share in in-commuters in the total number of jobs available in the destination city.
- Commuters which have both the place of residence and the place of work or education in the same municipality are called internal commuters.
- A commuter flow is the number of commuters travelling from an origin municipality to a destination municipality.

All indicators are further distinguished by travel mode and distance.

3.6 Tourist flows

Like in all parts of the world, tourism is rapidly emerging as one of the key sectors of the economy in a variety of European contexts. It has long been the major engine of economic growth in Alpine and other mountainous areas, cross-border regions, coastal and insular regions, but also in cities of varying sizes. The tourism sector has been credited with creating jobs (directly and indirectly) and many observers believe that it generates a significant income multiplier. In an era where many traditional economic activities such as agriculture, logging or manufacturing have witnessed decline, tourism is boosted as one of the key sectors for economic restructuring.

Unfortunately, despite the obvious benefits associated with the tourist sector, there are also numerous negative impacts. The latter have led critics to question the value of tourism as a tool for economic development. Some academics have also argued that government officials and industry representatives regularly exaggerate the positive impacts of tourism in order to boost the sector's image, even though their statements are based more on opinion rather than rigorous analysis (see ESPON 1.4.5.).

Beyond these economic questions there are numerous other issues that have occupied the attention of researchers in recent years. For instance, how can we measure the carrying capacity of tourist environments? Is there a way to handle a large number of arrivals without detrimental impacts on the very attractions that bring them there in the first place? How can tourism lead to a greater degree of social equity?

The analysis of tourist flows is not limited, though, to the analysis of the actual tourist traffic. This results from the definition of a tourist adopted in the literature and in the systems registering tourist traffic. Thus, according to the most frequently used broad definition, a tourist is a person, who is out of own will temporarily outside of the place of permanent residence and the environment associated with the everyday life rhythm (Kowalczyk, 2001). In

the opinion of some authors tourism encompasses all trips except commuting (Gunn, 1988). The World Tourist Organisation adopted as the notion corresponding to 'tourist' the higher-level term of 'visitor', denoting a person, whose visit lasts at least one night, and whose proper purpose of travelling can be classified into one of three groups: leisure and holidaymaking, business and professional affairs and other tourist objectives. The category of tourists may include also day visitors, that is persons who do not make use of the accommodation facilities (Kowalczyk, 2001; Szwichtenberg, 2000). In practice, however, statistics count as tourists most often only persons having made use of accommodation facilities. Thus, persons on business trips are included in the category of tourists. In case of international tourism an additional source of information are the data collected at state borders. These data, however, include also persons crossing the border commuting to work or dealing with petty trade and so visiting the neighbouring country for just a couple of hours and therefore are not registered in the overnight stay statistics. That is why studies of tourist flows necessitate adequate precision in the use of available data and care in interpretation.

Flows of people referred to as tourist flows may therefore be treated as an object of inquiry (first of all of tourism itself, of tourist infrastructure, development perspectives, etc.) and as an indicator of intensity of the more broadly understood socio-economic interactions between the regions of origin and destination.

3.7 Cultural exchange

The range of activities occurring in the field of cultural exchange is so diverse that it is impossible to capture them with any chance of being exhaustive. This means that based on criteria of data availability and importance, a selective research strategy is appropriate. From such a perspective the following kinds of cultural exchange may be most successfully explored with priority:

Academic exchange

Partnerships between universities are relatively stable and can be assessed with a high degree of certainty. Student exchange flows are also institutionalised and recorded through national academic exchange institutions and the ERASMUS Programme.

It would be interesting to analyse whether there exist statistical correlations between demographic, economic or other variables at the national or re-

gional level and the magnitude and directions of student exchange flows. If it is possible to collect information on the development of student exchange flows over time, cautious forecasts of student exchanges can be made.

Twinned cities

Partnerships between cities are also relatively stable over time. It is more difficult to assess the joint activities that are generated by a partnership between twinned cities – most likely there will be a great variety in the intensity of partnerships, i.e. in the number and frequency of joint activities. Research questions of interest are whether there exist significant spatial clusters of twinning partnerships based on similarities between the twinned cities or the opposite, different characteristics. The latter may be typical for partnerships between cities belonging to countries that were in war with each other in World War II.

Language

The number of school children exposed to foreign language classes in schools may be a good indicator for the openness of a country or region to international cultural exchange. If this information could be combined with information on the average language proficiency of the adult population and its development over time, this could be a good indicator of the progress of European integration. It would also be of interest whether this indicator is correlated with other demographic, economic socio-cultural variables.

3.8 Information flows

The theory and methods of the analysis of information flows are in no way different from those of the analysis of material flows.

The traditional building blocks of travel analysis, trip generation, destination choice, modal split and assignment, can be applied to information flows as well. The theory behind these steps is also the same: Senders and receivers are perceived as intentionally rational agents who try to maximise their benefit under uncertainty and other constraints. This implies that larger origins are likely to send more messages than smaller origins and larger destinations are likely to receive more messages than smaller destinations. However, what is called impedance in travel analysis, i.e. the time, cost and effort to get from origin to destination, is incomparably less in telecommunications, and if the sender has a flat-fare access to the network, even perceived as zero.

The problem with the analysis of information flows is that they are invisible and to a large proportion unobserved (see Section 5.8). This constrains the analysis of information flows to an analysis of origins and destinations, e.g. Internet access or market penetration of mobile phones, and none of this information tends to be available at a disaggregate regional level. Moreover, the rate of change in the technology and use of telecommunications is more rapid than probably in any other field of spatial interaction. This makes the analysis of information flows in Europe and the forecasting of their future development and their likely implications for spatial development, i.e. the competition between regions and territorial cohesion and polycentricity a highly ambitious endeavour requiring ingenuity and innovation.

3.9 Environmental flows

Environmental flows, i.e. the analysis and prediction of the spatial distribution of water contamination, air pollutants or industrial or traffic noise is an established field of scientific analysis and modelling.

At the European scale, the International Institute of Applied Systems Analysis (IIASA) developed modelling tools to identify strategies to protect the local, regional and global atmosphere while imposing least burden on the economic development. The RAINS model is a model of European transborder flows of air pollutants allowing to assess scenarios of pollution abatement policies on the level of pollution and human exposure to air pollution in other countries. Similar models exist for the analysis and prediction of surface and ground water flows.

It is characteristic for environmental models that they work with high-resolution raster cell models of space. This is a practical barrier to the integration of environmental models with region-based models used in regional economic models, demographic models and migration models. An important methodological challenge is therefore to transfer information from raster-cell models to region-based models and vice versa.

4 Scope, results and limitations of flows analysis in ESPON 2006

In order to get an overview how spatial flows have been treated in ESPON so far, all ESPON studies were analysed. Each ESPON final report and the interim reports of ongoing projects were scanned to find out whether the analysis of flows was part of the project, how it was done, what results were obtained and what were the limitations. This chapter presents the main findings on flows-related ESPON research.

The analysis starts with projects in which flows are of potential value for the particular topic. Then, the analysis follows the thematic fields for flows analysis proposed in the previous chapter.

Most of the ESPON projects used to some degree concepts of flows for their analysis. However, with very few exceptions, flows analysis did not have prominent role in the analysis. Europe-wide flows analysis, again with very few exceptions, is nearly absent; most flows analysis was done in case studies for limited areas. As it will be seen in the subsequent sections, in many ESPON projects flow data would have improved the analysis. However, as such data hardly exist in a harmonised database covering the whole ESPON space, the projects had to look for second-best data, mostly static data or indicators of potential flows, to overcome the data gaps. Or, the projects ignored flows analysis altogether, which was in some cases surprising. A remarkable consequence is that in projects which tried to combine indicators from different fields into synthetic comprehensive indicators, flow indicators were almost completely missing.

Flows are also important elements in the development of scenarios in ESPON 3.2 (2006). The assumptions made in ESPON 3.2 on changing flows and the underlying causes cannot be reported here. The transport model KTEN supporting the scenario work will be briefly described in Section 6.3.

Flows and polycentricity

Within the concept of polycentricity, flows of all types are essential features at all spatial scales, i.e. the European level (macro), the interregional level (meso) and the intraregional (micro) level. Two structural aspects are seen as of particular relevance to polycentricity: the morphological aspect and the relational aspect based on the networks of flows and co-operation between urban areas at different scales (ESPON 1.1.1, 2006, 45). Relations are further broken down into institutional and structural polycentricity; the latter

might be measured by road, rail and air traffic, financial flows, information flows, etc. (ibid., 47). Flow data, such as flows of goods or services, travel flows or telephone calls or e-mail traffic, are also seen as ideal for measuring connectivity as one component of polycentricity. But ESPON 1.1.1 had also to face problems of data availability and could give only examples of flows indicating polycentric settings and had to use indicators describing the potentials for interactions instead of using real flow data (ibid., 61).

Flows and urban-rural relationships

Urban-rural relationships are characterised by several flows between areas changing over time. Before the industrial revolution it was mainly the flow of agricultural products from villages to cities in exchange for commercial products. In a second phase the rural areas became increasingly dependent on urban economies. In a third phase, which is still ongoing, "urban-rural linkages are now moving beyond the single one-way exchanges and demonstrate a more complex and dynamic web of interdependencies" (ESPON 1.1.2, 17). Flows of people and materials go today in both directions, but some of the flows are mainly in one direction (e.g. waste) whereas others are two-directional (e.g. tourist flows). However, for the urban-rural typology of regions in Europe, flow data did not play a role. The typology is based on population density and the administrative status of the region to reflect the degree of urban influence on the one hand and the share of artificial surfaces to reflect the degree of human intervention on the other.

Flows and EU enlargement

With the enlargement of the European Union several flow patterns changed compared to the time before the enlargement. ESPON 1.1.3 (2005) states that changing flow patterns indicate the degree of integration: "Increased mobility – e.g. labour force or residential migration – is generally a sign of increased integration, especially if it is not a one-way process" (ibid., 52). However, flow analysis was outside the scope of the project.

Flows and globalisation

ESPON 3.4.1 (2006) analysing the role of Europe in the world is the ESPON project with the largest portion of flows analysis. It was analysed how Europe is embedded in the world of flows and what is the area of influence of the ESPON countries. Dealing mainly with flows between countries, data

problems were not such an issue for ESPON 3.4.1 as for the projects looking at the regional level.

Trade flows

In ESPON 2.1.1 (2005) studying the territorial impacts of transport policies the regional economic model CGEurope was used to forecast socio-economic impacts of transport policies as the result of trade flows subject to changing transport infrastructure and transport costs. However, as the focus was on the regional economic impacts in terms of regional welfare, the trade flow matrices as such were not published.

ESPON 3.4.1 (2006) developed global maps on trade flows showing a triadic organisation with North America, Eastern Asia and the European Union as nodes in the global economic system. Trade flows between countries were also used to identify economic macro regions with close economic relationships. The analysis of trade flows supports a centre-periphery vision of the world seeing the three nodes mentioned above as centres. Trade relationships with neighbouring regions show different economic relationships with macro-regions surrounding the ESPON space. An analysis of the internal differentiation of trade flows of ESPON countries shows differences in the international orientation ranging from global orientation to European orientation thus raising the "question of globalization versus regionalization" (ibid., 205).

Financial flows

ESPON 1.1.3 (2005) analysed data on foreign direct investments (FDI) in the new member states. Three countries, Poland, the Czech Republic and Hungary received eighty percent of the FDI inflows. Seen on a per-capita basis, FDI investments differ much between countries, between Latvia with only 84 Euro per capita and some countries with more than 500 Euro per capita. However, this is much less than the average of the old member states with more than 1,000 Euro per capita. There are also huge disparities in FDI within countries, with the majority of investments in the large agglomerations.

The policy impact projects of ESPON analysed the impacts of various European policies, many of which come in the form of financial flows from European institutions to countries or regions. ESPON 2.1.2 (2005) examined the impacts of research and development policies, ESPON 2.1.3 (2005) the impacts of the common agricultural policy, ESPON 2.1.5 (2006) the impacts of fisheries policies, ESPON 2.2.1 (2005) the impacts of the Structural Funds,

ESPON 2.2.2 (2005) the impacts of pre-accession aid in the new member states and ESPON 2.2.3 (2005) the impacts of urban policies.

ESPON 3.4.2 (2006), which dealt with economic policies and the location of economic activities, showed the rise of FDI in the new member states and mapped for some of them the regional pattern of foreign investments.

Migration flows

ESPON 1.1.2 (2006) studied urban-rural relationships in a number of case studies. It concluded that outmigration to the suburban ring and beyond the suburbs into rural areas is a common trend. However, migration towards rural areas is spatially selective. The reasons "include quality of life issues associated with living environments, the prosperity of urban areas in the region, opportunities for home-working (via ICT for example), the declining costs of car ownership and use in comparison to average income, and the prevalence of dispersed employment and shopping areas" (ibid., 207).

ESPON 1.1.3 (2005) discussed changing migration patterns after the enlargement of the European Union. Driving forces identified are the removal of barriers for labour mobility and the economic transition in the new member states. These affect not only international migration patterns but also internal migration in the new member states which experienced already a movement from the rural areas to the agglomerations. However, migration analysis in the project was restricted: "The big problem concerning analyses of international migration is shortage of data with respect to origin and destination and the absence of flow data" (ibid., 57). Therefore, net migration data were used. One of the results is that the expected mass migration to western Europe due to the removal of barriers did not take place.

ESPON 1.1.4 (2005) analysed the spatial effects of demographic trends and the changing migration patterns in the last four decades: the rural exodus of the 1960s and 1970s was followed by counter-urbanisation, i.e. reverse migration from urban to rural areas. A new pattern emerged since the beginning of the 1990s when Europe as a whole became a continent with net immigration and an increased flow of east-west migration. However, due to missing migration flow data, migratory balances (net migration) for NUTS-3 (and partly NUTS-2) regions were calculated as total regional population change minus births plus deaths in a year for the second half of the 1990s and previous decades. Based on a combination of demographic indicators and net migration data, a typology of European regions was developed. The widely missing migration flow data have serious consequences for spatial analysis: "Without information on the place of origin and the place of destination it will be impossible to analyse the international migration flows and

to analyse the processes of convergence/divergence within EU29" (ibid., 31). The project did quantitative scenarios in which the current regional fertility and mortality rates were used as a base to forecast population change. In the scenarios different migration rates were added to the model; some of the rates were defined in a way that the number of immigrants necessary to keep a certain age group at its current level could be estimated.

ESPON 1.4.2 (2006) addressed the social dimension of territorial development. It identified flexibility as important for the ability to react to new challenges and changing conditions, in particular on the labour market. "Mobility is used as the territorial expression of this flexibility leading to commuting and migration" (ibid., 263).

In ESPON 2.1.1 (2005) and in ESPON 1.1.3 (2005) the SASI model was used to forecast socio-economic impacts of transport policies. A submodel of the SASI model forecasts migration for NUTS 3 regions, but so far only as net migration instead of migration flows. This was the motivation for one the demonstration examples, which will be discussed in Section 6.2.

ESPON 3.4.1 (2006) addressed the issue of international migration flows in the world. Although serious data problems concerning origin and destinations exist, the project could elaborate maps of push and pull factors and demonstrate that "the pattern of migration is different according to the education level of migrants. Migrations of low skilled workers follow the centre-periphery pattern when migrations of high skilled workers are rather submitted to the archipelago model" (ibid., 102).

Transport flows

In ESPON 1.1.1 (2006), functional urban areas (FUA) were identified and evaluated by seven functions, one of them being the transport function. Due to lack of other flow data, the number of passengers at airports and the container traffic at ports were used to identify the significance of a FUA in the transport system. It turned out that the transport system favours polycentricity in Austria, Germany, Italy, Finland, Norway and Sweden and is more monocentric than expected in the Czech Republic, Hungary and Slovakia. The development of air passenger flows was used by ESPON 1.1.1 to show that the European urban system is becoming somewhat more balanced as the largest growth rates are in major airports outside the pentagon.

ESPON 1.2.1 (2005) developed and mapped a set of indicators showing traffic volumes and flows mainly at the level of NUTS-2 regions. Using the KTEN model, indicators for personal travel such as trips generated in origin regions, trips attracted to destination regions, car-km by trip purpose and car

traffic volumes on roads and airport passenger traffic were mapped. Indicators for freight traffic were based on different databases and models and include freight transport generation by goods category and mode and freight traffic volumes on road, rail, seaways and in ports. Some flow indicators were also expressed as transit flows per NUTS-2 region. Other indicators, such as travel time, daily accessibility or potential accessibility are not flow indicators in a narrow sense; but information on destinations and travel time or cost to reach them express opportunities for flows. Using the concept of network vulnerability, some examples were shown how flows would be redirected if parts of the transport infrastructure would be out of operation due to natural or technological hazards. The project pointed to the problems of availability of updated and harmonised data, such as origin-destination matrices, link capacity and cost, traffic volumes on links and timetable information for trains and flights.

ESPON 1.3.1 (2005) did a risk assessment of air traffic. A hazard map of air traffic accidents per airport passenger was developed showing the risk potential of NUTS-3 regions. Another risk map related to transport flows was based on oil production and transport.

In ESPON 2.1.1 (2005) road traffic flow forecasts from the TEN-STAC project were processed to show the traffic intensity of NUTS-3 regions in terms of vehicle km per km².

In ESPON 3.4.1 (2006) international air flights were used to determine the structure of "the network of world cities which appears as an archipelago of cities linked to each other without considering national borders or continents" (ibid., 122). The analysis of air flows between ESPON countries and the neighbouring countries showed that "the neighbouring countries are generally more connected to the core of north-western Europe than to their immediate countries with which they share common borders" (ibid., 185), which was labelled as "tunnel effect". The geographical orientation of air traffic of ESPON airports was used to develop a classification as global gateway, central node or peripheral node.

Commuter flows

ESPON 1.1.1 (2006) looked at the different definitions in European countries to delimit functional urban areas (FUA). In many countries commuter catchment areas were used, but with very different definitions and thresholds. Because of the lack of commuter flow data for all ESPON countries, the project was not able to provide its own definition of FUA based on journey-to-work trips. Instead of commuter flow data, a travel-time threshold approach was used. It was admitted that this does not necessarily reflect the

real commuter movements, hence the urban regions so defined were labelled as "geography of possibilities" (ibid., 120).

In ESPON 1.1.2 (2006) the functional relationships between urban and rural areas was analysed in case studies. The conclusion from the case studies was that the size of functional urban regions measured by commuter catchment areas does increase because of improvements in physical infrastructure and the development of new communication technologies. At the same time commuting by rural people working in the cities was seen as one of the biggest forces for change of the countryside. However, it was also pointed out that "the scarce availability of comparable data on commuting patterns hampers the analysis of functional urban regions in Europe" (ibid., 28).

ESPON 1.4.1 (2006) reviewed the different approaches to define urban areas. Besides administrative and morphological approaches, in many European countries functional approaches are used in which commuter flows play often the key role to delimit the labour market area of a core city.

ESPON 1.4.3 (2006), reviewing and updating the results of ESPON 1.1.1, argued that "commuting based analysis is an inadequate indicator to describe relational polycentricity as it focuses only on some types of relations (workers' journeys from home to work) and favours a strong bias towards morphological polycentricity based on spatial proximity" (ibid., 17).

Tourist flows

In ESPON 1.1.1 (2006) on of the seven functions to analyse functional urban areas (FUA) was tourism. However, no flow data were used, instead the number of hotel beds was applied as indicator for tourist flows received.

ESPON 1.3.2 (2006) in its analysis of the natural heritage stated that scenery and climate are the most important factors for the selection of a tourist destination. Tourist flows were considered a risk for the natural heritage.

ESPON 1.3.3 (2006) studied the cultural heritage and concluded that "cultural tourism is probably the most immediate strategy to make the heritage 'rentable'" (ibid., 45). However, the project warned that this might not be a long-term benefit for the destination region and that the cultural heritage is threatened by huge streams of tourists. Tourist-related indicators are therefore also as "pressure" indicators.

ESPON 1.4.5 (2006) is a preparatory study on spatial aspects of tourism. It discusses the benefits but also disadvantages of tourist flows. A set of indicators for inbound and outbound tourism was developed. The main focus of the analysis is on the destination region and the impacts of tourism there.

The interim report gives examples for tourism trends in different European countries. The data situation seems to be better than for other flow types with demand data available at NUTS-2 and supply data at NUTS-3.

Cultural exchange

In ESPON 1.1.1 (2006) information on students was used to get more insight into the interactions between cities in the polycentric urban system of Europe. When the number of students was used as indicator for the knowledge function characterising FUA, a rather balanced picture of the urban system of Europe emerged. The analysis of the exchange of students between universities through the ERASMUS programme, however, showed a very polarised pattern. Large cities and cities located in attractive locations such as south-western Europe or, for language reasons, in the UK and Sweden, receive more students than they send, at the expense of smaller cities.

In ESPON 3.3 (2006), which examined the territorial dimension of the Lisbon-Gothenburg strategy, European maps of inbound and outbound students and researchers were developed (ibid., 80-82). Whereas the inbound maps indicate regions that are attractive and competitive in higher education and research, the outbound maps show regions in which students and research workers have a high personal mobility to benefit from cultural exchange.

Information flows

ESPON 1.2.2 (2005), which studied telecommunication services and networks, looked into infrastructure and regional penetration and adoption of communication technologies. Information flows, such as telephone calls or internet traffic, were not the subject of the project. However, one might interpret indicators such as telephone or mobile phone penetration or access of the population to the Internet as proxies for origins or destinations of information flows. Also e-commerce defined as the "trading of goods and services over computer-mediated networks, such as the Internet" (ibid., 139) can be interpreted as trade flows induced by a particular form of information flows.

ESPON 1.2.3 (2006), in its analysis of the spatial aspects of the information society, concluded that the discussion on the information society "has shifted its focus from the mere development of technology toward the social notion, toward the primacy of content and communicative applications" (ibid., 52). The Internet Society Index developed by the project consists of indicators encompassing the resources and skills for ICT use ("readiness"), the availability and use of ICT technologies ("growth") and the economic implications

("impact"), but no data on information flows were used for the construction of the indicator. It was stated that appropriate data below NUTS-0 and reliable and comparable time series data are hardly available: "The review of data availability has clearly indicated the data constraints, which in turn affected the methodological opportunities" (ibid., 11).

ESPON 2.1.2 (2005) addressed the territorial impacts of EU research and development policies. In this context the role of spatial proximity in facilitating knowledge exchange was discussed. The positions ranged between the statement that proximity remains important and the view that due to modern communication systems proximity becomes a relative concept. In any case "all authors though acknowledge the importance of non-local linkages as a means of introducing new knowledge into a system and overcoming tendencies towards lock-in and path dependency" (ibid., 4).

Environmental flows

ESPON 1.3.1 (2005), in its assessment of natural and technological hazard risks, included environmental flows such as floods, landslides, storm surges and tsunamis. Hazard maps were developed which show the spatial distribution of these types of natural hazards. Together with other hazards, comprehensive risk maps of hazards were presented.

ESPON 1.3.2 (2006), when discussing the management of the natural heritage, demonstrated that in regions with a high share of semi-natural areas the risk of floods is higher than in other areas.

ESPON 2.1.4 (2005) was concerned with the spatial impacts of EU energy policy. In its analytical part it produced maps on energy production, i.e. the origin of energy flows. By relating this information to energy consumption, the degree of energy self-sufficiency of a region, i.e. its potential to export energy or its dependency on energy imports was assessed. Energy import dependency is lower in northern and eastern countries in Europe than in western and southern countries. However, the analysis could only be done at the country level because of data problems: "Systematic energy data at the regional level is still scarce and in many countries no recent data regarding the intended territorial disaggregation is available" (ibid., 7).

5 Data availability for flows analysis

As for any other territorial analysis the availability of data of good quality with appropriate spatial resolution is crucial for flows analysis. Therefore for the relevant types of flows identified in Chapter 2 the availability of flow data in Europe was examined and data gaps were identified. The availability check commenced with the ESPON Data Navigator and was amended by research into European and national statistics by searching publication lists of statistical agencies and meta analysis of existing research reports.

From the analytical framework in Chapter 3 it has become apparent that there is no unique measurement procedure for all flows of interest because of different information needs on different flow types and the great differences in data availability between the flow types. However, it is possible to describe the different places at which numerical information about flows can be obtained.

The first group of flow data contains information only for one single measurement place of a flow (Figure 3):

- Flows can be measured at the place of origin. This answers the question of how many flows of a certain type with certain characteristics are generated at a certain place. Examples are the number of workers or students living in an area, the volume of goods to be exported or the amount of pollution emitted.
- Flows can be measured at the place of destination. This shows how many flows are attracted by a certain place. Examples are the number of workers or students commuting to an area, the number of persons migrating into a region, the number of visitors or tourists coming to a place or the amount of foreign direct investments received by a region.
- Flows can also be measured while flowing at points where they are passing through. Examples are data from traffic counts, e.g. the number of cars on a road or the number of persons using an airport. Air or water pollution data can also be interpreted as the measurement of a flow at a certain measurement station.

These types of flow data contain already important information on flows, where they are generated, by what places they are attracted and which areas are passed through. These data are of particular relevance if they contain not only absolute numbers, but are differentiated by attributes describing the flows in more detail. However, they lack information about spatial interaction: Where does a flow go to and where does it come from?

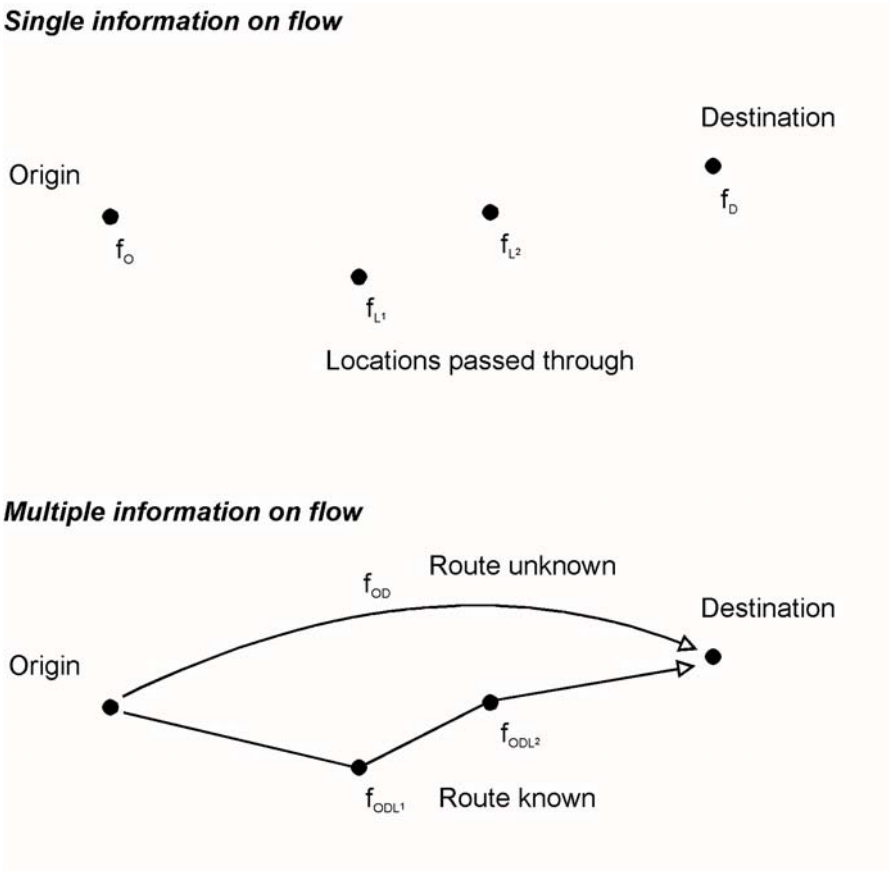


Figure 3 Options for the measurement of flows

More complex flow data contain information on at least two places that are touched by a flow:

- The "classical" flow data contain information on the origin and the destination but not on the path of a flow through the territory. Such data are typically stored in the form of a matrix. Examples of matrices are trade, migration or commuter matrices.
- Most complex are flow data which contain information on origin, destination and locations in between, ideally the complete route of a flow. Such data are either measured at places on the route, e.g. based on passenger surveys in stations, or modelled data, e.g. from transport models in which for each trip a route along the network is generated in the traffic assignment step.

Data with single information on flows are usually more easily available than more complex flow data containing information on several locations of a flow. For the latter, several data generation methods have been developed to estimate flow matrices or the alignment of flows to networks. The subsequent subsections of this chapter describe the data situation for the different types of flows.

5.1 Trade flows

Trade exchange at the country level is characterised by good accessibility of data encompassing the entire ESPON area. The basic source of these data is constituted by the SAD (Single Administrative Document) forms filled in by the operators (in case of trade with countries outside of the EU) and the INTRASTAT forms (in case of the EU internal trade). However, information on trade at the NUTS-2 and lower levels is most often fragmentary (despite the fact that both of the forms mentioned contain precise locations of the origin and destination points) or are just estimates. Moreover, even when they are available, they do not give a complete picture of flows of goods, since, by definition, they do not include the flows between the regions within one country. That is why the foreign trade statistics account for flows between Frankfurt/Oder and Słubice (1 km), whereas flows between Milan and Sicily (1,000 km) are not accounted for. However, it is exactly the data on foreign trade at the regional level that allow for grasping the image of economic interactions at the continental scale.

The World Trade Organization (WTO) conducts statistics in the domain of foreign trade by region (regions in the perspective of WTO are continents or groups of countries, such as, e.g., the European Union, the North American Free Trade Agreement (NAFTA), the Southern Common Market (MERCOSUR), and individual countries. The most detailed data refer to exports and imports by product and country, but without more precise information on the direction of flows. The most recent information dates back to 2004.

Data of Eurostat contain basic information for the EU member states, such as the Eurostat Yearbook 2005 (see Annex Internet Sources):

- the contribution of the member states (in value and %) to the external trade of the EU
- the contribution of the member states (in value and %) to the internal trade within the EU
- the share of trade exchanges with the EU (% of imports from the EU in the total imports and % of the exports to the EU in the total exports) of the member states and of the main players in the world market
- the trade of the EU, the Euro zone and the member states with the rest of the world (imports, exports and trade balance by product group)
- External trade of the EU by main trading partners for each product group
- External trade of the EU by member state and product group

Besides, Eurostat maintains the COMEXT database. Data on external trade of the EU are compiled on the basis of figures collected by the member states.

The member states transmit the data to Eurostat according to concepts and methods defined in the European Union legislation. Statistics on trade with non-EU countries are based on Council Regulation (EEC) No 1172/95 and Commission Regulation (EC) No 1917/2000 and Statistics on trade between the member states are based on Council Regulation (EEC) No 3330/91 and Commission Regulation (EC) No 1901/2000. This assures a harmonised and comparable dataset.

Nevertheless, a member state may apply different concepts when publishing figures for national purposes. The compilation of external trade statistics is divided into two different statistical systems: statistics on the external trade of the EU (Extrastat) and statistics on the internal trade within the EU (Intrastat). The statistics on external trade of the EU cover the cross-border trading of goods between the member states and non-EU countries. The statistics on internal trade within the EU cover the trading of goods between the member states.

The data on the external trade of the EU are collected by using information from customs declarations. Trade operators fulfilling their reporting obligations to the customs authorities in a member state are providing at the same occasion the statistical data. Data on internal trade within the EU are collected directly from trade operators as a consequence of the abolishment of customs control at the borders between the member states. The reporting burdens are simpler compared with those of external trade and private individual and small scale traders are excluded. However, any natural or legal person registered for VAT in a member state carrying out trade within the EU and being above a certain threshold is obliged to report monthly on its trade within the EU to the competent national statistical authorities. The national authorities use data on the total taxable amount of acquisitions and deliveries of trade within the EU provided by the fiscal authorities to identify the target population and maintain registers on trade operators.

The COMEXT database contains basically all physically incoming and outgoing movable goods, including electricity, recorded and documented. Detailed trade flows from and to each member state with other countries are presented for products on a monthly basis indicating the trade value and quantity. Aggregated trade flows are compiled on the basis of detailed data. They include seasonally adjusted time series and growth rates as well as unit-value and volume indices. The following main indicators are published by group of reporting member states, partner country and product (see Annex Internet Sources):

Detailed data:
- trade value in Euro,
- trade quantity in 100 kilograms,
- trade quantity in supplementary units.

Aggregated data cover both short and long term indicators:

Short term indicators:
- gross and seasonally adjusted trade value (in million Euro),
- unit-value indices,
- gross and seasonally adjusted volume indices,
- growth rates of trade values and indices,
- trend-cycle component of trade values and volume indices.

Long term indicators:
- trade value (in billion Euro),
- shares of Member States in EU and world trade,
- shares of main trading partners in EU trade,
- volume indices.

Besides, basic information on trade turnover (imports, exports, balance, main directions of exports and imports, trade by product, etc.) is contained in the data collected by the national statistical offices of individual member states.

5.2 Financial flows

Among the data on financial flows, data on foreign direct investment (FDI), the EU structural funds as well as transfers carried out by natural persons are particularly important. In the first two cases data availability is satisfactory only at the NUTS-0 level, while in the third case information is completely lacking.

Statistical data showing the flow of foreign investments are collected by the United Nations Conference on Trade and Development (UNCTAD) on the basis of information transmitted by national agencies dealing with foreign investments. Currently, data for 112 countries are available, including 25 EU member countries (data for Cyprus and Malta are missing), as well as Croatia, Norway and Switzerland. Data are aggregated by geographical criteria (locations of origin, two-way flows) and structural criteria (i.e. the economic sectors in which funds are invested), and they encompass mainly the years 1994-2002. For EU25 the balance of flows of foreign investments is also available, although these data are not complete (data from the years 1980, 1990 and 2000-2004).

Eurostat provides also data on financial flows at country level (for the majority of EU countries, for groups of countries like EU27, EU25, EU15, Euro zone countries, as well as for Croatia and Turkey). These data are not always complete. They contain the following information:

- financial accounts and transactions (assets, liabilities)
- balance of payments – international transactions
- European Union direct investment
  - EU direct investment by country and economic activity
  - EU direct investment flows by partner country and economic activity
  - EU direct investment income by partner country and economic activity
  - FDI structural indicators (average value of inward and outward FDI flows divided by GDP)

FDI data at the country level for most of EU countries are collected also by the Organisation for Economic Co-operation and Development (OECD). The International Direct Investment Statistics Yearbook 1992-2003 gathers detailed statistics on international direct investment into and from OECD countries. Comparative tables and charts complement the information included for individual countries by geographical and sectoral breakdowns for direct investment flows and stocks. Comparable tables are presented in US Dollars and OECD Country tables are presented in national currency values. Longer time series of data presented in this book are available on CD-ROM and online (see Annex Internet Sources)

The following FDI data are available on the OECD website (years 1991-2004; these data are not complete):

- outward and inward FDI stocks
- inflows of foreign direct investment
- outflows of foreign direct investment.

Inward stocks are the direct investments held by non-residents; outward stocks are the investments held in other economies. The stock tables also show the distribution of stocks by industry (mainly manufacturing) and services (see Annex Internet Sources).

The European Bank for Reconstruction and Development (EBRD) is the largest single investor in Central Europe and mobilises significant foreign direct investment beyond its own financing. It provides project financing for banks, industries and businesses, both new ventures and investments in existing companies. It also works with publicly owned companies, to support privatisation, restructuring state-owned firms and improvement of municipal services. The Bank uses its close relationship with governments in the region to promote policies that will bolster the business environment

The EBRD provides data for the years 1991-2005 on direct investments in the new member states, candidate countries and third countries (mainly the ones of CIS): entire value of a project, financial contribution of the EBRD, economic sector. The data refer only to investment projects in which EBRD has a stake.

Data on foreign investments at the level of NUTS-2 or NUTS-3 regions are at the disposal of respective agencies in some countries. Thus, for instance, the Polish Information and Foreign Investment Agency (PAIZ) publishes information on the volume of investments in particular provinces at the NUTS-2 level. However, both in Poland and in other countries these data are collected most often with the "company method", which means that the value of investment is assigned to the region in which the company has its headquarters. This leads, as a rule, to an overestimation of the volume of investments in the largest centres, especially in the capitals, in particular with respect to such branches as banking, hotel chains etc.

General information concerning the magnitude of the financial means disbursed for particular purposes, including assistance within the frameworks of various programmes, is contained in the detailed budget of the European Union (see Annex Internet Sources). More precise information is provided by the European Commission on its web page (see Annex Internet Sources). These are the data on the majority of assistance programmes that were officially accepted by the Commission in the framework of the Regional Development Programmes 2000-2006. The archival data base contains some 700 programmes carried out in the framework of the ERDF in the years 1994-1999. Querying in the data base is possible by year and country. Information accessible contains detailed objectives of programmes, territorial reach of programmes, total cost of projects, and the contribution of the Union funds in financing of the projects.

Information is also available on current programmes carried out in the years 2000-2006. Querying is possible by geographical criterion (countries and regions) and thematic criterion (nature of programme, detailed thematic scope). Data in question encompass all 27 EU member states as well as for Turkey. The database contains information on project financing, that is total project cost, EU financial contribution, contributions from other sources (public assistance) and the goals (priority areas), to which assistance is extended. The data include such programmes as:

- Objective 1 – Development of the least favoured regions
- Objective 2 – Conversion of regions facing difficulties
- Interreg III – Interregional co-operation
- Urban II – Sustainable development of urban areas

General information on the implementation of programmes associated with the Structural Funds is contained in the periodical reports issued by the European Commission (see Annex Internet Sources). The use made of the Structural Funds in some EU countries is also presented on the web. Such information is also contained on the internet pages of the ministries of finance of some of the member states (e.g., Poland, Latvia, Estonia).

The description of the project ESPON 2.2.2 "Pre-Accession Aid Impact Analysis" contains general statistical data at the country level on the aid extended to the candidate countries, provided in the framework of the SAPARD, ISPA and PHARE programmes. There is also information on the value of financial assistance to the new member countries for the years 2004-2006 provided in the framework of various programmes (INTERREG, Cohesion Fund, EQUAL, Objectives 1-3).

The ESPON database includes fragmentary data on the volume of EU financial aid at the NUTS-2 and NUTS-3 levels (Structural Funds, PHARE, CBC, ISPA). However, owing to significant gaps these data cannot be used for comparative purposes. The Eurostat statistical database does not provide information on the use of the Structural Funds. Deeper studies are necessary and the inquiries to be carried out directly in the respective agencies of the member states dealing with the Structural Funds (e.g. the ministries of finance, in Poland also the Ministry of Regional Development). The accessible data for Poland, for instance, include accumulative financial flows from the first day of accession and the years 2004, 2005 and 2006.

5.3 Migration flows

The availability of data on migration flows is very different for the different spatial levels of migration.

International migration

The EU member states are required to provide data on international migration flows to Eurostat. However, because of different data sources (e.g. population registers, household surveys and population censuses) and ambiguities of definition of what is a migration, the availability of consistent country-to-country migration data is very low. Some member states do not record origin country of immigrants, whereas others do not have emigration statistics and rely on occasional surveys. A special problem is illegal immigration generally not included in the statistics. Even if statistics are available, their quality, reliability and comparability tend to be low. A recent

overview on the availability of international migration data is given in Nowok and Kupiszewska (2005).

There are several institutions addressing problems of international migration data, such as the International Centre of Migration Policy Research (ICMPR), Vienna, Austria, the Central European Forum for Migration Research (CEFMR), Warsaw Poland, the European Migration Information Network (EMIN) of University College London, the European Migration Network, Berlin, Germany, the European Forum for Migration Studies, Bamberg, Germany, and the Working Party on Migration Statistics of Eurostat. The recently completed EU 6th Framework Project THESIM (Towards Harmonised European Statistics on International Migration) aimed at promoting awareness for the importance of harmonising European migration data.

The Organisation for Economic Co-operation and Development (OECD) has done substantial research on international migration between its member countries and on possibilities to arrive at harmonised migration statistics (Lemaitre et al., 2006). In a study on the expected impacts of EU enlargement it analysed the likely impacts of the EU enlargement on border controls, the control of flows, labour migration, family-linked migrations, refugees and asylum seekers (OECD, 2001).

Data on international migration flows come in one or more of three possible formats:

- immigrants (emigrants) of a country without specification of nationality or origin (destination) country,
- immigrants (emigrants) with specification of nationality or origin (destination) country,
- migration flows between countries (i.e. a matrix of international migration flows).

The second format, i.e. immigrants and emigrants with specification of origin or destination country is the most frequently found format.

In its yearly publication *Trends in International Migration* (OECD, 2003-2006) the OECD provides inflows and outflows by nationality to and from selected OECD countries in the years 2001 to 2005.

Eurostat provides annual migration flow data for the old and new member states since 1999:

- inflows by origin country
- outflows by destination country
- migration balance (net migration)

However, there are gaps in the tables. For the years 2000 to 2003 there are data for only about half of the countries, for 2004 for about two thirds. There are no data for Belgium, France, Switzerland, Bulgaria, Ireland, Luxembourg, Poland and Liechtenstein. Moreover, if one compares the inflow from a certain country reported by the destination country with the outflow to that country reported by the origin country, one finds in general serious incompatibilities, which have to be attributed to the differences in definition and registration of migrants in the two countries discussed in Section 3.3.

The ESPON database provides some data of immigrants, but not with specific origin country and mostly for immigrants from non-EU countries.

Interregional migration

Data on migration between regions within countries are not available from a unified source for all countries of the European Union. Eurostat provides interregional migration data for some countries, but with considerable delay (see Table 1):

Table 1 Interregional migration data available from Eurostat

Country	Oldest data	Most recent data	NUTS level
AT	1996	1999	0,1,2
BE	1975	1999	0,1,2
CZ	1993	2000	0,1,2
DK	1990	1999	0,1,2
DE	1975	1993	0,1
ES	1979	1999	0,1,2
FI	1981	1999	0,1
HU	1990	2000	0,1,2,3
IT	1979	1996	0,2
NL	1975	1999	0,1,2
PL	1990	2000	0,1,2
PT	1985	1992	0,1,2
RO	2000	2000	0,1,2.3
SE	1980	1999	0,1,2
SI	1991	2000	0,1,2,3
SK	2000	2000	0,2
UK	1979	1996	0,1

In addition the same difficulties as with international migration flows exist with respect to the differences between the countries in the definitions of what constitutes a migration (see Section 3.3).

A further problem is the linkage between international and interregional migration. Emigration by origin region down to NUTS-2 is available only for Denmark, Estonia, Finland, Hungary, Spain, Italy, the Netherlands and Sweden. Incomplete data are available for Austria, Belgium, the Czech Republic and Germany. The corresponding immigration data are even less complete: Only Estonia, Finland, Hungary and the Netherlands have complete data.

The situation is even less satisfactory with respect to disaggregation of interregional migrants by age, gender, occupation or nationality.

In conclusion, the establishment of a Europe-wide database of interregional migration flows would be a major effort that could only be conducted by a permanent institution in co-operation with national statistical offices.

5.4 Transport flows

In the field of transport there are both existing Europe-wide harmonised databases and well-established methods for the generation of such databases.

Existing transport databases

Transport is one of the few thematic fields for which Europe-wide harmonised databases exist, even if this is especially true for freight transport rather than for passenger transport. Some of these databases are built and maintained by official sources like Eurostat, while others are the results of research applications, surveys, etc.. Exactly because several transport flows indicators sources are the result of studies and specific projects, it is impossible to review all existing databases at the European level.

In Table 2 a summary of the most representative sources covering different kinds of transport flows data is provided. In the table references are given where possible; in the several cases where data is not freely available, references to the project where data has been developed are given instead.

Table 2 summarises the most important existing databases on European transport flows. The Internet addresses referred to in Table 2 are listed in the Annex Internet Sources.

For transport flow data in the form of origin-destination matrices at the European level there are two main sources.

Table 2 Main transport flow data sources at the European level

Source name	Main data and segmentation	Methods	Countries covered	Regional detail	Reference
ESPON	Aggregated data on passenger trips generated and attracted by mode and trip purpose, distance travelled by mode and purpose and total trip-km by mode and purpose	Estimated data through a modelling application	EU25	NUTS-2	Data is not available from a public site.
EUROSTAT Transport	Aggregate data on total pass-km and tonne-km by inland mode of transport and commodity type, tonnes generated by region, inland mode of transport and commodity type, freight traffic at main seaports and traffic at main airports	Estimated data from sampling surveys carried out by EU member countries according a homogenous methodology	EU25. For some data also Switzerland and Norway	Mainly NUTS-0 and NUTS-2. Few data available at NUTS-3 level	Most of EUROSTAT transport data are freely available on the EUROSTAT Transport website. Other data is available on dedicated publication issued by EUROSTAT
EUROSTAT Intra- and extra-EU Trade by mode of transport	Matrix of tonnes traded by mode of transport	Observed data collected from declarations of firms and forwarders.	EU25. Non-EU countries are mentioned as partners	NUTS-0	EUROSTAT, Intra- and extra-EU trade - Annual data, 1988-2003 (CN - Supplement 2/2004) (DVD, 1.300 €)
ETIS-BASE	Matrix of freight flows in Europe by commodity type and mode of transport, matrix of passenger flows in Europe by mode of transport	Estimated data through different methods	EU25. Non-EU countries are mentioned as partners	NUTS-2	Information about ETIS-BASE is available on the project website.
Dateline project	Several data on long-distance trips by mode and purpose, matrix of long-distance trips	Estimated data from a sampling surveys	EU25. Non-EU countries are mentioned as partners	NUTS-0	Dateline data can be download from the project website.
Alps Crossing database	Number of tonnes travelling through main Alps passes, number of road and rail vehicles travelling through main Alps passes, matrix of freight traffic flows travelling from the surveyed Alps passes	Estimated data from a sampling surveys carried out at main Alps passes. Data is updated every five years	All EU countries surveyed as origin or destination of vehicles at main Alps passes	NUTS-2 for origin-destination data	Data is not available from a public site. A summary of the Alps Crossing data is available on the Minister for transport of Switzerland

Table 2 (continued) Main transport flow data sources at the European level

Source name	Main data and segmentation	Methods	Countries covered	Regional detail	Reference
UNECE E-road census	Average Daily Traffic on main European road network (E-Roads)	Estimated data from road counts provided by countries every 5 years	All Europe*	n.a.	Information on the UNECE E-road census can be found on the UNECE transport division website.
TEN-STAC	Matrix of freight flows in Europe by commodity type and mode of transport, matrix of passenger flows in Europe by trip purpose and mode of transport	Estimated data through a modelling application	All Europe*	NUTS-2	Data is not available from a public site. Information about the TEN-STAC project is available on the project website:
SCENES	Matrix of freight flows in Europe by commodity type and mode of transport. matrix of passenger flows in Europe by trip purpose and mode of transport	Estimated data through a modelling application	All Europe*	NUTS-2	Data is not available from a public site. Information about the SCENES model is available on the project website.
NEAC	Matrix of freight flows in Europe by commodity type and mode of transport	Estimated data through a modelling application	All Europe*	NUTS-2	Data is not available from a public site. Information about the NEAC model is available on the NEA website:
VACLAV	Matrix of passenger flows in Europe by trip purpose and mode of transport	Estimated data through a modelling application	All Europe*	NUTS-3	Data is not available from a public site. Information about the VACLAV model can be found in Burgess et al (2004) and Schoch (2004).
TRANS-TOOLS	Matrix of freight flows in Europe by commodity type and mode of transport, matrix of passenger flows in Europe by trip purpose and mode of transport	Estimated data through a modelling application	All Europe*	NUTS-2 for freight NUTS3 for passenger	The TRANS-TOOLS project is ongoing when this report is being written. More information on the project and the model can be obtained at the project website.

* all countries belonging to the European continent, including non EU countries, Island, Turkey, Russia until Urals but excluding overseas territories of EU member states.

The first major source is ETIS-BASE (2005), which is the database recently developed within the European Transport Policy Information System (ETIS). Within the ETIS (European Transport policy Information System) project, ETIS-BASE was responsible for the development of the reference database, which will become the reference database for European strategic modelling, especially for application focused on TEN-T policy issues. ETIS-BASE provides several data, including socio-economic data, transport cost data, transport external effects data.

ETIS-BASE data are estimated making use of several sources and methods for filling gaps. "In conclusion, the modelling approaches envisaged in the ETIS reference database development for filling the gaps can be considered as a combination of data, also from external sources, and estimation techniques (methods), based on analytical tools (regression analysis) and conceptual models (object-oriented framework)" ETIS-BASE (2004a).

As far transport flows are concerned, the ETIS-BASE data include origin-destination matrices for both passengers and freight covering the EU25 and EEA countries. The regional detail of the matrices is the NUTS-2 level for both passenger and freight matrix. Matrices are segmented by mode of transport and, as far as freight demand is concerned, a break-down into 11 commodity groups is also available, while passenger matrix only provides the total number of trips.

A relevant feature included in the ETIS-BASE freight data is the explicit treatment of freight consignment as multi-modal chains. Therefore not only origin and destination regions are indicated in the database, but also transshipment regions. This information is especially important for analysing the role of regions in freight transport chains (ETIS BASE, 2005).

The second major source is the Eurostat database "Intra- and extra-EU Trade". This database, also known as COMEXT, is not primarily a transport database, but a specific section is devoted to trade data in volume and value by mode of transport. The relevance of this database for freight transport analysis depends on several factors. Firstly, the database consists of observed trade data collected through the declaration of firms and forwarders. So in principle there is a full coverage of goods moved to, from and within EU25 countries. Secondly, a very detailed segmentation of commodities is available. Thirdly, all transport modes are covered, including maritime shipping. Finally, annual data are available since 1999 (and 1988 for EU15 countries) and therefore a large amount of data can be used for analysis of transport development through time.

At the same time, exactly because this database is not primarily conceived as a transport-oriented database, it has some limitations that should be

taken into account. Firstly, it does not provide any detail below the national level, so only NUTS-0 to NUTS-0 data are available. Secondly, there are reasons to believe that the relevance of different modes of transport is not correctly reflected in the database. Namely, road transport is most likely overestimated as in some cases the subjects that declare to have received or sent goods are not aware of multimodal chains. Thirdly, since when within EU countries controls customs have been abolished, data is collected on declarations that are drawn up on a voluntary basis: this circumstance induces to believe that a share of goods transported is not reported in the database. Last, but not least, being a trade database, COMEXT does not include any information on domestic transport, which is however responsible for the largest part of freight moved.

The section of the "Intra- and Extra-EU Trade" database including transport data is available on DVD by EUROSTAT (see Table 2)

Both the ETIS-BASE and the EU trade database have been already used in ESPON project 3.2. In particular, data from these sources were used for the development of the KTEN meta model (ESPON 3.2, 2006).

Still making reference to matrices of transport flows, several modelling applications, often developed in projects awarded by the European Commission in the last years the RTD Framework Programmes have estimated matrices. Table 2 refers to some of them: SCENES, NEAC, VACLAV, TEN-STAC and TRANS-TOOLS.

TRANS-TOOLS is particularly relevant as this model is being developed to serve as reference tool for EU-wide modelling exercises. TRANS-TOOLS aims at producing an intellectual-property-rights free European transport network model covering both passengers and freight as well as intermodal transport, which overcomes the shortcomings of current European transport network models on the basis of the best available knowledge (Burgess et al., 2004). The TRANS-TOOLS model will work with transport flow matrices at the NUTS-2 level for freight and NUTS-3 level for passengers, so improving the level of geographical detail available. In TRANS-TOOLS the experience of previous projects and models like SCENES, VACLAV, NEAC, TEN-STAC will be combined. This means, for instance that TRANS-TOOLS will include information on transshipment regions like in the ETIS-BASE freight matrix.

For other types of data, Table 2 reports other sources. The EUROSTAT database reports within the transport theme aggregated data on international and domestic passenger and freight demand for road, rail and inland navigation as well as traffic at main ports and airports. The Transport Division of UNECE organises every five years traffic counts on the main European road networks, from which Average Daily Traffic is computed. The Alpine coun-

tries organise every few years a sampling survey to collect data about Alps crossing traffic by road and rail.

In addition to European sources, also national sources exist. Each member country collect some transport data in a homogenous way according to Eurostat directives and these data are then included in the EUROSTAT database. In addition, each country has its own procedure to collect other transport data. However, for the time being the only way to collect information about current situation of transport data in EU countries would be to contact each national authority.

5.5 Commuter flows

Most part of daily commuting happens within agglomerations or between core cities and their surrounding countryside, i.e. commuting takes place mainly below the overall target level NUTS-3 of ESPON research. This is true even in countries that have relatively small NUTS-3 regions such as Germany, Belgium or the Netherlands. Consequently, the ideal commuter flow data would be at the municipality level, i.e. LAU-1 or LAU-2.

Table 3 gives an overview on available commuter flow data by country obtained from the ESPON Data Navigator. Besides the definition of the data, the sources, the available years and the NUTS level are indicated. Because commuting data can be easily aggregated to higher NUTS levels, only the lowest available spatial level is indicated in the table.

Table 3 shows that there are huge data gaps regards commuter flow data. For many countries, it is also unclear from the nomenclature whether the data are related only to origin and destination region or whether commuter flow matrices are available. It is also unclear for time series data whether the data relate to the latest statistical division of the country, i.e. whether past data have been transformed to new spatial units if there was a change in these. On the other hand, the information from the ESPON Data Navigator seems to underestimate the availability of commuter flow data. For many more countries such data exist, but access to them might be more difficult than in other countries or they exist only for parts of the country or parts of the work force, or the costs for purchasing such data are very high.

The estimation of commuter flow data based on information for origins and destinations such as population and employment data is common practice in transport modelling (see previous section), because journeys to work are responsible for a good portion of daily traffic.

Table 3 Availability of commuter flow data (ESPON Data Navigator)

Country	*Nomenclature*	*Source*	*Year*	*NUTS*
Austria	Commuters by place of work/ school/university, place of residence, means of transport and distance (census data)	Statistics Austria	1971 1981 1991	LAU 2
Belgium	Working population by home place, working place and commuting duration	INS – NIS Recensement de la population et du logement	1981 2001	LAU 2
Denmark	Commuting by region, sex, sector, in-, out-, day and night	Statistic Denmark	yearly since 1993	LAU 2
Estonia	Employed persons by transport means, commuting distance	Statistical Office of Estonia	yearly since 1997	not given
Finland	Commuting	Statistics Finland	yearly	LAU 2
France	Commuting home-job differentiated by demographic and socio-economic characteristics and means of transport	INSEE- Recensement de la population, 1999, exploitation principale	1975 1982 1990 2003	LAU 2
Germany	Commuter by Gender	Federal Statistical Office Germany and statistical offices of the Länder		NUTS 3
Hungary	Commuting workers	Hungarian Central Statistical Office	2001	LAU 2
Italy	Commuting time, mode, origin-destination (census data)	Istat (National Institute for Statistics)	every 10 years	LAU 2
Ireland	Travel to work data	Quarterly National Household Survey	2000	NUTS 3
Latvia	Main purpose and number of trips	Central Statistical Bureau of Latvia	2003	NUTS 2
Luxembourg	Commuters by duration and means of transport	Recensement de la population	every 10 years, last 2001	LAU 2
	Foreign commuters employed in LU by municipality of residence	Atlas des Communes	1996	LAU 2
Portugal	Commuting (census data)	INE (Instituto Nacional de Estatística)	2001	LAU 1
Slovenia	Commuting by type of transport (census data)	Statistical Office of the Republic of Slovenia		
Sweden	Local labour market database	Statistics Sweden (SCB), Swedish Business Development Agency (NUTEK)	yearly since 1988	LAU 2
Switzerland	Persons in employment by places of life and work, means of transport and duration (census data)	Swiss Federal Statistical Office	1970 1980 1990 2000	LAU 2

In any case the development of a Europe-wide commuter flow data base at LAU-2 level that would contain not only information on in- and out commuter for the origin and destination regions but a full matrix of flows would be of enormous value for spatial analysis. However, the development of such a database would be a huge exercise in terms of data mining, data generation and data harmonisation which is much beyond the scope of this feasibility study.

5.6 Tourist flows

Data on tourist visits, overnight stays and accommodation infrastructure at the country level are relatively easily accessible. Problems arise as the level of detail of the data sought increases. It is very difficult to obtain data on tourist visits by country of origin for NUTS-2 and lower levels.

Eurostat conducts detailed statistics for all EU27 countries (and for Switzerland) for NUTS-2 or NUTS-3 regions with the following indicators:

- number of establishments, bedrooms and beds (NUTS-3, annual)
- arrivals of residents (NUTS-2, annual)
- nights spent by residents (NUTS-2,annual)
- arrivals of non-residents (NUTS-2, annual)
- nights spent by non-residents (NUTS-2)

Data from Eurostat allow analysing the magnitude of flows, but without indication of their direction. The analysis of tourists flows between the old and new EU member states is possible only at the country level. The data needed for more detailed analyses may be found only at national statistical offices.

The UN World Trade Organisation (WTO) collects data on tourist flows from member countries as well as countries not being members of the organisation. In total data are collected from 211 countries, including the countries of the European Union and Norway and Switzerland. Unfortunately, not all countries provide all data requested by the WTO. There are therefore considerable gaps in the figures. There are also differences in definitions.

Only in a few cases do the data on arrivals concern flows of visitors at the border: Finland, France, Greece, Ireland, Italy, Portugal, Sweden and the United Kingdom. Nevertheless, these data do not always result from a census operation, as it is in the case of France which extrapolates, using Balance of Payment estimates, observations made only from time to time. Flows of visitors measured at borders usually include travellers visiting friends and relatives (i.e. staying in unpaid forms of accommodation) and

day visitors (particularly relevant for small countries). For the other countries, statistics of arrivals refer to arrivals of non-resident tourists in all types of tourist accommodation establishments or hotels and similar establishments. The effect of the two different forms of measurement is unknown, but surely important. Finally, the criterion of residence is not always used either, as certain countries still produce their statistics based on nationality (e.g. Greece, Italy, Portugal). The impact of this difference is unknown.

NUTS-2 and NUTS-3 region data are available from Eurostat, NACE and the ESPON database for the following categories:

- The capacity of collective tourism accommodations (hotels, campsites etc.) for which data are required annually and down to around county level or equivalent (i.e. NUTS-3),
- Guest flows at these collective accommodation establishments showing arrivals and nights spent in different broad types of accommodation. Most information is again required annually, with data down to NUTS-2. Some information on arrivals, nights spent and occupancy rates, is available monthly for countries (ESPON 1.4.5, 2006).

TourMIS is a marketing information system for tourism managers. The major aim of TourMIS is to provide information and decision support for tourism managers and scholars. Therefore, TourMIS provides online tourism survey data, as well as various tools to transform data into management information. The data in TourMIS are collected with the help of tourism managers and the staff of over 130 tourist offices all over Europe who enter them online into the database. The database contains the most recent (though not always complete) data, mainly with respect to visits of tourists taking advantage of accommodation establishments. Information on border traffic is lacking. Data are collected at the level of countries.

The ESPON database contains data on tourist visits and nights spent only for some EU countries at the NUTS-3 level, but these data are not complete.

Information on tourist visits by country of origin for NUTS-2 regions is available at only some national statistical offices (e.g. those of the Czech Republic, Estonia, Denmark and Poland). There are countries, such as Spain and France, where the available data are partial, i.e. concern visits of tourists from selected countries or groups of countries. A detailed listing of data on tourist traffic available at statistical offices of particular countries (based on an Internet search) is shown in Table 4.

Table 4 Availability of tourist data

Country	Description	NUTS level				
		0	1	2	3	4
Austria	Overnight stays (all types of accommodation) in 2002-2004 by country of origin	X		X		
Belgium	Arrivals of residents and non-residents in 2002-2005	X	X	X		X
Czech Republic	Guests at collective accommodation establishments: by country in 2000-2004	X			X	
	Number of overnight stays: by country in 2000-2004	X			X	
Denmark	Nights at hotels by citizenship and time in 1988-2006	X			X	
	Nights spent at camping sites by citizenship and time (months) in 1998-2006	X			X	
	Nights spent in youth hostels by citizenship and time (months) in 1997-2006	X			X	
	Nights spent at hotels and holiday resorts by type, citizenship, month in2005-2006	X			X	
Estonia	Accommodated tourists by country of residence (months) in 2002-2006	X				X
	Nights spent by country of residence in 2002-2006	X				X
	Accommodation by year and region (total, non-residents, share of accommodated foreign visitors)				X	
France	Arrivals of non-residents from chosen countries (UK, Spain, Germany, Belgium, Italy, Netherlands, other countries, total in 2003-2004			X		
Greece	Arrivals in collective accommodation establishments (by resident and non-resident) in2003	X	X	X		
	Nights spent in collective accommodation establishments (by resident and non-resident) in 2003	X	X	X		
Hungary	Nights in public accommodation establishments (by resident, non-resident) in 2000-2005 (2005 by month)	X		X		
	Tourist nights in hotels (by residents, non-residents) in 2000-2005 (2005 by month)	X				
	Tourist arrivals and tourist nights of public accommodation by type of establishment	X				
	Tourist nights in public accommodation establishments by country	X				
	Tourist nights in hotels and in spa hotels by country	X				
	International arrivals by country and by month	X				
	Passenger traffic data of border relations in 2002-2005	X				
Italy	Arrivals of non-residents in 2002-2003	X		X		

Table 4 (continued) Availability of tourist data

Country	Description	NUTS level				
		0	1	2	3	4
Latvia	Persons crossing Latvia's border by purpose of trip, year and residents, non residents in 2000-2004	X				
	Number of visitors by type of accommodation by country in 2000-2004	X				
	International visitors: nights spent in accommodation in 2000-2004	X				
	International visitors: nights spent in accommodation in 2000-2004	X				
Lithua-nia	Number of guests and bed nights in Lithuanian hotels and guest houses in 2002-2005	X				
	Number of arrivals to Lithuania by country in 1997-2003	X				
Poland	Passenger border traffic	X				
	Arrivals of foreigners to Poland by country	X		X		
	Tourists at collective accommodation establishments (by country)	X		X		
Portugal	Nights spent in hotel establishments by country (Portu-gal, Germany, Spain, France, Italy, Netherlands, EU 25)	X				
Slovenia	Overnight stays of tourists by country of origin in 1990, 1995, 2000-2004	X				
	Tourist arrivals and overnight stays by municipality, country and type of tourist accommodations in 2003, 2004					X
	Arrivals of tourists by country of origin in 1990, 1995, 2000-2004	X				
Spain	Arrivals of tourists by country in 2000-2004	X		X		
United Kingdom	Number of visits to the UK by nationals of the European Union and the Accession Countries by country and quar-ter in 2002-2006	X				

5.7 Cultural exchange

As to be expected given the diverse and qualitative nature of cultural exchange, data on cultural exchange flows are generally poor, in particular on flows below the national level. This is why in Section 3.7 concentration on three kinds of cultural exchange flows was recommended.

Academic exchange

There is no database of bilateral partnerships between universities in Europe. This information would therefore have to be retrieved from individual universities, and this is likely to be a major effort. There is, however, information on teacher and student exchange in the SOCRATES and ERASMUS programmes at the official ERASMUS website (see Annex Internet Sources). The statistics section of the website provides information on teachers and students by origin and host country for several years and the distribution of students on universities in the host countries (ESPON 1.1.1, 2004). A full matrix of student exchange flows between origin and host universities in different countries is not available. It may be possible to estimate such a matrix from student exchange flows between countries and the distribution of ERASMUS students across universities in each country.

Twinned cities

There is a comprehensive but not complete list of twinned cities in Europe on the Internet (see Annex Internet Sources). The list includes also partnerships with cities in other continents. Information on the town-twinning programme of the European Union is available on the website of the European Commission (see Annex Internet Sources). Although this information may be a good point of departure, significant additional data collection from diverse sources will be necessary to establish a comprehensive overview on European town twinning.

Language

There is an article on language education in Europe in the English-language edition of Wikipedia, which may serve as a point of departure for data collection about language education at schools in Europe (see Annex Internet Sources). A preliminary survey was carried out by the Council of Europe in among member states in 2005 to obtain an overview of the curricula used at national or regional level to teach language as a subject.

5.8 Information flows

When, a long time ago, national telecom companies were still public, it was possible to analyse economic complementarity and co-operation between cities as a function of the number of telephone calls between them (Camagni and Salone, 1993). Since in most countries telephone companies have been privatised and much of telephony is conducted by mobile phones, such information has become fragmented and inaccessible because of its commercial value. The situation is even worse for Internet traffic which is, if at all, recorded by transmission line, but not by origin and destination.

The analysis of telecommunication flows is therefore largely constrained to data on the availability of telecommunications infrastructure. There are surveys of information and telecommunications technology in NUTS-2 regions commissioned by the European Commission in 1999, 2002 and 2004 (EOS Gallup, 1999; INRA, 2003; 2004), which, however, do not cover the new EU member states. The World Telecommunication Indicators Database of the International Telecommunications Union (see Annex Internet Sources) contains data for the years 1960, 1965, 1970 and annually from 1975-2004 for around 80 communications statistics covering telephone network size and dimension, other services, quality of service, traffic, staff, tariffs, revenue and investment, telephone lines in operation, mobile cellular subscribers and Internet users for over 200 countries. Telegeography Research, a private company, offers a large set of indicators on telecommunications infrastructure and traffic (see Annex Internet Sources).

These data sources, as far as they were available at the time, were used by ESPON 1.2.2 (2005) for the compilation of data on telecommunications infrastructure and their impact on regional economic development and territorial cohesion. Similar data were used in ESPON 2.1.1 (2004) to feed the STIMA model of spatial impacts of information and telecommunications infrastructure on regional economic development.

A good impression of the diverse potential data sources in the field of information and telecommunications infrastructure gives the *Atlas of Cyber Space* developed by Martin Dodge at the Centre for Advanced Spatial Analysis (CASA) of University College London (see Annex Internet Sources). The *Atlas* shows maps of broadband network infrastructure, concentrations of Internet domain locations and estimated Internet traffic between countries. However, the analysis is fragmented, focused on particular countries or at a global scale showing at best countries.

The conclusion is that before analyses of the spatial impacts of information flows can be conducted, a substantial amount of data mining and experimentation with the combination of different data sources will be required.

5.9 Environmental flows

Extensive air and water quality data are collected by the European Environment Agency (see Annex Internet Sources), although on the EEA website only aggregate data by country are available. The French PREV'AIR system since 2003 publishes daily measurements of ozone and PM12 pollution of large parts of western Europe at a fine level of spatial detail (see Annex Internet Sources).

Trans-border flows of air pollutants are by their nature not measurable. A quantification of such flows therefore has to rely on three-dimensional air flow ('wind field') models of air dispersion, such as the RAINS model (see Section 3.9).

As ESPON is not likely to have the capacity to develop its own environmental modelling expertise, it seems advisable to follow a strategy of collaboration with established environmental research institutions, such as the EES or IIASA to obtain output of their models as input to further spatial analyses relating these data to socio-economic variables or using them as input to quality-of-life calculations.

6 Data generation methods

In this chapter, first some widely used data generation methods will be presented in broad terms. Then specific applications to some types of flows will be introduced.

6.1 Basic methods

From the review in Chapter 5 it can be concluded that even if a large amount of information exist, in several instances observed flow data are either not readily available or exist only at a coarse level of detail or include gaps. However, the sources of flow data are not limited to observed statistics, but include datasets generated by suitable modelling methods. Such methods have been developed in some fields like transport demand analysis, but some of them are of general relevance and can be applied to different types of flow.

There are two main categories of data generation methods: numerical algorithms and algorithms based on trip generation and distribution models. Numerical algorithms estimate flow patterns by making use of mathematical rules and have a wide range of application. Algorithms based on trip generation and distribution models make use of theories to explain flow patterns and are therefore developed in each specific domain (e.g. finance, transport). In this paragraph some numerical methods are presented.

Monte Carlo sampling

One of the most widely used methods for generating data is Monte Carlo sampling. Numerical methods that are known as Monte Carlo can be loosely described as statistical simulation methods, where statistical simulation is defined in general terms as any method utilising sequences of random numbers to perform a simulation.

A Monte Carlo simulation consists of a physical or mathematical system (e.g. an area where subjects can move from one point to another) that can be described in terms of probability distribution functions. These probability distribution functions describe the evolution of the overall system (e.g. the final destinations of subjects moving from one given point). The goal of Monte Carlo sampling is to simulate the system by random sampling from the probability distribution functions (and by performing the necessary supplementary computations needed to describe the system evolution if required). The method is therefore a purely numerical one as the physics and mathe-

matics are replaced by random sampling of possible states from distributions that describe the system. However, as far as the identification of the most suitable distribution function is concerned, underlying expectations based on theories can used as well as *a priori* information. Literature on Monte Carlo sampling is huge. An introductory text is the electronic book from the Computational Science Education Project available on the internet.

Entropy maximisation

Consider a system made up of a large number of distinct elements (e.g. individuals travelling through a study area). Each element can be defined and described by its *micro* state specifying its characteristic (e.g. origin, destination, mode, time of journey, etc.). However, for many practical purposes it is sufficient to work on the basis of a more aggregate specification: the *meso* state could for instance specify just the number of trips between each origin and each destination. In general, there are numerous *micro* states which produce the same *meso* state. There is also an even higher level of aggregation, a *macro* state, for example the total number of trips on particular links or the total trips generated and attracted to each zone. In general, most of the available information is at the macro level.

Entropy maximising can be applied to estimate a matrix of flows consistent with constraints at the *macro* level (e.g. the total number of trips) while the required output is at *meso* scale (e.g. the number of trips between each origin and each destination). The basis of the method is to accept that, unless we have information to the contrary, all *micro* states consistent with our information about a *macro* states are equally likely to occur. According to this assumption, the most probable *meso* state is the one that can be generated in a greater number of ways, i.e. has the greatest entropy. For more details on entropy maximisation see Ortúzar and Willumsen (1994).

Biproportional adjustment (Furness method)

This method can be applied to estimate a matrix of flows when information on flows generated to and attracted from each zone is available (e.g. the origins and destinations of a trip table or the total number of immigrants and outmigrants of all regions). Biproportional adjustment proceeds by changing the values in the cells of the matrix from arbitrary initial values by applying correction factors such that first the row totals are replicated correctly and in the next iteration the column totals. This iterative procedure is applied until a good approximation of both row and column totals is achieved. For more details on biproportional adjustment see Ortúzar and Willumsen (1994).

6.2 Migration flows

Given the absence or poor quality of international migration data, many efforts have been made to improve the quality of existing migration data or create synthetic migration data with data generation methods. There are two basic approaches for this:

One group of approaches tries to fill data gaps in international or interregional migration matrices by estimating missing cells by biproportional adjustment (see Section 6.1). In biproportional adjustment the rows and columns of a matrix are iteratively adjusted so that the row and column totals match given migration origins and destinations. A variant of this method is the method of harmonisation of migration matrices of different origins proposed by Michel Poulain of the Université Catholique de Louvain (1999). This method complements biproportional adjustment by assigning qualitative confidence weights to incompatible information.

The other approach is the natural movement method. In the natural movement method, the migratory balance (net migration) of a country is the difference between two differences: the difference between its population at the end and the beginning of a period and the difference between births and deaths in the period. The rationale for the method is that population, births and deaths are usually registered with more precision and reliability than migratory processes.

Interregional migration

The situation with respect to data on interregional migration within countries is very different between the EU member states. Eurostat provides internal migration flows between NUTS-2 regions for most EU member states in matrix form. For the new member states the data have more gaps than for the old member states. In addition the migration flow data of different countries are not compatible because of the differences in definition and registration of migrants discussed above.

To compile a EU-wide matrix of interregional migration flows would therefore present a substantial methodological challenge. However, because of the regional focus of ESPON, exactly this would be of particular interest for spatial analysis and indispensable for reliable regional population forecasts. In the ESPON project "The Spatial Effects of Demographic Trends and Migration" (ESPON 1.1.4, 2005) therefore the natural movement method (see above) was applied to estimate migratory balances (net migration) for NUTS-3 (and partly NUTS-2) regions for the second half of the 1990s and the previous decades and to disaggregate these by age group.

The problem with the natural movement method is that it does not allow to analyse the effects of different national migration policies resulting in constraints on migration between different countries. This can be done only by methods analysing migration flows.

In the demonstration example on migration flows (see Section 7.2) therefore an attempt is made to estimate an ESPON-wide interregional migration matrix by fitting interregional migration flows predicted by an interregional push-and-pull migration model to national origins and destinations or migration balances of countries.

Forecasting migration flows

There are essentially two approaches to forecasting migration flows in the literature:

- The first approach assumes that current trends in migration flows will prevail and therefore try to establish migration probabilities and apply these to future populations. In its most sophisticated version this approach is linked to a multiregional cohort-survival model of natural population development in the framework of multiregional demography (Rogers and Willekens, 1986). In multiregional demography, migration flows are the result of migration probabilities, such as the probability that a male person of a certain age and educational background will in a certain period migrates from region *r* in country *r'* to region *s* in country *s'*. The drawback of this approach is that it is unable to take account of changes in the socio-economic conditions in the origin and destination regions giving rise to migration.
- The second approach models push factors (at the origin) and pull factors (at the destination) explicitly drawing on concepts analogous to the gravity model in physics (Ravenstein, 1885; Zipf, 1949): In such migration models the number of migrations between two regions is proportional to the number of potential migrants in the origin region and the number of opportunities (e.g. jobs) in the destination region and inversely proportional to the distance between the two regions. These models can show the effects of changes in the socio-economic conditions in the origin and destination regions by adjusting the push and pull factors in response to, say, economic growth or decline, or show the effects of economic barriers or political constraints on migration by adjusting the distance variable.

The second approach is therefore more appropriate for ESPON, in particular for modelling international migration flows, which are, as it was pointed out above, not so much the result of decisions of individuals or households to

move from one country to another in search for better living conditions or income but rather the complex interplay between the desire to migrate on the one hand and the barriers and constraints to immigration on the other, with the constraints being stronger.

There are today several models of interregional migration flows in use at universities, research institutions and national planning agencies in many EU member states (see Stillwell and Congdon, 1991; van Imhoff et al., 1997; Rees et al., 2001; Champion et al., 2002; Stillwell, 2005; van Wissen et al., 2005). However, there is to date no model of interregional and international migration covering the whole of Europe.

6.3 Transport flows

Transport flows, especially origin-destination matrices, are often modelled rather than observed data, especially when the spatial detail required is high, given the limited availability of spatially disaggregate data. In addition to full transport models, also numerical methods are used to estimate synthetic trip matrices. The box below reports an example of application of the biproportional adjustment method.

Estimating matrices from traffic counts

The idea behind this method is that a given traffic flow observed on a given link (e.g. a road) is the result of the contribution of traffic demand between a number of origin-destination pairs which uses that link. If several counts are available on different links, mathematical relationships can be used to find the most likely origin-destination matrix that can give rise to the observed traffic data (see Ortúzar and Willumsen, 1994). This method does not need any information *a priori* on generated and attracted demand in the zones (although if such information is available, it can be use to improve the estimations).

The gravity model

The gravity model is based on distribution models, i.e. on synthetic explanations of the amount of flow between two zones. It estimates the flow between two regions as a positive function of the trip generation of the origin region and trip attraction of the destination region and a negative function of the 'distance' between the two regions:

Example of application of biproportional adjustment

Consider a simple network with four origin-destination nodes and imagine that the following prior matrix is known.

Origin i / Destination j	1	2	3	4	Σ j	Target G_i
1	5	50	100	200	**355**	**400**
2	50	5	100	300	**455**	**460**
3	50	100	5	100	**255**	**400**
4	100	200	250	20	**570**	**702**
Σ i	**205**	**355**	**455**	**620**	**1635**	
Target A_j	**260**	**400**	**500**	**802**		**1962**

To solve the problem biproportional adjustment starts with the first iteration applied to the cells of the prior matrix T_{0ij}:

$T_{1ij} = T_{0ij} * G_i/G_{0i}$

$T_{2ij} = T_{1ij} * A_i/A_{1i}$

Origin i / Destination j	1	2	3	4	Σ j	Target G_i
1	5.6	56.3	112.7	225.4	**400.0**	**400.0**
2	50.5	5.1	101.1	303.3	**460.0**	**460.0**
3	78.4	156.9	7.8	156.9	**400.0**	**400.0**
4	123.2	246.3	307.9	24.6	**702.0**	**702.0**
Σ i	**257.8**	**464.6**	**529.5**	**710.1**	**1962.0**	
Target A_j	**260.0**	**400.0**	**500.0**	**802.0**		**1962.0**

Origin i / Destination j	1	2	3	4	Σ j	Target G_i	Tolerance
1	5.7	48.5	106.4	254.5	**415.1**	**400.0**	**3.8%**
2	51.0	4.4	95.5	342.5	**493.3**	**460.0**	**7.2%**
3	79.1	135.1	7.4	177.2	**398.7**	**400.0**	**-0.3%**
4	124.2	212.1	290.7	27.8	**654.9**	**702.0**	**-6.7%**
Σ i	**260.0**	**400.0**	**500.0**	**802.0**	**1962.0**		
Target A_j	**260.0**	**400.0**	**500.0**	**802.0**		**1962.0**	

At this step, the tolerance for the total generated trips are calculated and verified: as the tolerance for zone 1, 2 and 4 is not acceptable, the iterative procedure is replicated until a satisfactory results is obtained.

$$T_{ij} = \alpha\, O_i\, D_j\, \mathrm{f}(d_{ij})$$

where O_i are the trips originating in region *i*, D_j are the trips attracted to destination region *j* and f(d_{ij}) is the deterrence function and α the gravity constant to be calibrated.

The more naive version of the deterrence function is the inverse distance between regions *i* and *j*. However, physical distance is generally a poor measure of the effort required to travel between two regions because there are other conditions (e.g. the type of road, the level of congestion, etc.) which have a significant impact. In order to take these aspects into account, functions of generalised cost have been introduced to work as deterring functions. Some examples of alternative forms of the deterrence functions are reported in Figure 4 below.

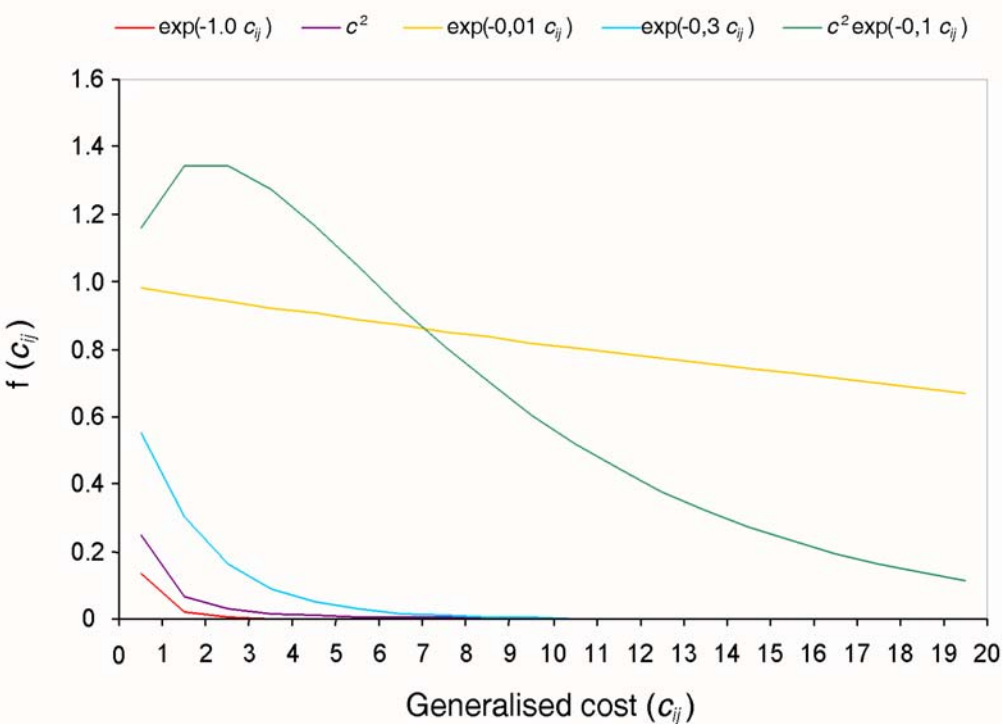
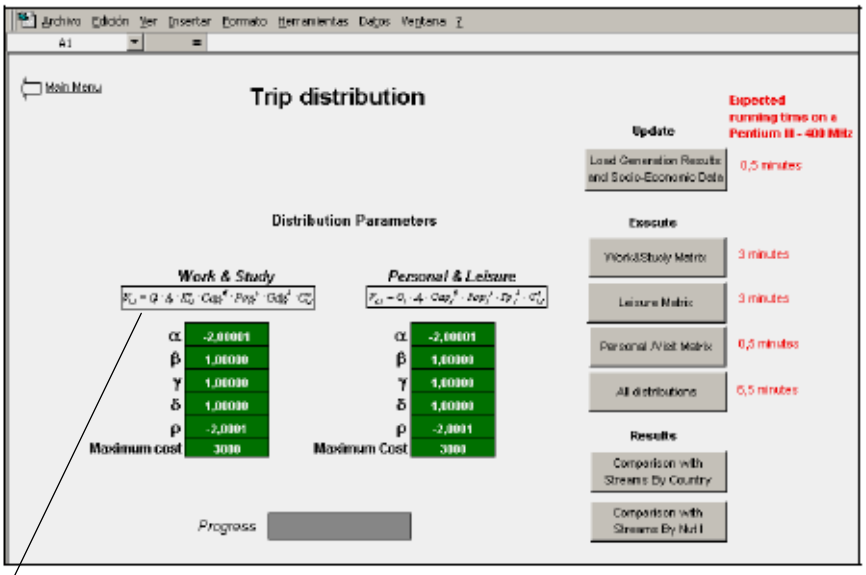


Figure 4 Examples of deterring functions (adapted from Ortúzar and Willumsen, 1994)

A relevant example of the application of a gravity model is the KTEN model applied in ESPON project 3.2 (ESPON 3.2, 2006). The KTEN (Know Trans-European Networks) model is a passenger and freight traffic forecast meta model developed to facilitate a strategic analysis of the trans-European transport networks in a wider pan-European and Mediterranean scale. Within ESPON, KTEN has been used to define transport network scenarios and evaluate them from a European perspective. KTEN uses a trip generation

model based on trip rates to compute the number of trips generated from each NUTS-2 region and then applies a gravity-type distribution model to compute the matrix of origin-destination flows (see Figure 5).



$$V_{i,j} = O_i \cdot A_i \cdot K_{i,j}^{\alpha} \cdot Cap_j^{\beta} \cdot Pop_j^{\gamma} \cdot Gdp_j^{\delta} \cdot C_{i,j}^{\rho}$$

Figure 5 Trip distribution model and user interface of the KTEN travel model (ESPON 3.2, 2006)

Spatial input-output models

In integrated land-use transport models the transport matrix can be derived as result of location and trade choices (DETR, 1999). The basic concept of the input-output approach is that the production of some economic activity, output, consumes a range of other types of economic activities as input. This concept is made spatial by applying rules for the distribution of the required amount of input from alternative regions of production. With such rules, production of each zone and 'distance' (e.g. generalised cost) are used to calculate the amount of purchases from each zone. Constraints are applied to make sure that all production of each zone is allocated and the total amount of input required in each zone is purchased.

An example of the application of the spatial input-output model is the Regional Economic Model (REM) of the European transport model SCENES (ME&P and TRT, 2001). REM calculates the matrix of freight flows between regions in the modelled area (internal zones) at the NUTS-2 level and to and from the rest of Europe (external zones) at the country (NUTS-0) level.

7 Demonstration examples

In the second phase of the project seven demonstration examples showing the potentials and also limitations of introducing flows analysis into ESPON were conducted.

One function of the demonstration examples is to get more insight into the spatial pattern of flows and the relevance of certain flow types for certain regions, i.e. into the spatial evidence of flows. However, the main function of the demonstration examples is to give an impression of the potentials of flow data analysis, i.e. the case studies show opportunities for larger studies in ESPON 2013 and what type of results could be obtained from them.

Table 5 gives an overview on the demonstration examples including their geographical coverage and spatial resolution.

Table 5 Demonstration examples

Case study	***Geographical coverage***	***Spatial resolution***
A Trade flows	All European countries	Matrix for trade of Polish regions with European Countries, i.e. - NUTS-3 for Poland - NUTS-0 for other countries
B Migration flows	ESPON Space	NUTS-3
C Freight flows	ESPON Space	NUTS-2
D Passenger flows	ESPON Space	NUTS-2
E Tourist flows	Selected new member states of the EU (Czech Republic, Hungary, Poland, Slovakia and Slovenia)	Depending on country: NUTS-1, NUTS-2, NUTS-3
F Cross-border flows	Poland	Individual border crossings
G Commuter flows	State of North-Rhine Westphalia, Germany	LAU-2

Not all case studies address Europe-wide flow data, some focus on smaller geographical units. Most demonstration examples are based on data available from public authorities or agencies, however, some of them include also data generation methods. Because of data limitations, the demonstration examples are not always based on NUTS-3 regions, and because of budget and time restrictions not all thematic fields discussed in the previous chap-

ters are accompanied by a demonstration example. In some demonstration examples experiments with visualisation of flow data in maps and diagrams are made.

7.1 Trade flows

The exchange of goods with other regions is the essential basis for the economic development of regions in Europe. The amount and direction of international trade flows in Europe have undergone significant changes during the last two decades, in particular between the old and new member states of the European Union. An accurate regional determination and analysis of these east-west trade flows from a spatial point of view is one of the necessities for the assessment of transport demand and the need for additional transport infrastructure and gives insight into the economic performance, relationships and interdependence between regions.

This demonstration example dealt with Polish foreign trade. Trade exchange with Poland constitutes around fifty percent of the whole exchange between the old and new EU member states. In the demonstration example the regional distribution of trade was analysed before and after Poland became a member of the European Union using data from the years 2000 and 2005. Particular attention was paid to the dynamics of the phenomenon and the situation in the domain of trade exchange with three neighbouring countries: Germany, a country of the old European Union and at the same time the primary trade partner of Poland, the Czech Republic, a new member state and Ukraine, a country outside of the European Union.

Data

The database used are trade matrices for the years 2000 and 2005 showing trade flows between 379 poviats (counties) or LAU-2 regions in Poland and all European countries. Figures comprising the amount of import and export are given for each relation and are expressed in tonnes as well as in US dollars based on information from SAD (Single Administrative Document) and INTRASTAT. The SAD forms encompass the entire trade with the countries outside of the European Union. The ITRASTAT system is founded on reports from companies conducting foreign trade. In accordance with the information obtained in the Polish Ministry of Finance, Poland the system includes 90% of the trade with the remaining 24 countries of the EU. This implies certain constraints of comparability of the data from the years 2000 and 2005. In 2000 the entire Polish trade was registered in the SAD.

Carrying out of the dynamic analysis was not possible for poviats which have been split up after the year 2000. The conduct of such an analysis would require estimation of the respective values for the two new poviats. Since the time the administrative reform the number of counties increased in Poland from 373 to 379 (including towns having the rights of counties).

The data for the year 2000 come from the Computer Centre of Foreign Trade, the governmental agency dealing with processing of trade data. Since the accession of Poland to the European Union the data are at the disposal of the Customs Department of the Ministry of Finance. The results presented below constitute an example of the use of this database. The analysis was carried out first on the basis of the value of trade between Polish counties and the European countries (expressed in US dollars – the data from before the accession of Poland are available only in US dollars or Polish zlotys). In a more elaborate analysis it would also be possible to analyse the weight of the exported and imported goods and to study the complete industry structure (according to the European Classification of Activities) in the poviats. The possible levels of spatial aggregation of data are, besides NUTS-4 as presented here, also NUTS-3 and NUTS-2.

Methods applied

The fundamental research instrument, applied in the analysis of trade flows is the trade matrix with the rows corresponding to poviats and the columns to foreign countries. The cartographic reflection of such a matrix is the map of interactions showing the strongest links. In addition, significant indicators which serve to demonstrate the spatial structure of foreign trade are the coefficients of concentration and diversification of the trade partners. The magnitudes of export and import are presented in absolute values and in relation to the demographic potential (population) or the economic potential (GDP or for smaller units industry sales). The qualitative measures describing the character of exports from poviat are the share of technologically advanced industries and the share of developed destination countries (most frequently members of the OECD).

This regional analysis of international trade is a more detailed counterpart of the general analysis of trade flows at the national level. It shows only a certain part of total interregional flows as the trade matrix analysed is not complete: it does not account for internal flows nor for trade between the partner countries.

The values of exports and imports may also be used for the construction of synthetic indicators, such as, for instance, indicators of regional competitiveness (Maćkowiak, 2002). They make it possible to delimit areas of con-

centration of export and to carry out a qualitative assessment of industrial characteristics (Komornicki, 2004).

Main results

In 1991 Poland signed the Association Agreement with the European Community, which determined the directions to trade in subsequent years. Classic effects of the creation and shifting of trade ensued. The place of the Soviet Union as the main trading partner of Poland (which accounted for 31% of exports and 33% of imports in 1980) was taken by the reunified Germany (28% of exports and 25% of imports as of 2005). The 24 other current member states of the EU accounted for 81% of Poland's exports and 77% of its imports in year 2003. Leaving aside Germany, the other large trading partners for Poland, the current EU member states and the USA, represent a rather diverse structure. The most important roles in trade are played by Italy, France, the United Kingdom and the Netherlands. Russia maintains a position in the ranking mainly because of imports of crude oil and natural gas. In 2005 the ESPON space countries accounted for 82% of Polish export and 69% of import.

Poland is characterised by a very uneven regional breakdown when it comes to exports (Figure 6). Most exports come from Warsaw and the western part of the country, in which almost all poviats participate in foreign trade. In contrast, in eastern Poland, foreign trade is concentrated almost uniquely within the largest centres. The main concentrations of exports are: (a) the Warsaw agglomeration (9.4% of total exports in the year 2005), (b) certain urban areas in Upper Silesia, (c) the Legnica-Głogów copper-mining district, (d) other large urban and industrial agglomerations, above all that of Poznań, and (e) selected smaller centres in which modern industrial plants are located (mainly with foreign capital playing a role).

An even greater concentration exists for imports (Figure 7). The position of Warsaw (as the seat of importing firms) is absolutely dominant in this case (accounting for 26% of the value of all inward movements of goods reported in 2005). The roles of the remaining agglomerations, especially Poznań (5%) and Gdańsk (4%) are greater than in the case of exports. In contrast, the Upper Silesian Industrial District is of lesser significance. The direct transfer of foreign goods to local centres is of limited importance (except in Wielkopolska and Lower Silesia). The large centres of import are the cities in which the large petrochemical concerns are located, i.e. Płock (5% of total imports) and Gdańsk. Clearly visible are the centres of modern industries, in which production for export is associated with imports of components as well as sometimes the machinery needed to modernise output.

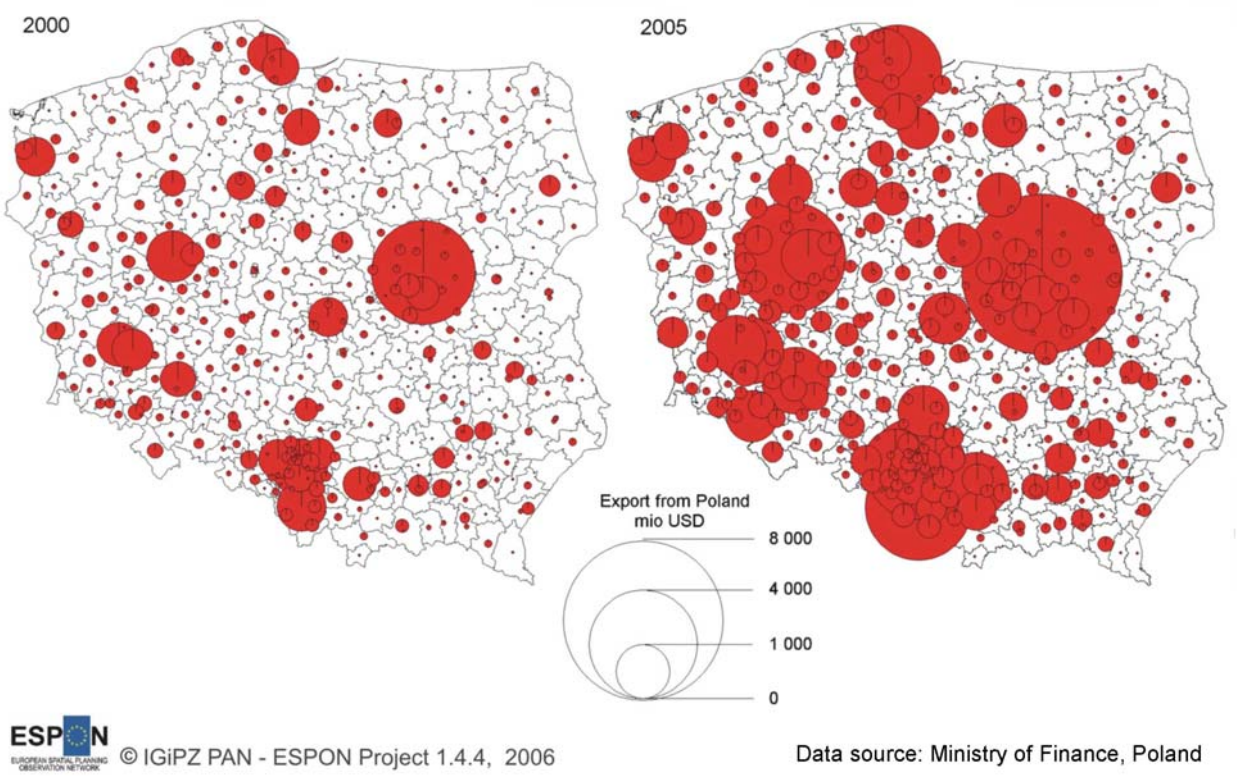


Figure 6 Regional breakdown of Polish exports in 2000 and 2005

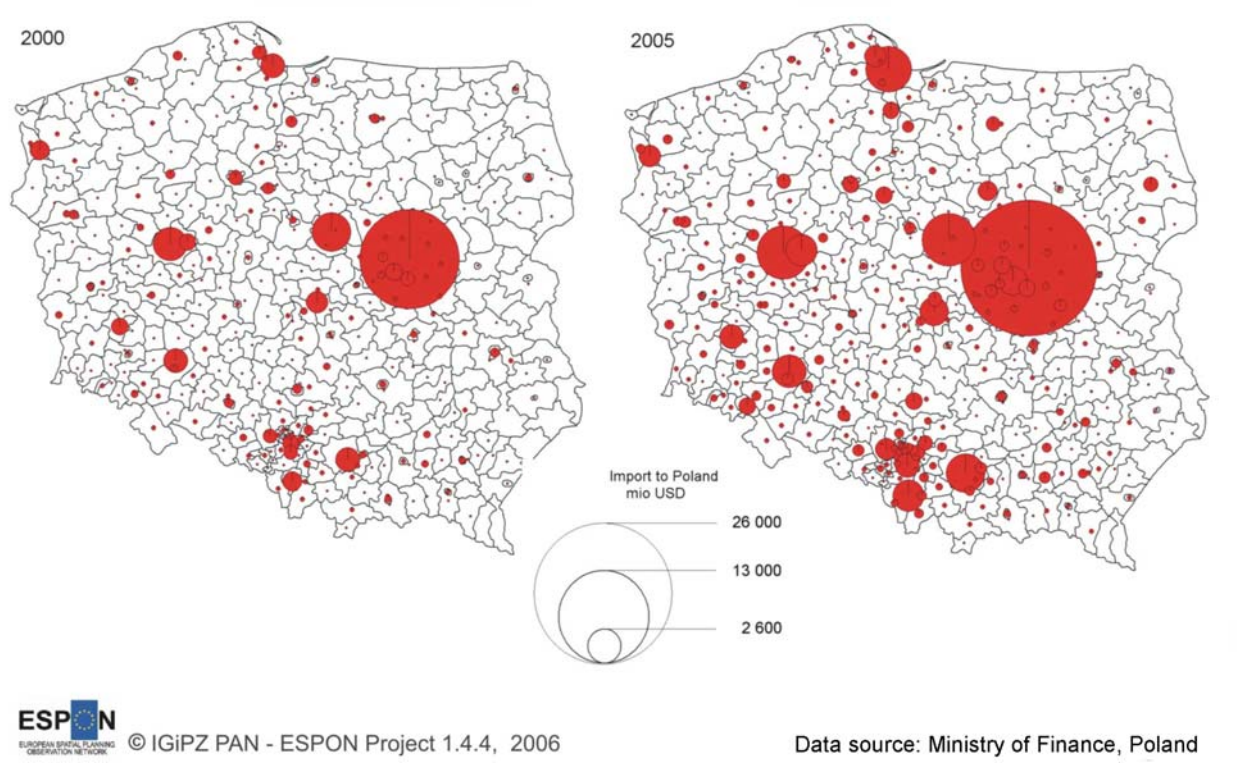


Figure 7 Regional breakdown of Polish imports in 2000 and 2005

In some areas in Poland belts of increased significance of foreign trade have emerged. These are often related to transport infrastructure. Such belts exist along the Berlin-Wrocław-Kraków-Ukrainian border route, the Warsaw-Lublin-Ukrainian border route and along the seacoast between Szczecin and Gdańsk. A belt-like concentration of foreign trade can also be observed along the "Via Baltica", the corridor from Warsaw to Lithuanian.

After the enlargement of the EU the main export centres remained almost unchanged. A diffusion of exports into more peripheral areas could be observed, though, especially in central and south-eastern Poland. A distinct increase of exports was noted in the areas with special economic zones, such as Wałbrzych, Mielec and Gliwice. The value of exports decreased only in few counties. The increase was somewhat higher in the eastern part of the country and relatively lower in areas which had strong international economic connections already before the EU enlargement (Figure 8).

For imports the analogous phenomenon of deconcentration appeared to a much lower degree (Figure 9). The increase was proportional in the biggest import centres. There was a slight reduction of the role of Poznań, while the significance of the Tri-City, Wrocław and Cracow increased. Again, some of the special economic zones, first of all the one of Wałbrzych, turned out to be perceptible. In several dozen peripheral counties the value of imports decreased. Import values increased intensively in Lower Silesia and in the eastern regions of Lublin and Podlasie. For both exports and imports north-western Poland experienced relatively little change. The significance of foreign trade for this region was high already in 2000. Export from the area was largely based on products of the Polish wood-and-paper and light industries. The very high percent increases in some peripheral areas of Masovia are the result of very low initial values.

In exports and imports alike the concentration of trade in the capital city Warsaw decreased in the years 2000-2005 a decrease. This confirms the proposition that the enlargement of the Union was favourable for the development of international contacts by companies from smaller centres. Despite this, Warsaw developed a huge trade deficit, much higher than Poland as a whole.

The importance of the EU as a destination for exports declines as one moves eastwards through Poland (Figure 10). Its place is gradually taken over by countries of the former USSR. While the diversity of partners is generally higher in the large agglomerations, especially Warsaw, Upper Silesia and Gdańsk, it also increases towards the east, as EU markets are augmented by partners in Eastern Europe. There are even certain industrial centres in the Podkarpackie voivodship which enjoy links with the USA.

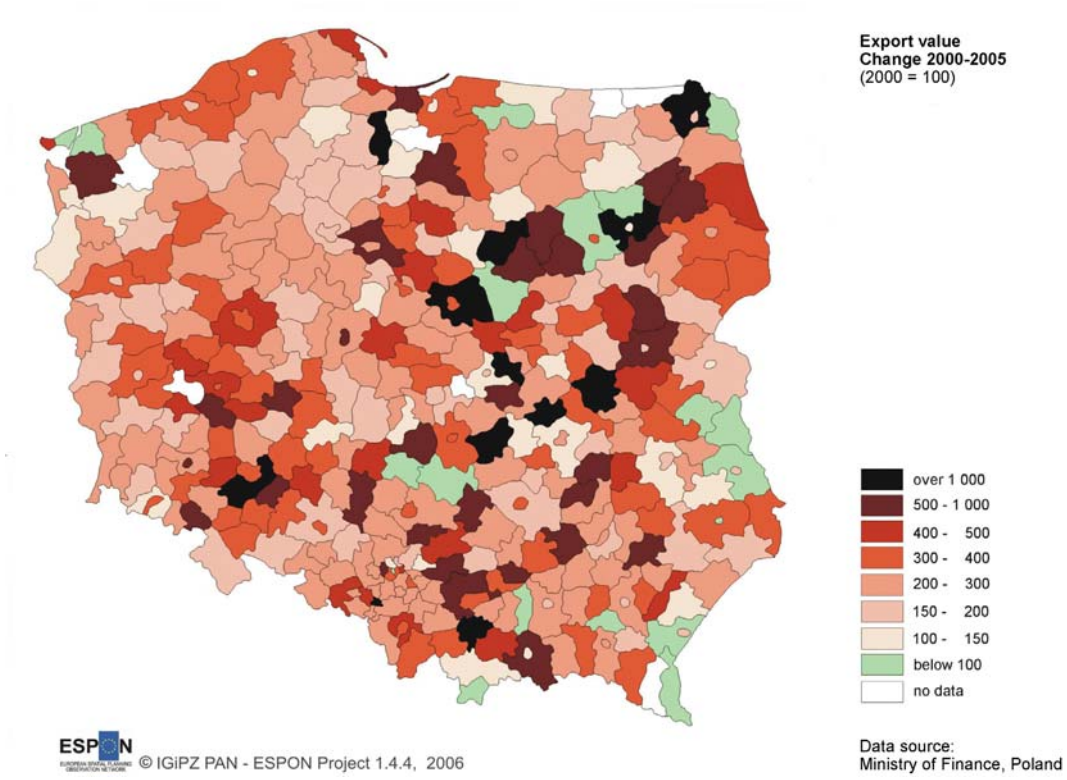


Figure 8 Export value of Polish regions, change 2000-2005

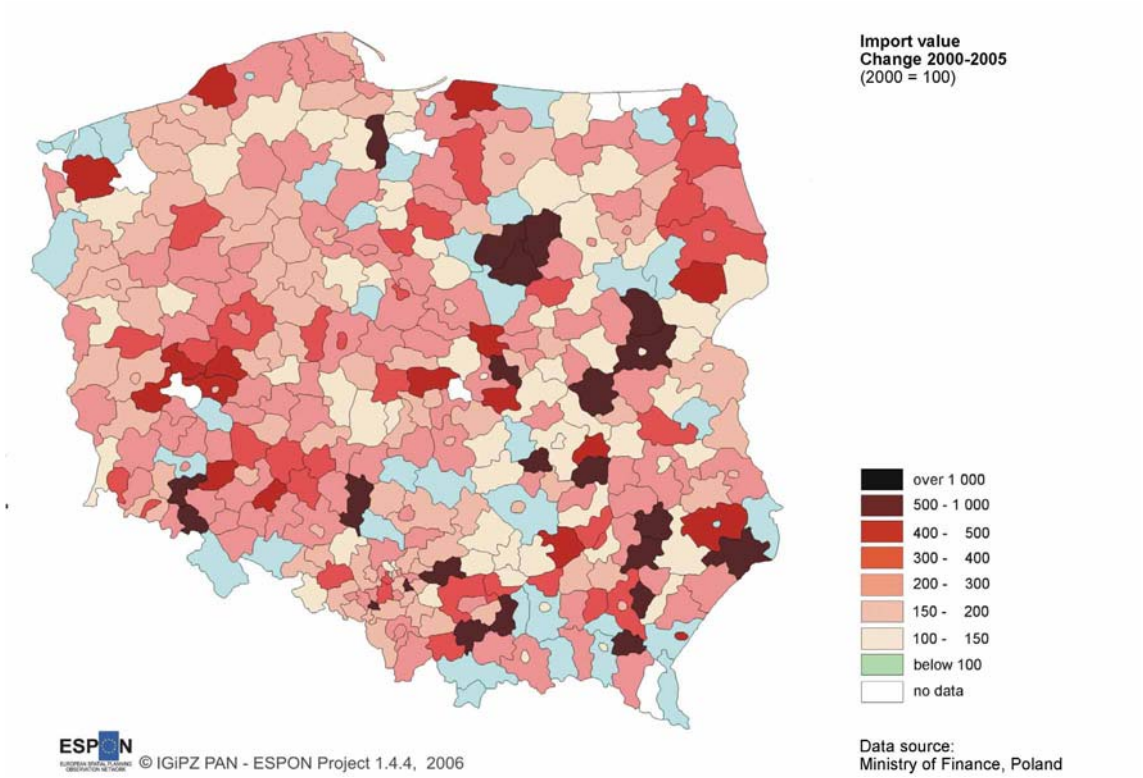


Figure 9 Import value of Polish regions, change 2000-2005

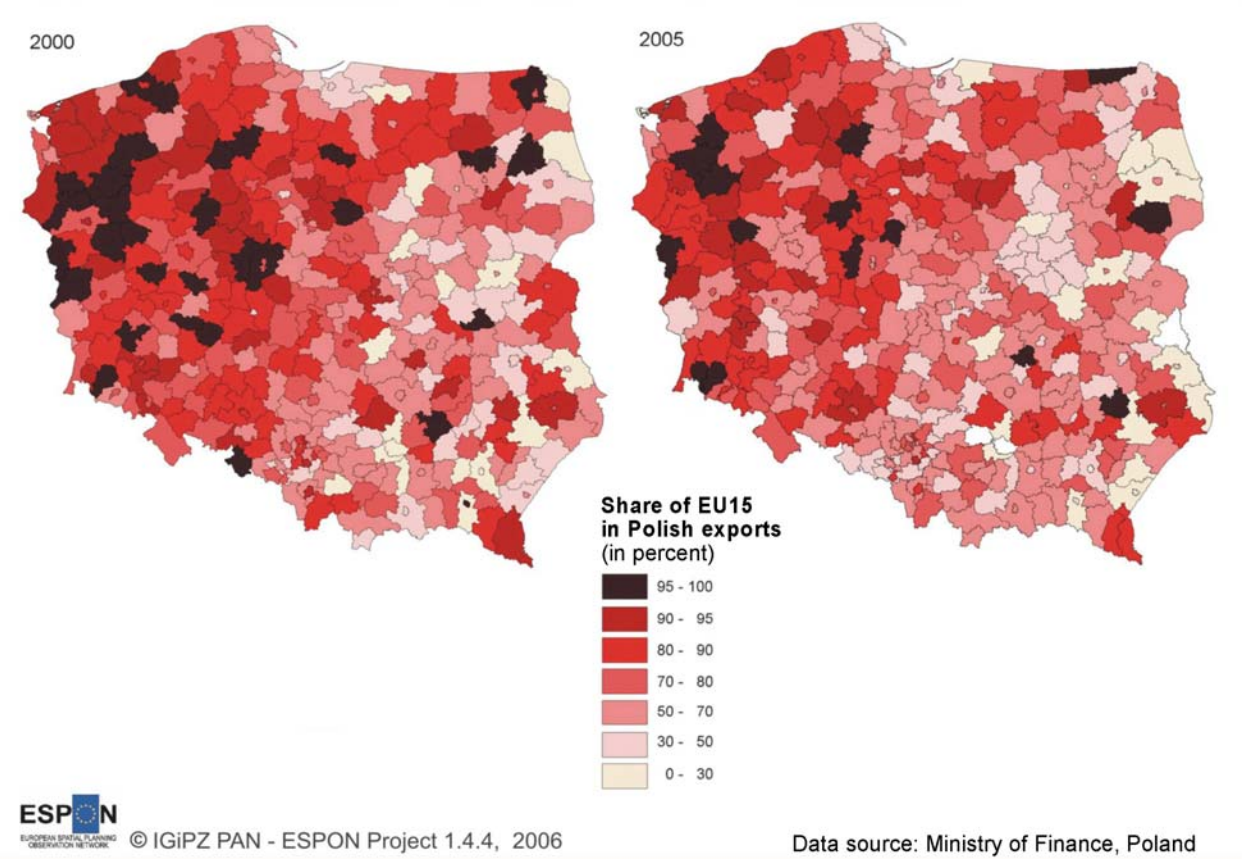


Figure 10 Shares of old EU member countries in Polish exports 2000 and 2005

In the years 2000-2005 there was a relative decrease of the share of old EU member countries in the exports from the majority of counties. This was associated with a rapid development of trade ties with the new EU member states and with third countries.

The pattern of strongest trade interactions between Polish provinces (voivodships) and foreign countries is shown in Figure 11. Germany is the main export partner for all provinces, although in the case of the Lublin province the value of exports to Ukraine is only marginally smaller. The strongest absolute exports are observed for province of Wielkopolska with Germany. This is, in particular, due to the German investments in this area and a concentration of motor industry and furniture production plants in the vicinity of Poznań. The ties of the Silesian and Lower Silesian provinces with Germany are, however, only slightly weaker. Countries the positions of which are clearly visible in the matrix are France, the United Kingdom and the Netherlands. The highest concentration of export connections is in the province of Masovia and the provinces of Lower Silesia, Pomerania, Silesia and Wielkopolska. Only the Masovian and Silesian provinces have stronger ties with countries outside of the European Union.

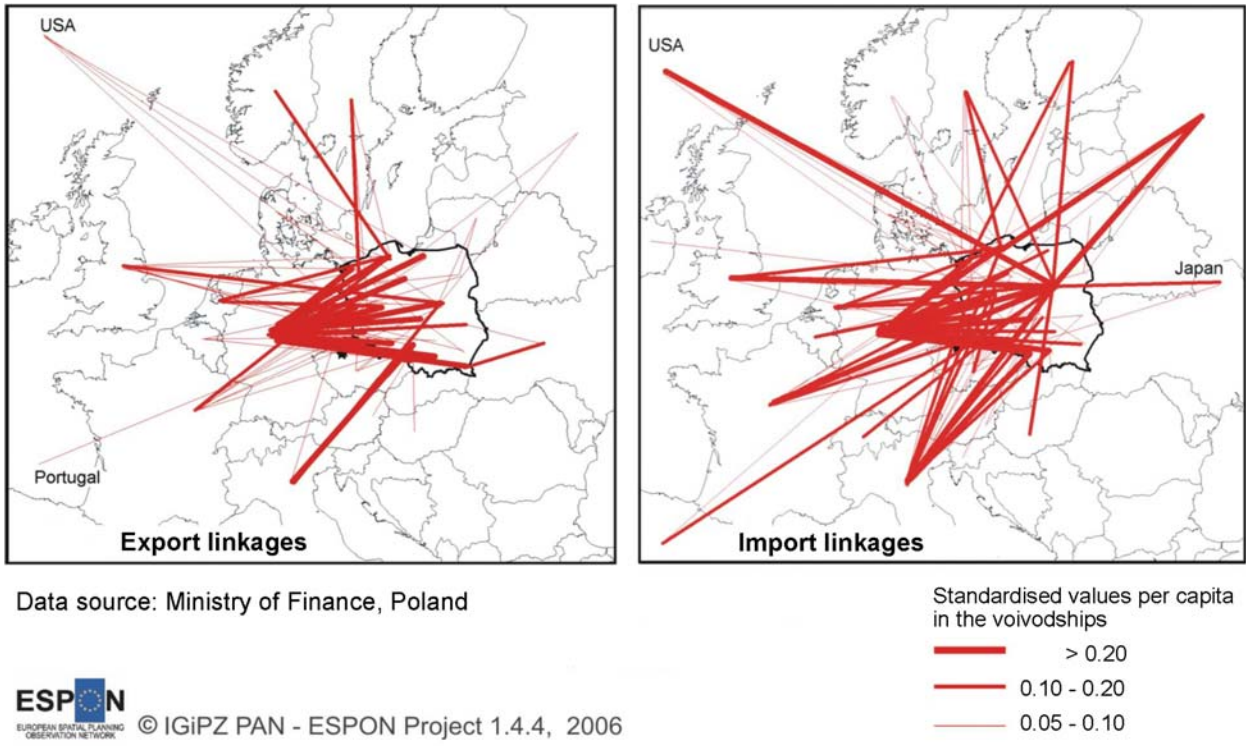


Figure 11 Polish international trade linkages

Countries outside of the EU with strong ties with Polish provinces are Ukraine and the United States. The lowest export ties are observed in the provinces of Świętokrzyskie, Podlasie, Lublin and Warmińsko-Mazurskie. In the provinces of Lubuskie, Małopolskie, Łódź and Opole strong ties are observed only with Germany.

In the matrix illustrating the main import connections, the strong connections with other EU countries becomes again apparent. The spatial distribution of these connections, though, is different from those for exports. There is a lower concentration of connections to Germany, while the significance of other countries of EU15 (mainly Italy, France, Sweden, but also Spain and Belgium) and the United States increases. The overall concentration of imports within Poland is higher than for exports, with the province of Masovia being the focus of concentration. The strongest import connections in absolute terms exist between Germany and the province of Masovia. There are also strong connections of Masovia and Pomerania with Russia (import of oil for the refineries in Płock and Gdańsk), and of Masovia with the United States. The strongest concentrations of import connections are in the provinces of Masovia, Silesia and Wielkopolska. The graphical image of import relations is clearly more symmetric than that of export relations.

The presence of outside investors appears to be the decisive element for the intensity of foreign trade in smaller and medium-sized centres. The key factor is, though, not the volume of investment, but the position of the investor (most often an international corporation) on the world market. Distance from the borders and from international transport networks has regional significance. Both factors can be observed when analysing the trade turnover with neighbouring countries. The neighbourhood of Germany (including the large market of Berlin) allows small businesses from the western borderland of Poland to conduct export activity. Simultaneously, local centres of export to the countries of the former Soviet Union exist along the transport routes towards the eastern border.

Polish-German trade

Germany is the biggest Polish trade partner. The turnover in trade exceeded the value of 50 billion US dollars in 2005 and dominates in almost all industries and across almost the whole country. Contrary to the majority of the remaining countries of the European Union, Polish trade with Germany is well balanced (in 2005 a slightly positive balance for Poland was noted).

The industry structure of this trade is the effect of different stages of economic development of the two countries and the resulting complementarity between them. The list of exported goods is topped by furniture, garments, combustion engines, passenger cars, simple wooden products, ships, metal structures. Raw materials, such as copper and hard coal are ranked much lower. The top positions among the goods imported from Germany are occupied by industrial machines, synthetic materials, passenger cars, trucks, car parts (including engines), followed by, in particular, pharmaceuticals, paints and animal feed stuffs.

A more detailed analysis of the industry structure of trade indicates the complementarity of the Polish and German economies. At the same time it reflects the traditional division of work, with the Polish side exporting less processed goods, and importing hi-tech products (Kundera and Ostrowska, 1998). The spatial distribution of the trade with Germany (and of the share of Germany in total value of exports, see Figure 12) seems to be the effect of the economic factor (locations of the modern industries and the industries which declined in Germany), the geographical factor (distance from the border), and historical factors (higher intensity in the areas that belonged to Germany in the past). An especially intensive trade is observed in south-western Poland, in the vicinity of Poznań and along the seacoast. The position of Warsaw is relatively weaker (the capital city features the most differentiated geographical structure of the trade partners).

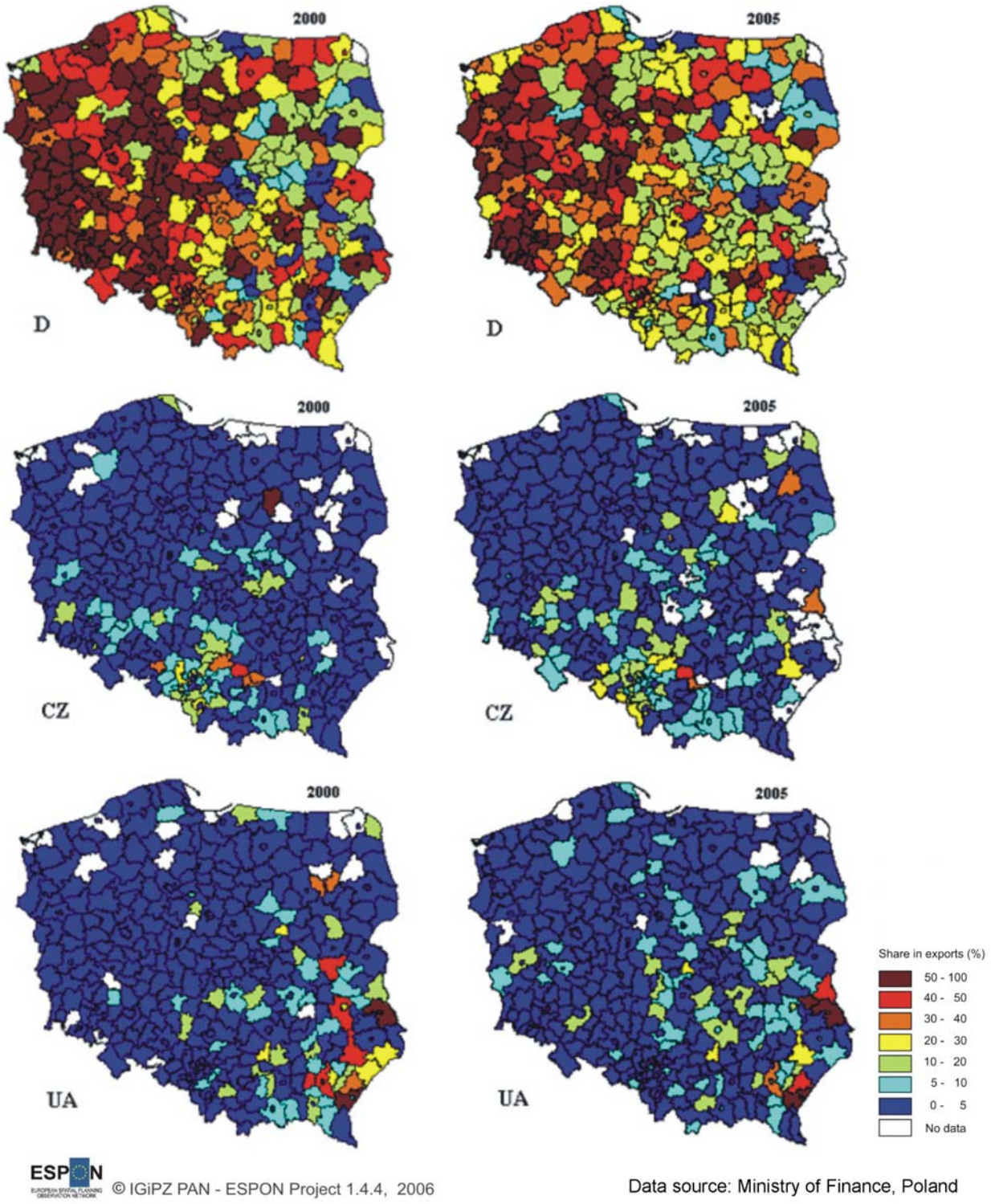


Figure 12 Share of neighbouring countries in Polish exports 2000 and 2005

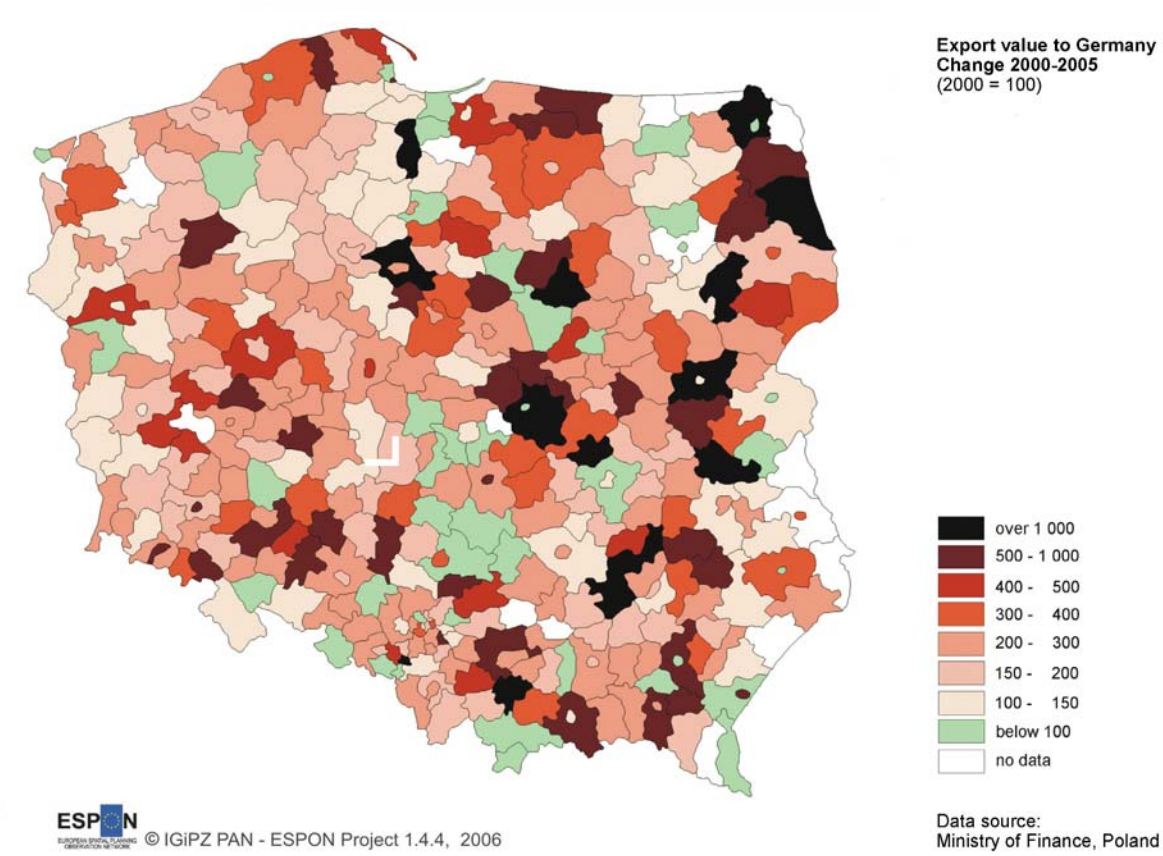


Figure 13 Change of Polish regional exports to Germany 2000-2005

Three belts of intensive economic contacts with Germany can be identified: (a) from Berlin and Dresden through Upper Silesia to south-eastern Poland; (b) from Berlin through Poznań towards Bydgoszcz and Olsztyn; (c) from Berlin through Szczecin towards Gdańsk. The lowest intensity of economic ties with Germany is observed in north-eastern Poland.

In the period of 2000-2005 exports to Germany underwent a significant increase over the whole of Poland (Figure 13). In relative terms the increase was most intensive in the central and eastern parts of the country, while the least intensive were in the areas close to the German and Ukrainian borders. A decrease of exports to Germany occurred in a dozen or so counties, mainly in the province of Lodz. As a consequence of the transformations described the disproportions in the share of Germany in exports became somewhat smoothed out.

Polish-Czech trade

The role of the Czech Republic as the trade partner of Poland, after a distinct breakdown in the initial period of the socio-economic transformations, is again increasing in importance. During the 1990s the bilateral trade balance was negative for Poland. After 2000 this situation changed dramatically. Currently, the balance is positive for Poland. In 2005 the value of exports in this direction amounted to 4.1 billion US dollars (fifth biggest export destination), and of imports to 3.6 billion US dollars. The Czech Republic is the most important purchaser of the Polish soap and other sanitary means, an important buyer of hard coal and coke, copper, passenger cars, metalworking products, tires, furniture, legumes, glass and paper. Trade with the Czech Republic is concentrated in south-western Poland (the area close to the Czech border, Upper Silesia, Cracow, Wrocław and the copper basin), as well as in Warsaw and Poznań. On the remaining parts of Poland trade with the Czech Republic plays a marginal role (Figure 12).

In the period 2000-2005 the zone of intensive trade exchange with Czech Republic widened (Figure 14). This concerns first of all the region of Wielkopolska and some areas in Masovia. A significant, though smaller, increase of the bilateral trade was observed also in the location of its highest concentration date in Lower and Upper Silesia. North-eastern Poland still has only very weak economic ties with the Czech Republic. Export to the Czech Republic increased in some counties by more than factor of 10. This took place not only in the peripheral counties with low initial export values in 2000, but also in such centres as Gdańsk.

Polish-Ukrainian trade

Of the remaining neighbouring countries the biggest value of trade is noted with Ukraine. It is the second after Russia, Poland's main trade partner in Eastern Europe, and at the same time one of the few countries, with which Poland has a decidedly positive trade balance. In 2005 the value of exports to Ukraine amounted to 2.6 billion US dollars and the value of imports to 1.0 billion US dollars. After a domination of the raw materials in trade, Polish exports to Ukraine are today surprisingly diversified in terms of industries. It encompasses hard coal, food products, chemicals, synthetic materials, products of light industry, steel products, machines and devices as well as furniture.

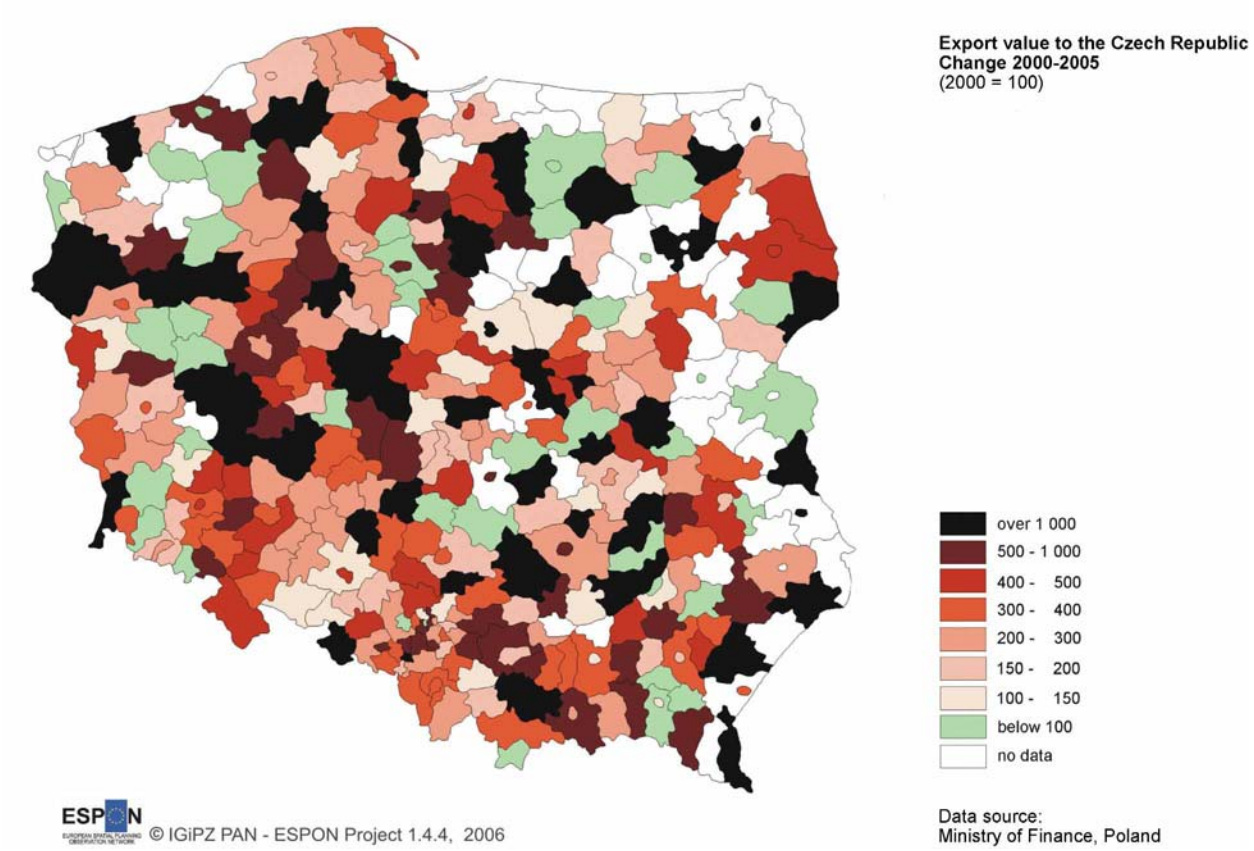


Figure 14 Change of Polish regional exports to the Czech Republic 2000-2005

An analogous diversification does not exist in imports, of which more than 70% in value consist of iron ore, natural gas and other mineral raw materials. The trade with Ukraine is in a very clear manner associated with the main transport corridors: the parallel one from Germany through Cracow to L'viv and the oblique one from Kujawy and Warsaw through Lublin towards Kiev and L'viv (Figure 15). The main centres of exports to Ukraine are Warsaw (above 21% value of exports in 2005), Lublin, Rzeszów, Lodz and Katowice. Goods imported from Ukraine go primarily to Cracow, Katowice, Dąbrowa Górnicze (iron ore for Polish steel works) and Warsaw.

The counties close to the Ukrainian border continue to be the areas of strongest concentrations of export to Ukraine. The reasons for this are the lower quality requirements by the Ukrainian market. Numerous small businessmen from eastern Poland could not stand the competition of the European Union market, whereas their not always modern products can still be sold in Ukraine.

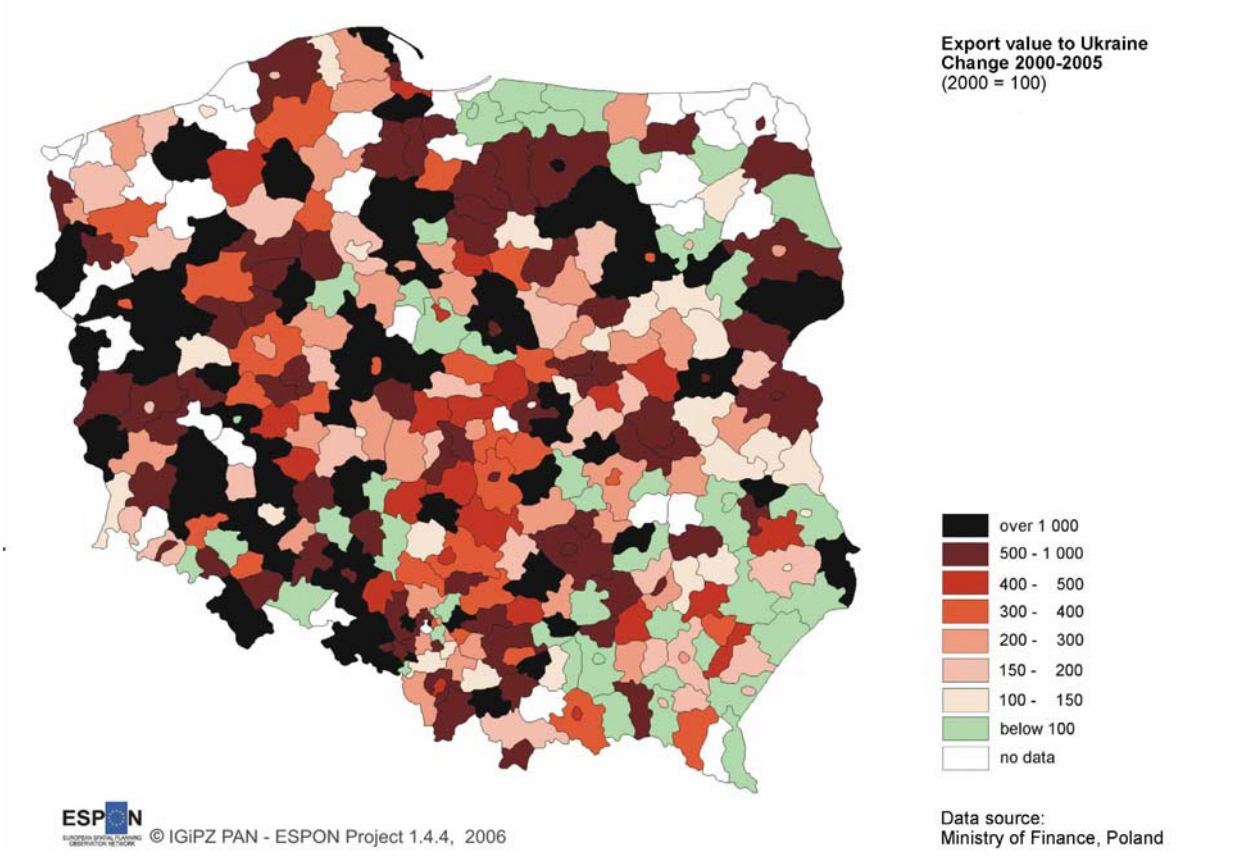


Figure 15 Change of Polish regional exports to Ukraine 2000-2005

A part of the effect could also be attributed to the location close to the Ukrainian border of companies dealing with re-exporting of goods imported to Poland before (Ukraine imports from Poland, in particular, coffee and bananas). The actual significance of the trade with Ukraine is even bigger in view of the still functioning unregistered trade.

In the years 2000-2005 there has been, however, a decrease of exports to Ukraine from the areas close to the Ukrainian borders (the provinces of Lublin and Podkarpackie). On the other hand there was a strong increase in the remaining areas, particularly in western Poland (Lower Silesia, Wielkopolska) and partly in northern Poland. In many counties there the value of exports increased more than ten times (e.g. in Gliwice, Olsztyn and in the counties near Wrocław). The increase exceeded five times in Warsaw, Opole and Gdynia.

Conclusions for ESPON

The analysis conducted leads to the following conclusions concerning the spatial structure of Polish foreign trade:

- Polish foreign trade remains strongly concentrated in space, which is conditioned by the distribution of the demographic and economic potential, and also by the distance to borders, foreign investments, and, in some cases, by historical factors. The pattern is quite stable, although the enlargement of the EU resulted in a tendency towards the deconcentration of exports towards smaller centres, while the strong spatial concentration of imports persisted. The domination of Warsaw in the entire foreign trade has been somewhat limited.
- The membership in the European Union brought a fast increase of international trade over the entire country and in most geographical directions (with the old and new EU member states and also with some third countries). Since the majority of customs barriers disappeared already in the earlier years on the basis of the Accession Treaty of 1991, one should consider among the important reasons for the overall growth in trade value the increase of trust in the small and medium producers from Poland and to the Polish market as a whole among the partners in the old EU member states.
- In the period 2000-2005 there has been an increase in the diversification of the foreign trade partners in most Polish regions. the domination of Germany as the most important trade partner in western Poland was somewhat weakened, while trade with the new member states increased. Trade connections with the neighbouring countries started to develop not only from the side of businesses close to the borders but also from locations farther away from the borders.
- In the areas close to the eastern borders of Poland exports to the direct neighbours decreased. This was compensated by new export connections of companies located deeper inside Poland. In the areas close to the borders this may, however, constitute a threat to small businesses – the negative effect of the enlargement of the European Union. Local contacts of the smallest businesses may have been limited by the introduction of visas for the eastern neighbour countries.

Due to the key economic role and availability of trade data, trade remains one of the best indicators of international economic connections. The regional analysis gives insight into the directions of trade interactions in individual countries. The observed interactions can be associated with the demand for transport infrastructure.

The analysis allows the identification of the spatial distribution of the international economic ties across a country. It shows the extent to which individual regions or even towns have become elements of the European economic space – a measure of the spatial economic integration of a country in the European Union.

The analysis is especially valuable for the assessment of the relations between the new and old EU member states and across the external borders of the European Union. For the outer borders, Polish databases allow the identification of border crossings through which exchange takes place. This creates the opportunity for the study of cross-border interactions with Russia, Belarus and Ukraine.

The study of changes in the dispersion of international trade connections among smaller centres may help to assess the effectiveness of cohesion policies.

The shares of particular destination countries in the exports from counties or provinces make it possible, for instance, to identify zones of strong ties with neighbouring countries as indicators for the local integration potential of border regions.

To summarise, the analysis of trade linkages at an international and interregional level should be an important component of studies aiming at monitoring and evaluating the effectiveness of cohesion policies in the EU – not only between the old and new EU member states but also between the new member states themselves. When coupled with freight transport analysis, a study of spatial trade patterns is of direct relevance for a possible reformulation of the EU transportation policy.

7.2 Migration flows

In this demonstration example the feasibility of estimating interregional migration flows by an interregional push-and-pull migration model is demonstrated by extending the migration submodel of the regional socio-economic model SASI and applying it to forecasting migration flows between NUTS-3 regions in Europe.

Method applied

The SASI model was developed in the EU 5th Framework Programme "Socio-economic and Spatial Impacts of Transport Infrastructure Investments and Transport System Improvements" (SASI) and applied in the ESPON projects "Particular Effects of Enlargement of the EU and beyond on the Polycentric Spatial Tissue with Special Attention on Discontinuities and Barriers" (ESPON 1.1.3, 2006) and "Territorial Impacts EU Transport and TEN Policies" (ESPON 2.1.1, 2005).

The SASI model differs from other regional economic models by modelling not only production (the demand side of regional labour markets) but also population and migration (the supply side of regional labour markets). Its current migration submodel is, because of lack of interregional migration flow data, a model of regional net migration based on regional push variables (e.g. unemployment) and pull variables (e.g. job opportunities).

Figure 16 shows the structure of the SASI model with the migration submodel highlighted.

In the demonstration example, the migration submodel of the SASI model was used to generate synthetic migration flows between NUTS-3 regions as a function of push variables of origin regions and pull variables of destination regions.

In the present simple migration model of the SASI model migration within the European Union and immigration from non-EU countries is modelled as the annual regional migration balance (net migration) as a function of regional indicators expressing the attractiveness of a region as a place of employment and a place to live in order to take into account both job-oriented migration and retirement migration:

$$m_r(t) = \alpha\left(\frac{q_r(t-3)}{\overline{q}(t-3)} - 1.5\right) + \beta\left(\frac{v_r(t-3)}{\overline{v}(t-3)} - 1.5\right)$$

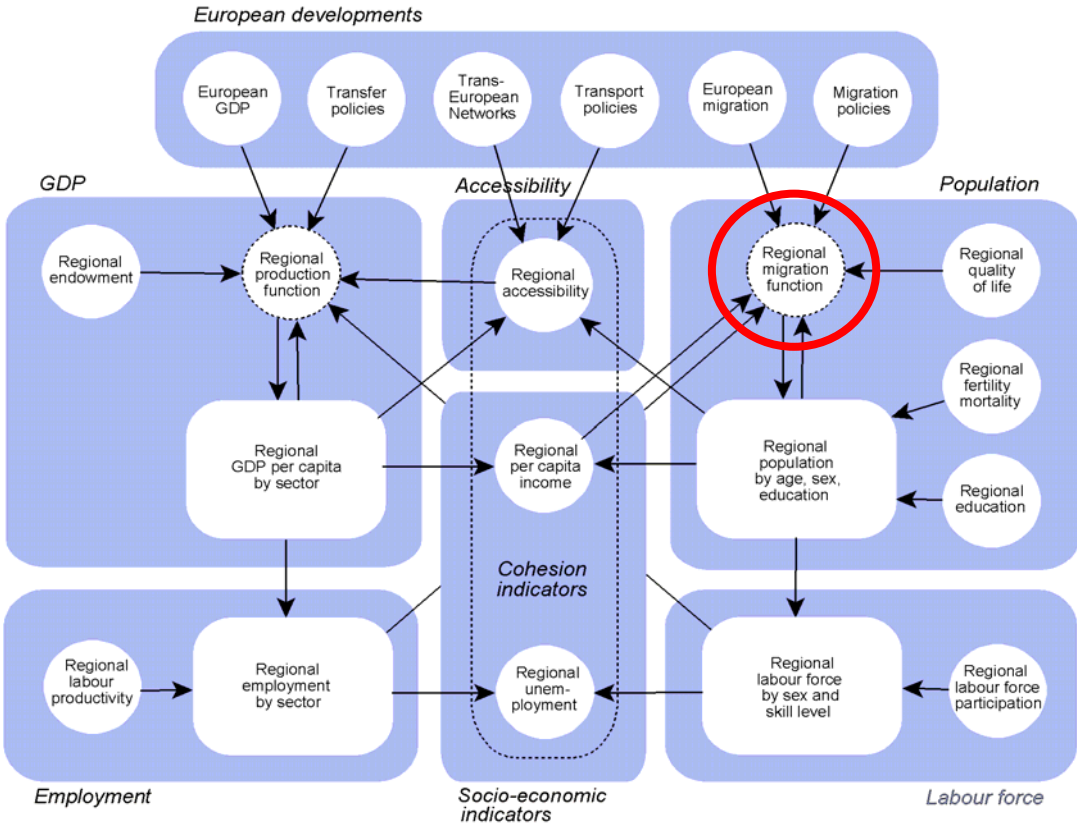


Figure 16 The SASI model

In the net migration model the attractiveness of a region as a place of employment is expressed as the ratio of regional GDP per capita q_r in year t–3 and average European GDP per capita $\bar{q}$ in year t-3. The attractiveness of a region as a place to live is expressed as the ratio of the regional quality of life v_r in year t–3 and average European quality of life $\bar{v}$ in year t-3. For the specification of the composite quality-of-life indicator, see Schürmann (1999). Both indicators are lagged by three years to take account of delays in perception. The forecasts of regional net migration are adjusted in size so that they comply with total European net migration forecasts by the *European Developments* submodel.

In the revised migration model not regional migration balances (net migration) but interregional migration flows are explicitly modelled using an interregional push-and-pull migration model, in which the push and pull factors are the same as the ones used in the net migration model shown above plus a third indicator, population density $p_r(t\text{-}3)$, expressing the trend of depopulation of remote, thinly populated regions.

Specific assumptions are made to take account of barriers to migration between some old member states and the new member states and between EU member states and non-EU countries, such as restrictions on immigration from certain countries as well as cultural and language barriers to take account of the fact that migrations between two regions in different countries are much less frequent than migrations between otherwise identical regions in the same country. These barriers were defined in analogy to the barriers to trade and travel assumed in ESPON 2.1.1 (2005). In addition, airline distance between regions is included as a barrier to migration.

Migration flows between regions *r* and *s* are then

$$M_{rs}(t) = P_r(t)\ E_s(t)\ g_{rs}(t-3)\ \exp\left[-\alpha\ b_{rs}(t)\right]\ \exp\left(-\beta\ d_{rs}\right)$$

with

$$g_{rs}(t-3) = \left(\frac{q_r(t-3)}{q_s(t-3)}\right)^{\gamma} \left(\frac{v_r(t-3)}{v_s(t-3)}\right)^{\delta} \left(\frac{p_r(t-3)}{p_s(t-3)}\right)^{\varepsilon}$$

where

$P_r(t)$	Population in region *r* in year *t*
$E_r(t)$	Jobs in region *r* in year *t*
$q_r(t\text{-}3)$	GDP per capita in region *r* in year *t*-3
$v_r(t\text{-}3)$	Quality of life in region *r* in year *t*-3
$p_r(t\text{-}3)$	Population density in region *r* in year *t*-3
$b_{rs}(t)$	Barrier to migration between regions *r* and *s* in year *t*
d_{rs}	Airline distance between region s *r* and *s*

Main results

A first test application to the 1,330 NUTS-3 regions of the ESPON space consisting of the 27 EU member states and Norway and Switzerland, and the Western Balkan countries Albania, Bosnia and Herzegovina, Croatia, Macedonia, Serbia and Montenegro with heuristically set parameters α, β, γ, δ and ε resulted in the migration flows shown in Figures 17 and 18.

In Figure 17 the red lines show all international migration flows within the European Union and the then 12 accession countries (EU27) over 1,000 persons per year in 2002, the last year for which international migration data are available from Eurostat, whereas the blue lines show the same for immigration emigration from/to Russia, Belarus, Ukraine and Turkey.

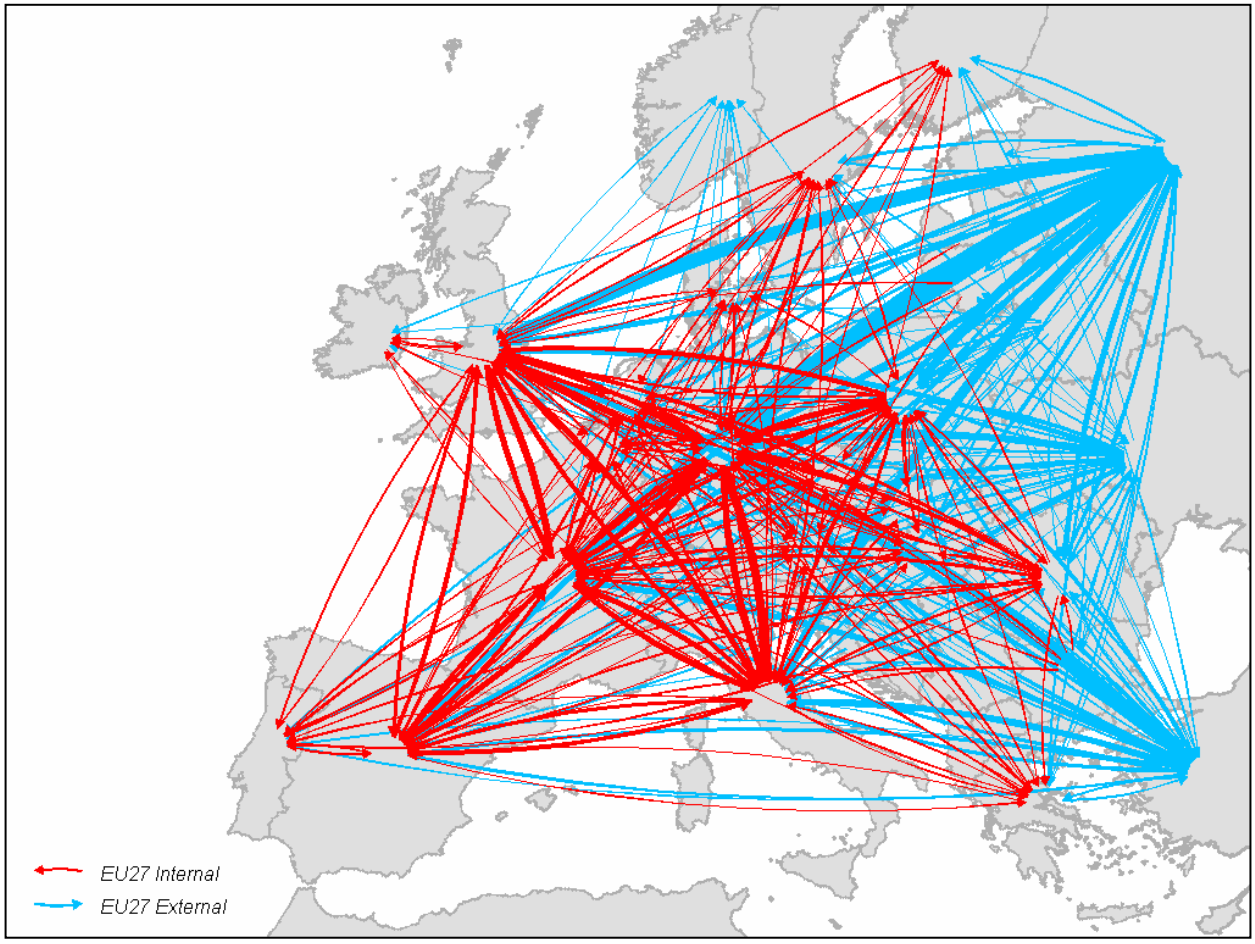


Figure 17 First model results: EU27 internal and external migration

Figure 18 shows the same migration flows aggregated to migration balances for the NUTS-3 regions of the ESPON space and the Western Balkan countries as a three-dimensional surface. Green areas indicate negative and yellow and red areas positive migration balances. The figure clearly shows the population movement towards the more affluent regions inside the 'Pentagon'. Within individual countries, the attraction of capital cities, such as Lisbon, Madrid, Paris and London is visible, but also the depopulation trend in the more remote regions of, for instance, northern Sweden and Norway. The barrier between the then 15 EU member states and the accession countries is pronounced.

The similarity of the image with the maps of migration balances calculated as residuals between population counts and natural population change in ESPON 1.1.4 (e.g. Map 3.10 in the ESPON 1.1.4 Final Report) is striking.

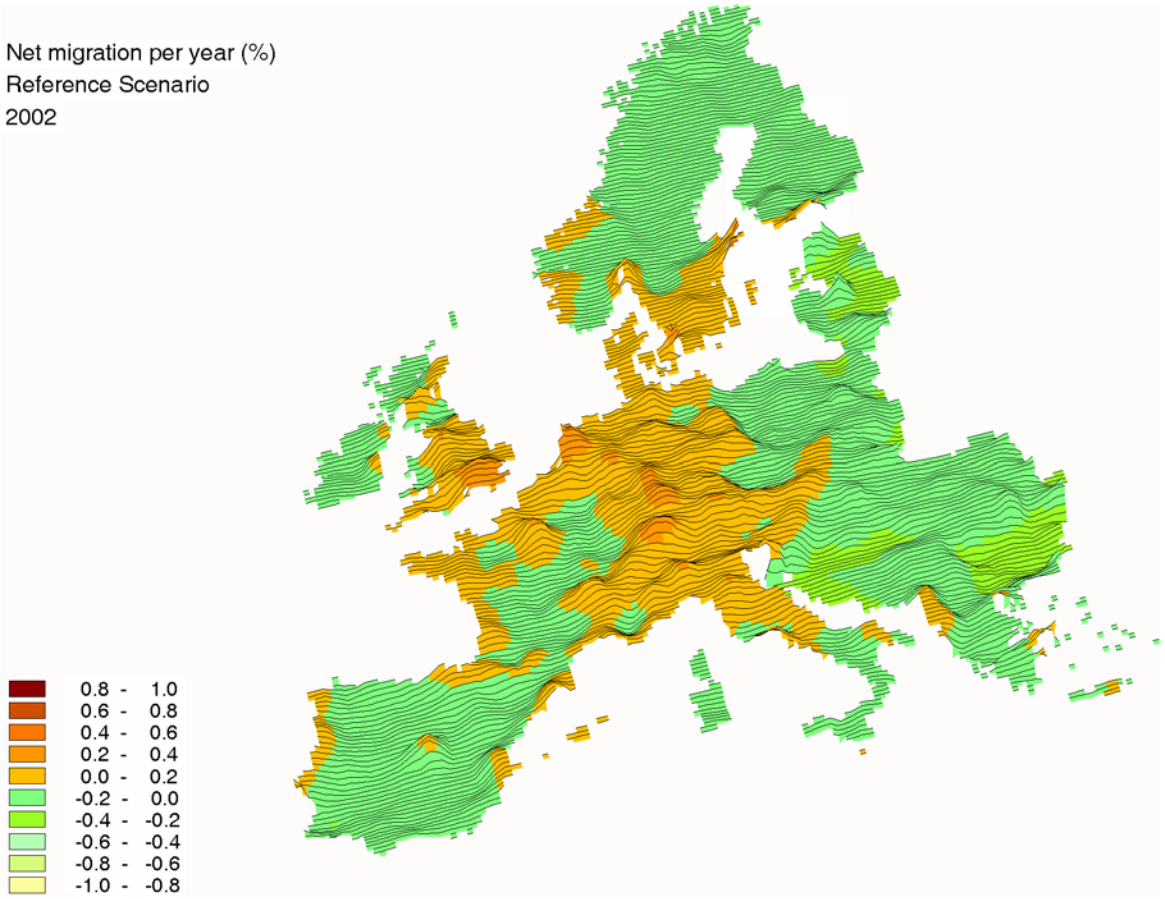


Figure 18 First model results: net migration 2002

Validation data

In a next step the modelled migration flows were compared with empirical data on international migration. As it was explained in Section 5.3, the data situation in this respect is very poor, as individual countries use different definitions of what is an international migration and different methods of counting and reporting. This leads to serious inconsistencies between the numbers reported for the same migration flow by origin and destination country.

To demonstrate this, Figures 19 and 20 show scatter diagrams in which for two different years immigrations reported by the receiving country (on the horizontal axis) are confronted with emigrations reported by the origin country (on the vertical axis). The letters besides the dots indicate the direction of migration, i.e. DEUK indicates a migration from Germany to the United Kingdom.

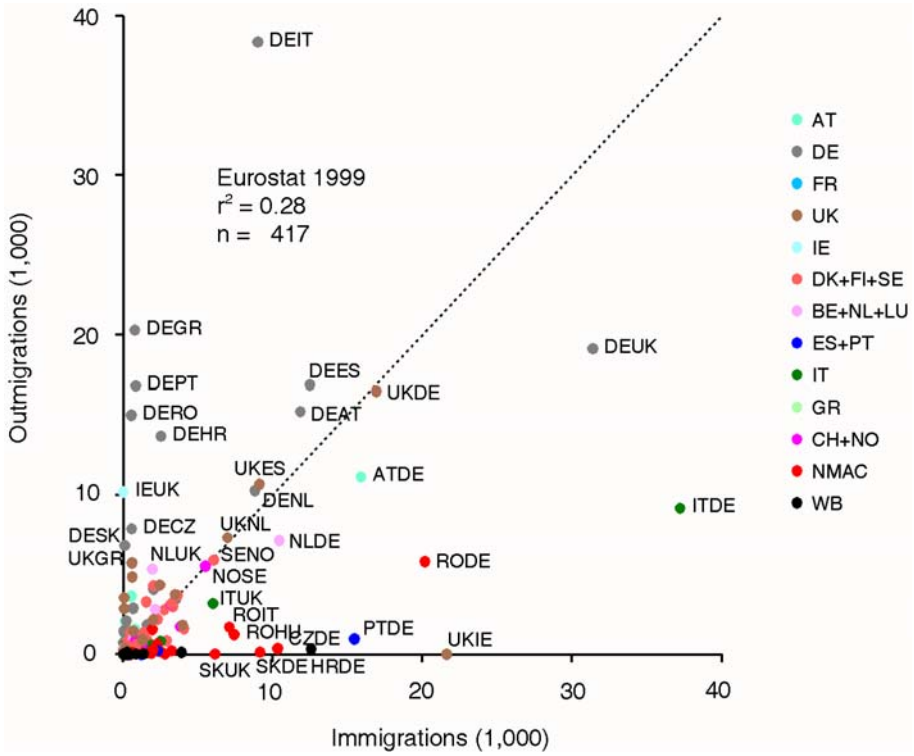


Figure 19 International immigration v. outmigration 1999 (Eurostat)

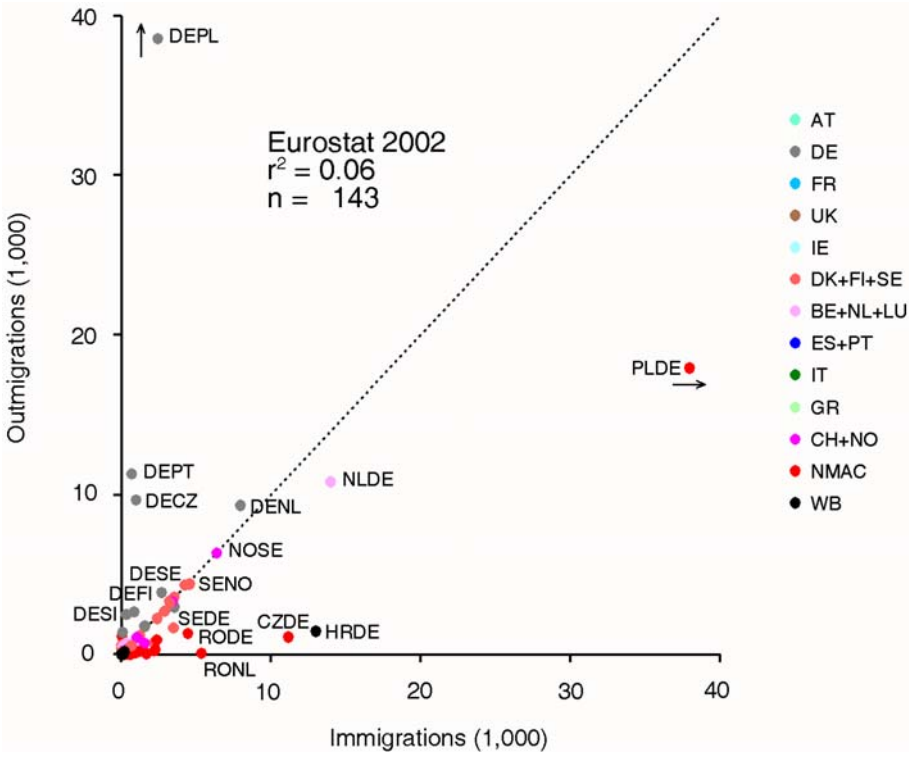


Figure 20 International immigration v. outmigration 2002 (Eurostat)

In each case two 34x34 migration matrices were compared where the rows indicate the origin country and the columns the destination country. In the diagrams only cells for which both immigrations and emigrations were reported are shown. This is the case only for a small share of the 34x34-34 = 1,122 cells of the matrix, 417 for the year 1999 and only 143 for the year 2002. And for these the numbers reported differ substantially, except for migrations between the Nordic countries which agreed on a common way of counting international migrations. One example of how to read the diagrams is to compare the entries DEIT and ITDE in Figure 19, i.e. migration from Germany to Italy and vice versa. Ideally, the entries should lie on the diagonal. However, Germany reported that in 1999 about 38,000 Italians migrated to Germany, whereas Italy reported only about 9,000. A similar discrepancy exists for the reverse direction. The explanation is that in Germany migrants are registered at every change of residence, whereas in Italy only persons staying abroad for more than one year are recorded.

That even highly respected, experienced scholars of international migration in Europe have not been able to resolve these inconsistencies is demonstrated by Figure 21, which compares immigration and outmigration matrices for 2002 compiled by the renowned Central European Forum for Migration Research (Kupiszewska and Nowok, 2005)

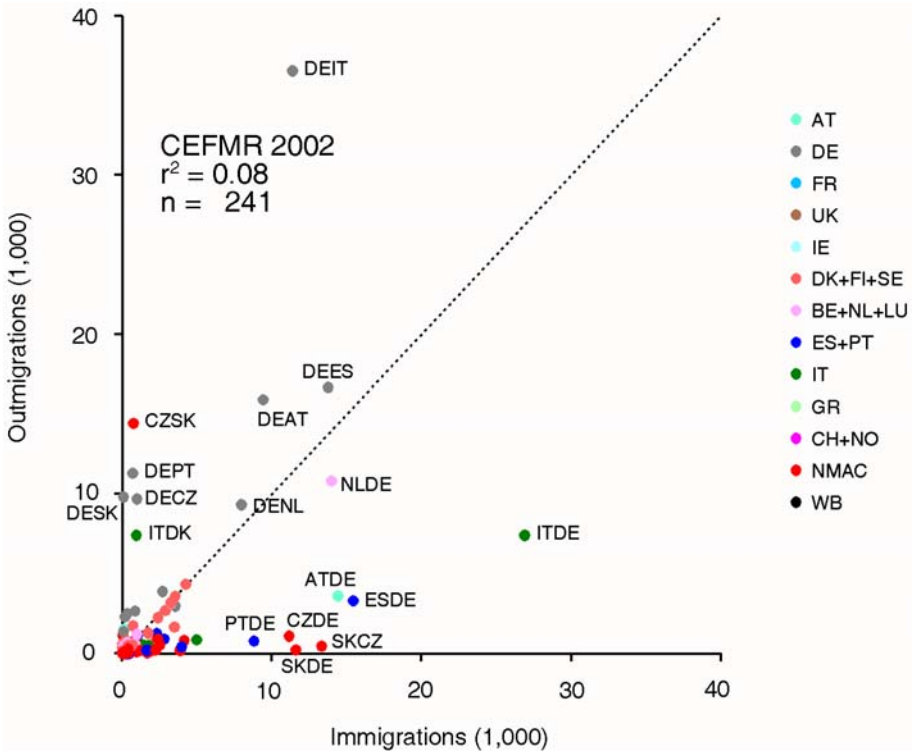


Figure 21 International immigration v. outmigration 2002 (CEFMR)

There exist several suggestions how to overcome the inconsistencies in the statistics on international migration. These were discussed in Section 6.2. The most sophisticated of these, the method proposed by Poulain (1999), combines biproportional adjustment and the assignment of qualitative confidence weights to origin and destination countries. The method, though intriguing, has the disadvantage that the confidence weights are determined solely on the basis of statistical properties of the reported numbers but do not take account of the agreement or lack of agreement of the underlying definitions of international migration applied in origin and destination countries.

In this demonstration example therefore a method of assigning confidence weights to origin and destination countries based on the degree of compliance with the definition of international migration recommended by the European Commission in 2005 (see Section 3.3) was used. The method is admittedly subjective and qualitative and will have to be refined, but it has the advantage that it is transparent and can be adapted to the expected convergence of national migration statistics from 2006 on.

Table 6 shows the criteria and confidence weights assigned to the 27 EU member states plus Norway and Switzerland and the five Western Balkan countries. The second column shows the definition of migration used. The third column shows to what degree the country would be able to provide migration data conforming to the one-year rule recommended by the European Commission. The fourth column indicates the consistency of the migration data provided by the country if compared with the corresponding value reported by the country at the other end of the migration. The fifth column, finally contains the confidence weight tentatively assigned to the country in the demonstration example: a high value indicates great and a low value low confidence in the numbers reported by the country. The table was compiled using information from various sources; special credit is due to the Central European Forum for Migration Research (Kupiszewska and Nowok, 2005).

The confidence weights defined in Table 6 were used to generate two matrices of international migration flows based on the immigration and outmigration matrices for 2002 compiled by Eurostat and CEFMR referred to in Figures 20 and 21, respectively.

Figures 22 and 23 compare the international migrations aggregated from the migrations between NUTS-3 regions forecast by the migration submodel presented above with the international migration flows in these two tables. It becomes apparent that considerable work still needs to be done to capture the barriers to migration existing between European countries.

Table 6 Confidence weights of international migration statistics

	Definition of migration[a]	Possibility of one year rule[a]	Flows in double matrix[a]	Confidence weight
AT	3 months	ex post	[E] high	60
BE	3 months	ex post		80
BG				40
CH				40
CY	one year	yes		100
CZ	[I] 3 months, [E] permanent	no	consistent	80
DE	none	yes	high	60
DK	6 months	ex post	high	80
EE				40
ES	none	ex post	[I] high, [E] low	60
FI	one year	[I] yes, [E] ex post	consistent	100
FR		no		40
GR		no		40
HU	[I] 3 months, [E] permanent	no		40
IE	none	no		20
IT	[I] none, [E] one year	[I] no, [E] yes	[E] low	40
LT	[I] 6 months/one year, [E] 6 month	ex post		60
LU	none	ex post	[I] low	40
LV	[I] none/one year, [E] 6 month	ex post	low	20
MT	[I] permanent	no		40
NL	[I] 4 of 6 months, [E] 8 of 12 months	ex post		80
NO				100
PL	permanent	no	low	20
PT	one year	yes	low	20
RO				40
SE	one year	[I] yes, [E] ex post	consistent	100
SI	[I] 3 months, [E] permanent	ex post	[I] low	80
SK	permanent	no	low	20
UK	one year	yes	oscillating	60
AL				40
BA				40
HR				40
MK				40
YU				40

a based on Kupiszewska and Nowok, 2005

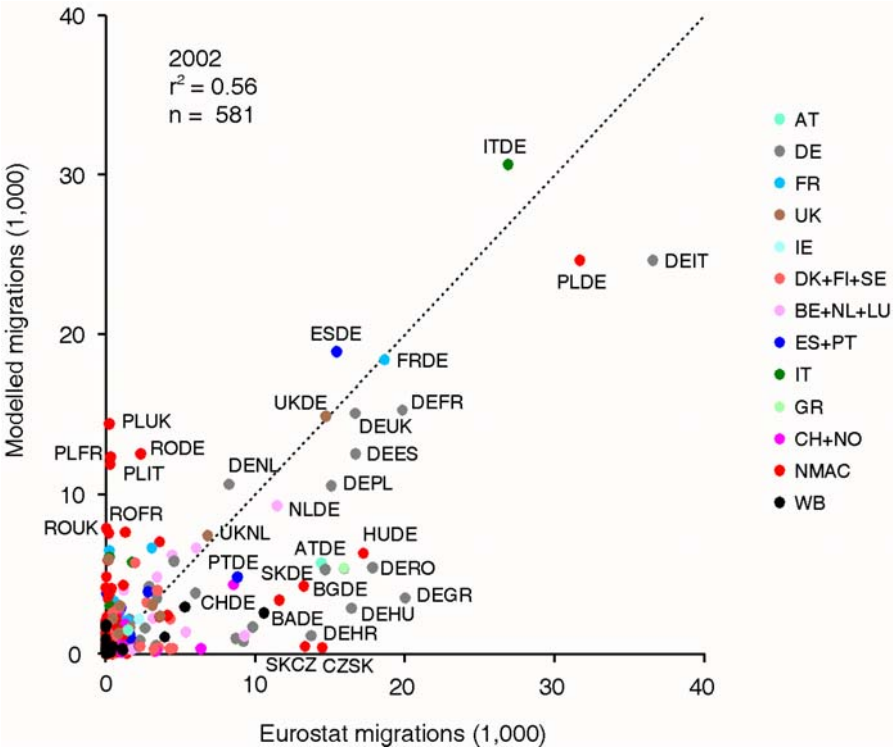


Figure 22 International migration flows 2002: model results v. Eurostat

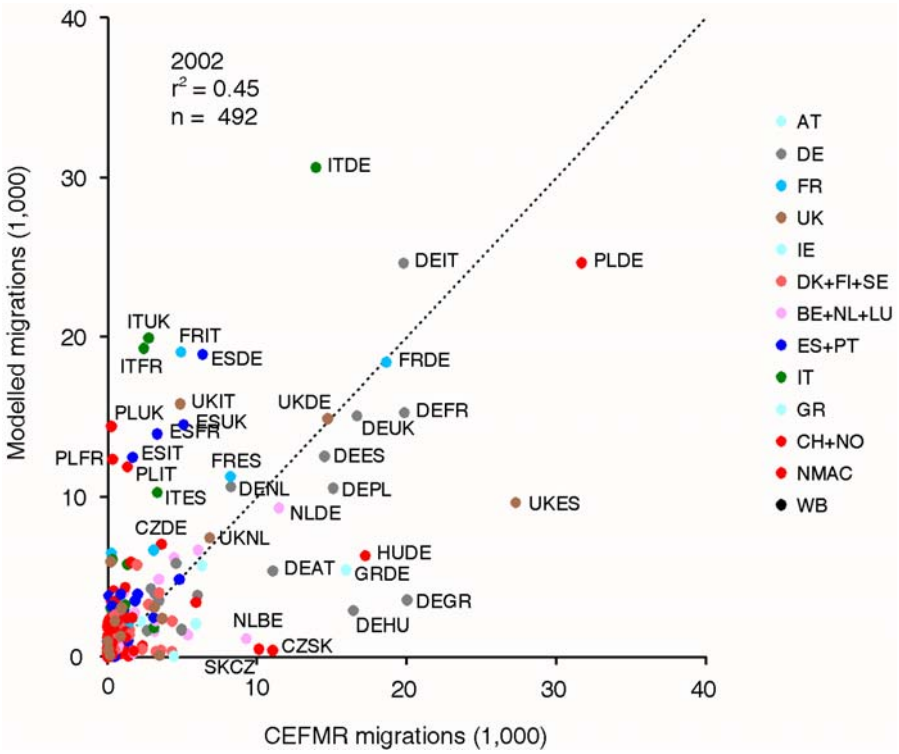


Figure 23 International migration flows 2002: model results v. CEFMR (2005)

Conclusions for ESPON

The demonstration example on migration flows differs from the other demonstration examples in that it did not generate or analyse spatial flow data but forecast migration flows from other observed data or modelled projections, such as population, employment, GDP per capita and quality of life and political, cultural and language barriers and physical distance between origin and destination regions. Migration data are needed only for the validation and re-calibration of the model, and because of the lack of consistent and comparable data on interregional and international migration in Europe, validation of such a model takes place at higher spatial levels, such as NUTS-2, NUTS-1 or whole countries.

However, once such a model exists, it can be used to provide the information on interregional and international migration flows indispensable for regional demographic or demo-economic analyses or projections usually not available in most existing models.

In accordance with the pilot study character of this project, the developed European migration model has a strictly exploratory character. It is not claimed that it is able to compete with the many sophisticated models of interregional migration developed and applied in universities, research institutions and national planning agencies of many EU member states (see Section 6.2).

However, it is to our knowledge the fist attempt to model interregional and international migration at the NUTS-3 level for the whole European space. Such a model is of central importance for a holistic view of European spatial development in the face of gradually disappearance of political barriers to personal movement and exchange of labour – a move to another country will not be more difficult than one within one's own country, though cultural and language barriers will continue to exist.

To model interregional and international migration in the whole of Europe is a challenging undertaking, in particular to find the right balance between the push and pull factors and barriers to migration of international and interregional migration. The model developed is therefore no tool ready to be applied but a demonstration that such a model is feasible and can be calibrated and validated with reasonable effort with available data.

Highest priority for future work will be to address the issue of the balance between interregional and international migration and to develop scenarios of how further progress in European integration will gradually reduce the barriers to international migration. In addition, several extensions of the model seem useful and feasible:

- To better distinguish between the different motives for student, labour and retirement migration, different models for these three types of migration should be developed.
- It will be important to make assumptions about the age composition of migrants to take account of characteristic age structures of student, labour and retirement migrants.
- The largely neglected issues connected with asylum-seekers and illegal immigrants should be explicitly addressed.
- The interface between interregional migration and intraregional migration, such as suburbanisation (which frequently extends beyond NUTS-3 or even NUTS-2 regions) deserves attention.

The main conclusion from the demonstration example is therefore that the development and thorough test of a model of interregional and international migration flows in Europe should be the topic of a dedicated ESPON project.

7.3 Freight flows

Goods transports constitute one of the most significant flow types in Europe. With growing political and economic integration of Europe, freight flows have dramatically increased during the past decades and are expected to grow in the future. It is therefore of great importance to monitor the evolution of freight flows and to analyse their impacts at the regional level. This demonstration example on freight transport aims at showing how transport flow data can be used to compute different indicators and how they can be interpreted to identify regional specialisations.

Data

Two data sources were used for the demonstration example. The main one was the origin-destination matrix at the NUTS-2 regions level provided by the ETIS-BASE database (see Section 5.4). The reason for using this matrix was twofold. On the one side, ETIS-BASE has been built to serve as reference database for transport analysis at the European scale, so it represents a recognised source and not just one of the several matrices estimated in one project. On the other side, ETIS-BASE allows the users to look at the freight flows in a detailed way by reporting not only the origin and destination regions and the mode of transport but also the full transport chain as well as regions where transshipments take place (see ETIS-BASE, 2005).

However, the ETIS-BASE database is not an exhaustive source of freight flows. The main limit is that ETIS-BASE does not provide link flow data (i.e. loads on the links of the transport network). For that reason, link flows estimations were extracted from a study carried out in 2006 (TRT, 2006) and based on the SCENES model. The SCENES model is a multimodal transport model at the European level which simulates the assignment of traffic flows on the main network (see ME&P, TRT, 2001).

Main problematic issues with the available data sources are the following:

- Observed link flow data exist, e.g. from UNECE (see Section 5.4), but only an aggregate measure of average daily traffic per link is available, the size of freight flows is only provided as a share of total average traffic in both directions. Therefore, all sources used report models estimations rather than observed data (which are used for the calibration of the models at a more aggregate level, e.g. in terms of country-to-country flows). Therefore, the information include a inherent degree of uncertainty.
- In the ETIS-BASE database data concerning transshipment are available only for regions where a maritime port is located, while inland distribution centres are not fully covered (ETIS-BASE, 2004b).
- The NUTS-2 level appears to be coarse in many instances, especially because the size of NUTS-2 regions is quite different across EU countries.

Methods applied

In the demonstration example on freight transport output variables were extracted from the available sources and manipulated by mixing data from different sources to compute indicators. The indicators derived are represented in maps to provide an overall view of the EU regions.

In addition, loads on road links were extracted and represented graphically. To improve the readability of the maps, only some macro regions are represented instead of the whole of Europe.

The objective of the demonstration example was to provide a range of different indicators and to highlight the informative potential of freight flow data rather than to analyse a specific aspect of freight flows. Therefore, a variety of indicators were computed and analysed before selecting some that appeared most significant and of which the quality of the available information was convincing. Most of the indicators considered are origin-destination data rather than regional data (e.g. the amount of tonnes destined to external regions instead of just total tonnes generated). This choice was made to emphasise the relational quality of flows.

Main Results

The first indicator computed concerns the "intensity of freight transport" of EU regions, computed as the ratio between the total tonnes transported to, from and within one region and the value of gross domestic product (GDP) of the region. The indicator shows that freight transport intensity is especially high in eastern Europe, where most of the regions move more than ten thousands tonnes for producing one million Euro of GDP.

This freight transport intensity indicator shows where moving goods is more relevant for the local economy, however it says nothing about the type of freight movements. For instance, transport intensity can be high because one region exports a large amount of goods. Another region can have the same transport intensity because it is specialised in producing services and purchases freight from outside. Figure 24 shows, together with the degree of transport intensity, regions which are net exporters and regions which are net importers of manufactured goods.

Freight flows are correlated to trade flows but are not the same. A relevant difference is that a given trade flow can give rise to several freight flows. For instance, sending a given amount of goods from region A to region B can generate a freight flow from region A to region C and a second freight flow from region C to region B. In the intermediate region a transshipment takes place. The transshipment can involve the same mode of transport (e.g. freight arriving at marshalling yards on heavy road freight vehicles and then distributed by smaller vehicles) or a mode shift (e.g. goods arriving by ship in a maritime port or by barge in an inland port and then forwarded by road or rail). Transshipment is often concentrated in some zones which assume the role of distribution centres. Such regions attract and generate freight which is not needed or produced internally; they sell transport and auxiliary services (e.g. storage) to other regions.

Figure 25 illustrates the size of transshipped goods in the EU regions. It is apparent that coastal regions are main transit points and this is especially true for the North Sea regions. However, the coverage of transshipment in inland regions within ETIS-BASE database is not complete.

Using a sample of regions in north-western Europe, Figure 26 shows that the role of coastal and inland regions for transshipment is often different. Maritime shipping is widely used for transporting bulk goods like oil, grains, chemicals, coal, etc. so transshipment at ports concerns mainly this type of commodities. Instead, inland regions often serve as distribution points for manufactured products.

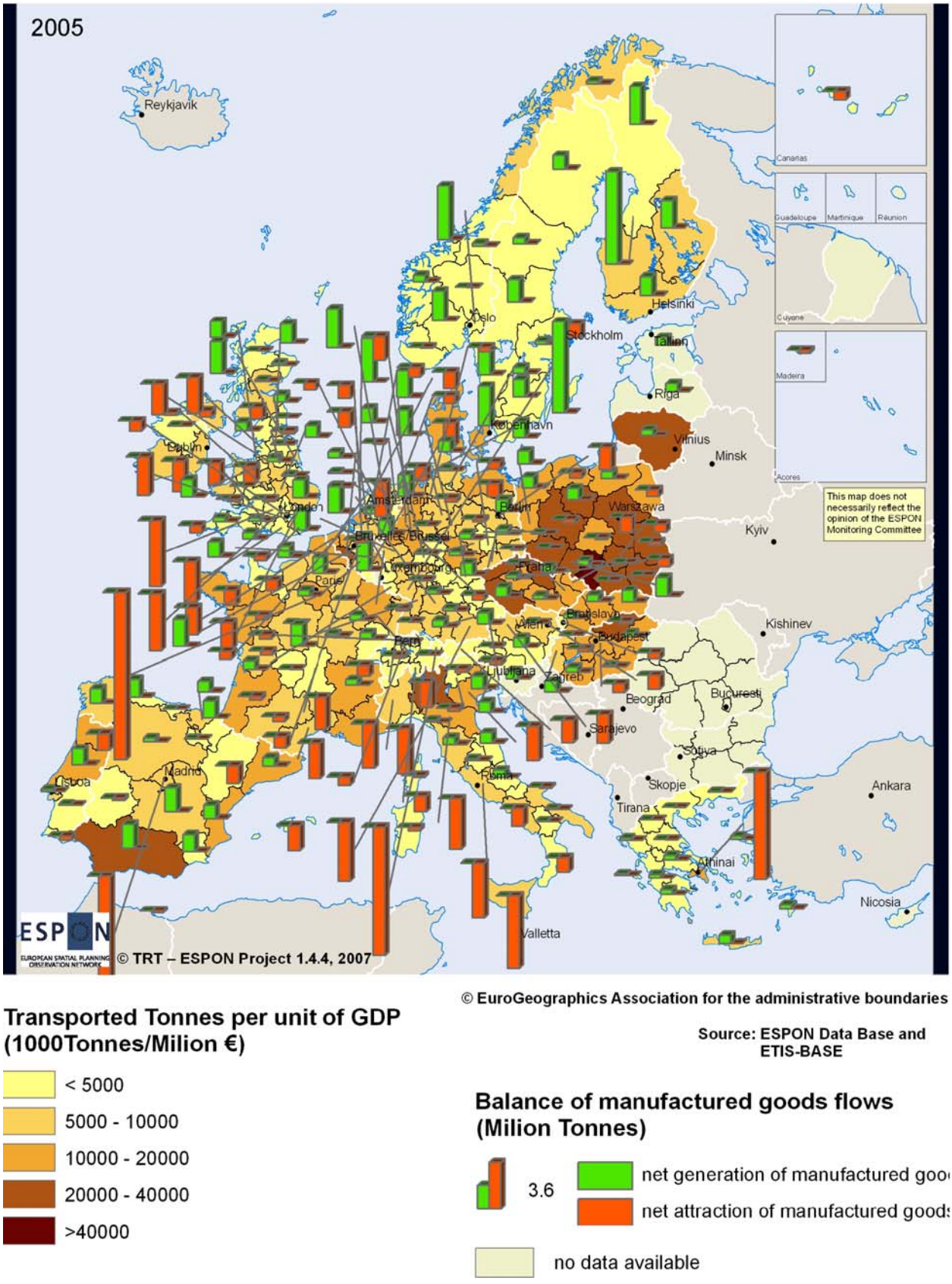


Figure 24 Transported tonnes per unit of GDP and balance of manufactured goods flows

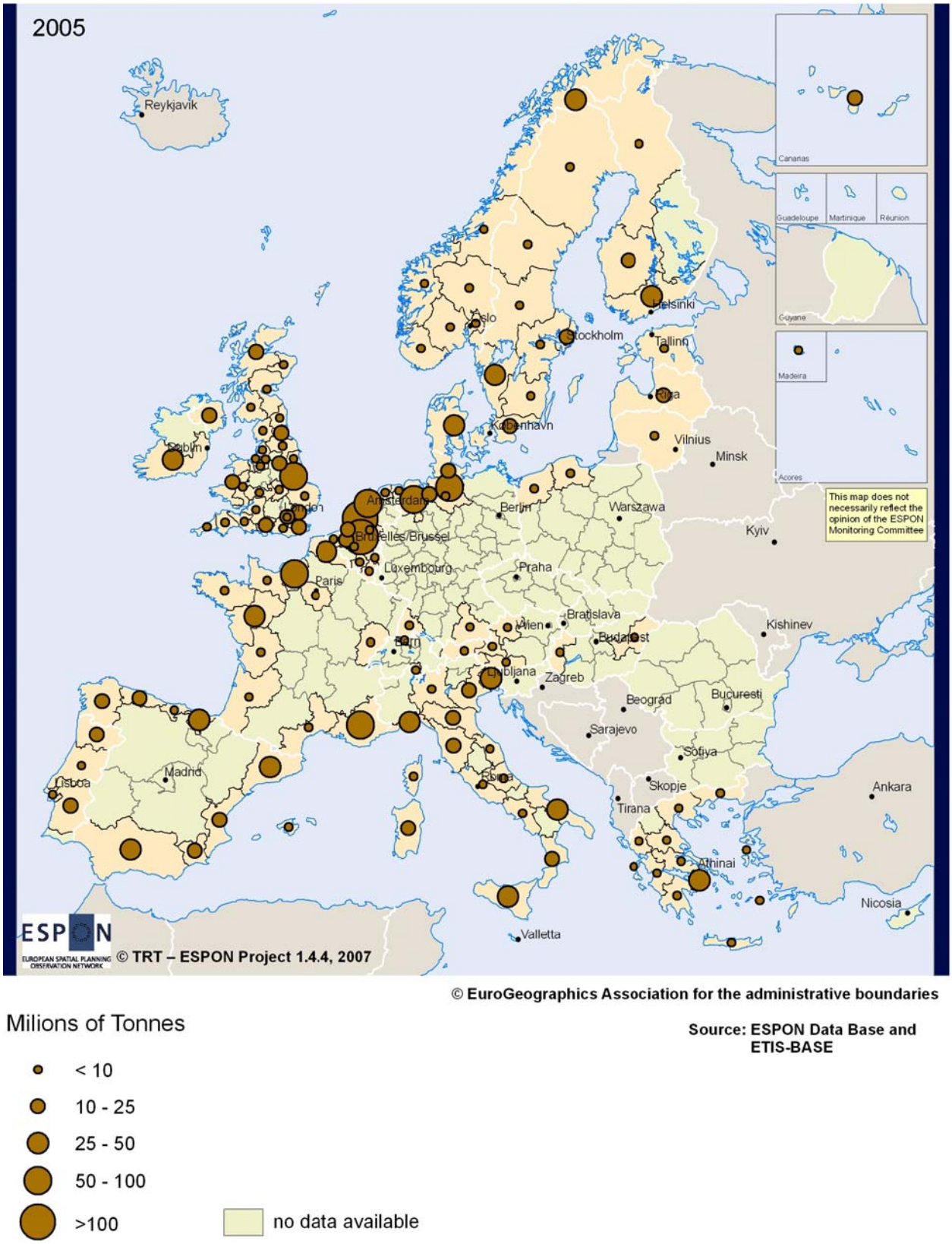


Figure 25 Size of freight transshipment

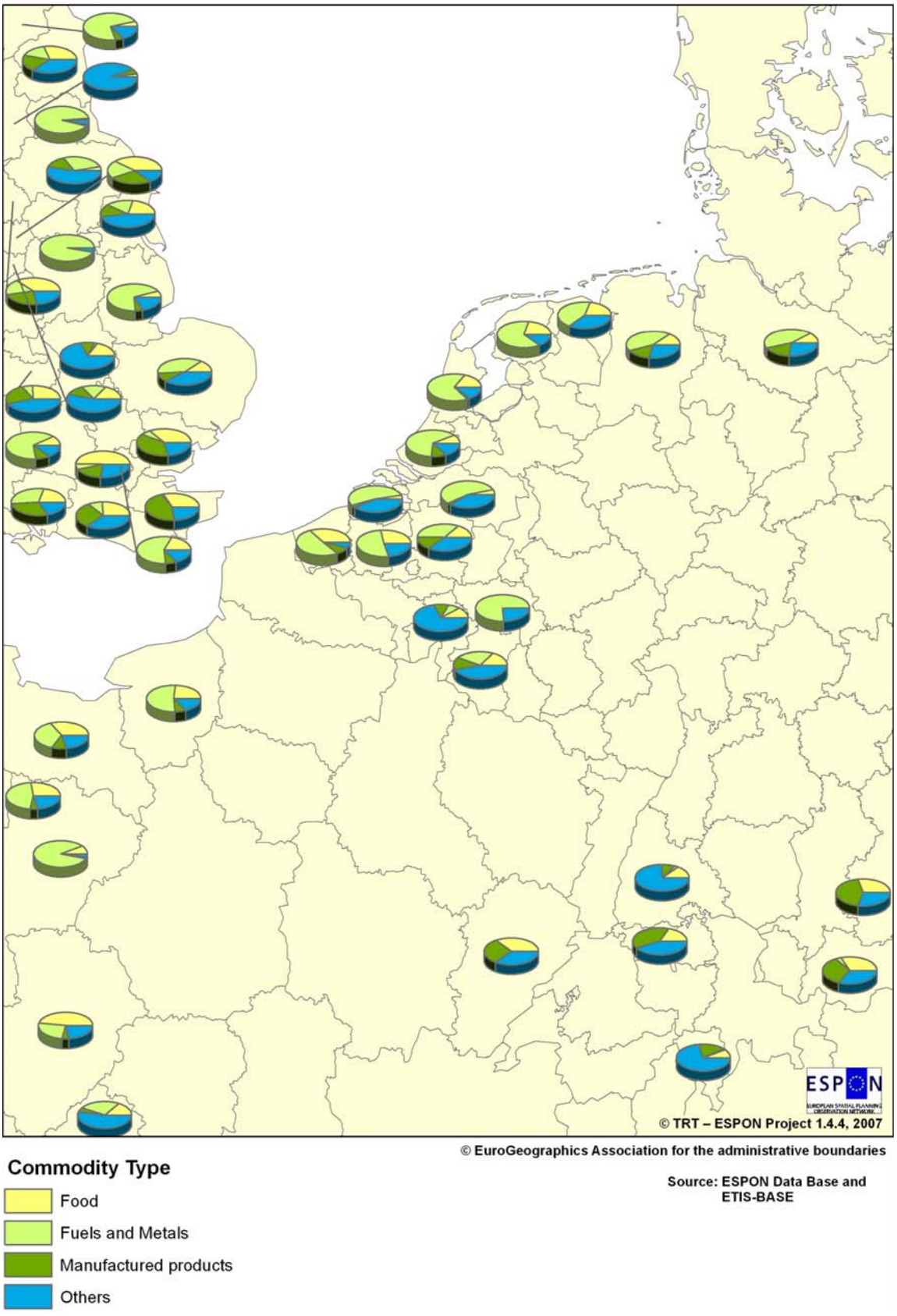


Figure 26 Composition of transhipped goods

Even if transshipment of long distance consignments is becoming more and more important, the greatest share of freight transport still takes place on relatively short distances (e.g. distribution of goods to retailers). An index of the relevance of short distance freight movements is the share of tonnes transported within the regions. Using the NUTS-2 data available in the ETIS-BASE database, this index is heavily affected by the size of the regions. NUTS-2 regions in countries like Germany or Belgium are much smaller than in countries like Spain or Sweden. Therefore, the share of intra-regional freight has been divided by regional GDP to compute an indicator which is more independent from the region size. Figure 27 provides the distribution of the indicator in the EU NUTS-2 regions.

Apparently, the relevance of intraregional freight transport is much higher in east European regions than in the rest of the continent. On average, about 90% of total tonnes shipped concern domestic transport. However, in some regions the amount of goods dispatched abroad is significant.

Figure 28 shows the values of an indicator computed as the ratio of tonnes dispatched to foreign countries and total tonnes dispatched out of the region. In this case, the size of the region is not really significant because, in principle, the attitude to international export does not depend on how large a region is. Looking at the map, the relevance of international freight transport seems to be higher for regions of northern Europe. As the indicator is computed not with the value but the volume of transported goods, it is high for regions exporting commodities like crude oil or petroleum products.

The indicators mentioned in this section were selected to give an idea of the several types of issues that can be analysed using freight transport flow data and especially matrices of flows between regions. Another type of freight transport flow data consist of traffic on transport networks. The maps in Figures 29 to 31 show freight flows on the main road networks of France, Greece and Switzerland and Austria, respectively. The maps show the road links and corridors where freight transport takes place. The absolute relevance of links can be readily identified. If measures of the capacity of links are associated to the size of flows, bottlenecks and infrastructure needs can be highlighted.

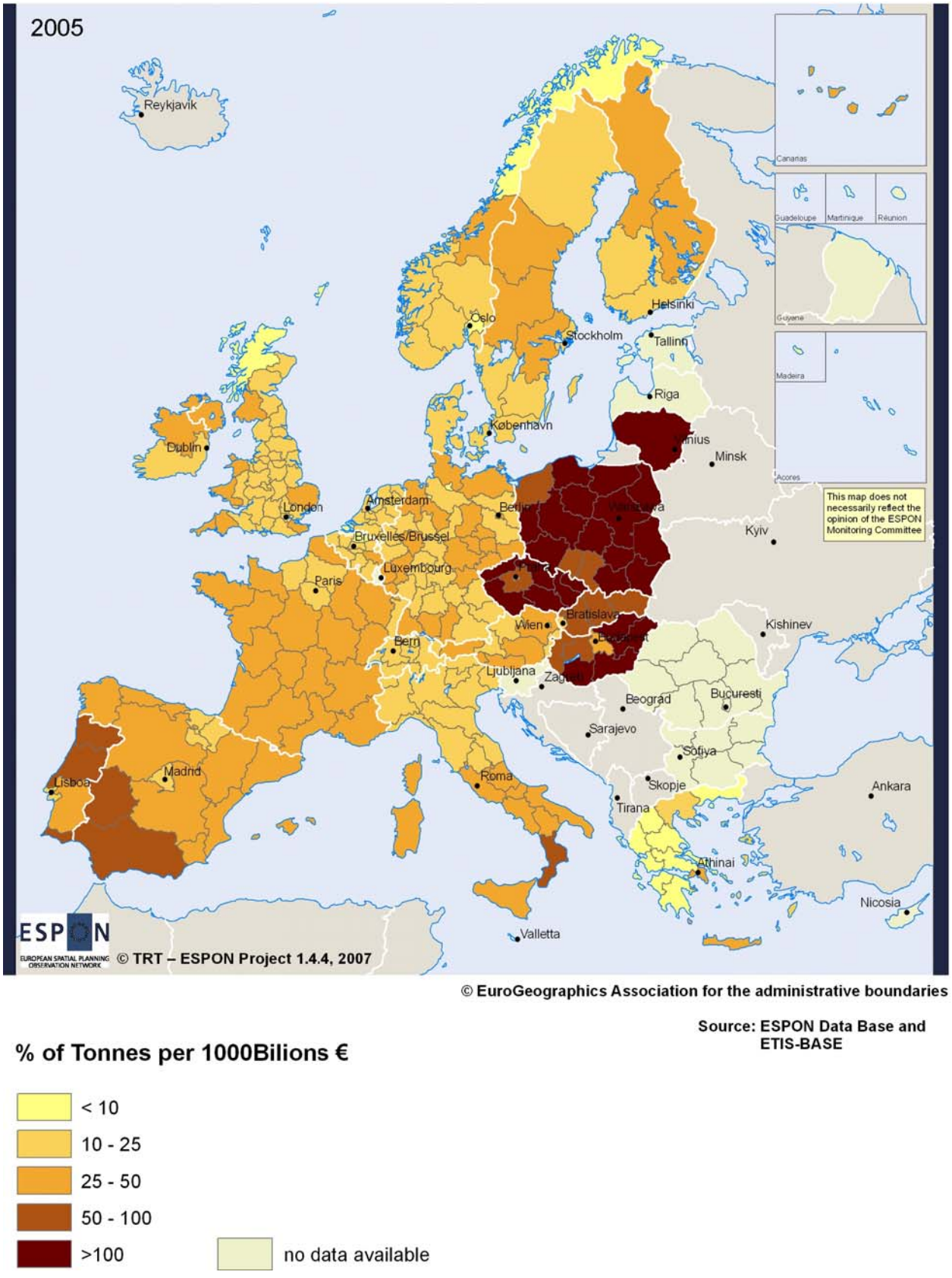


Figure 27 Share of intraregional freight transport per unit of GDP

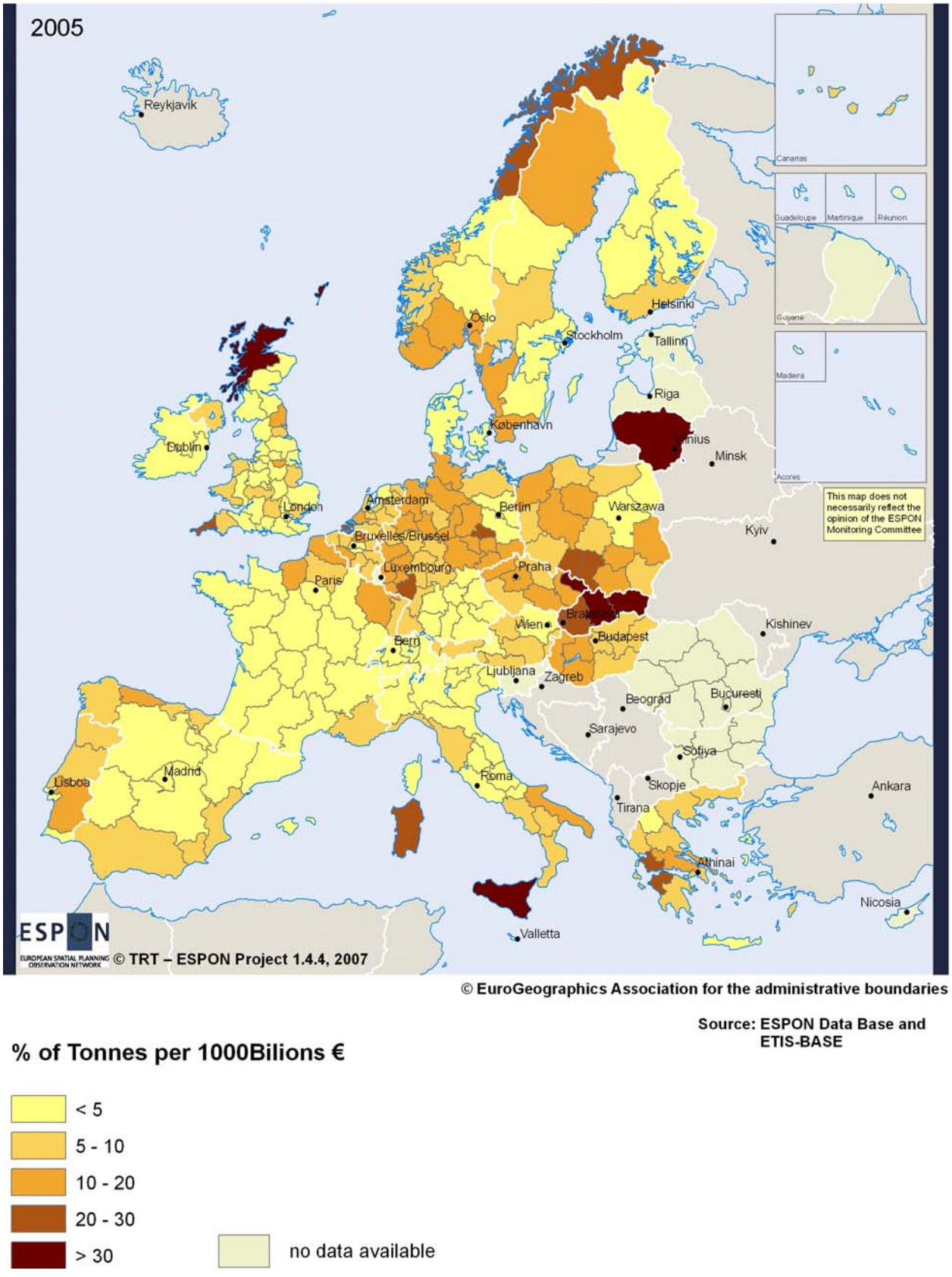


Figure 28 Share of freight transported abroad per unit of GDP

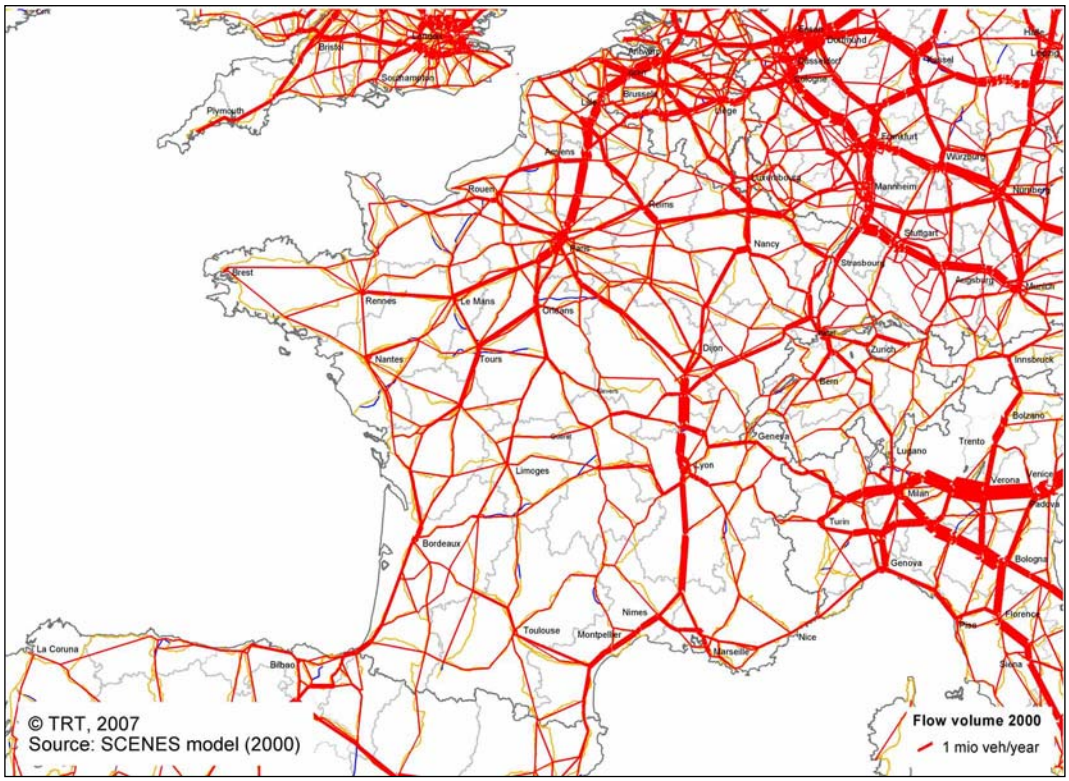


Figure 29 Road freight flows on the main network: France

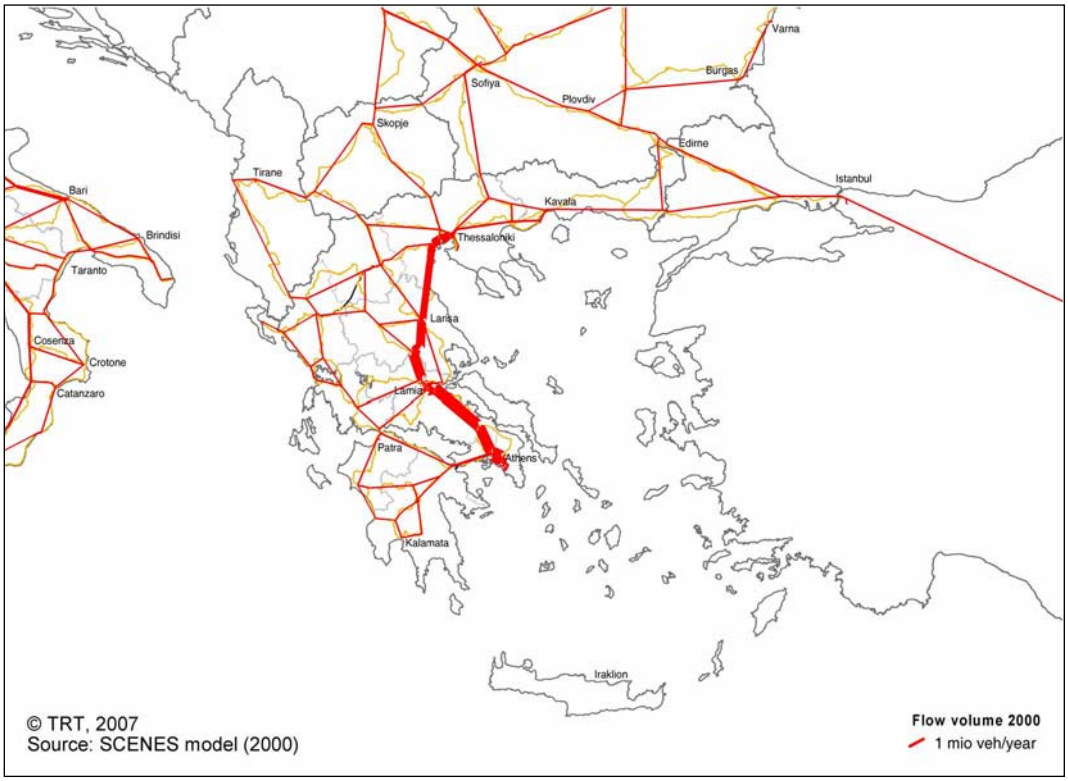


Figure 30 Road freight flows on the main network: Greece

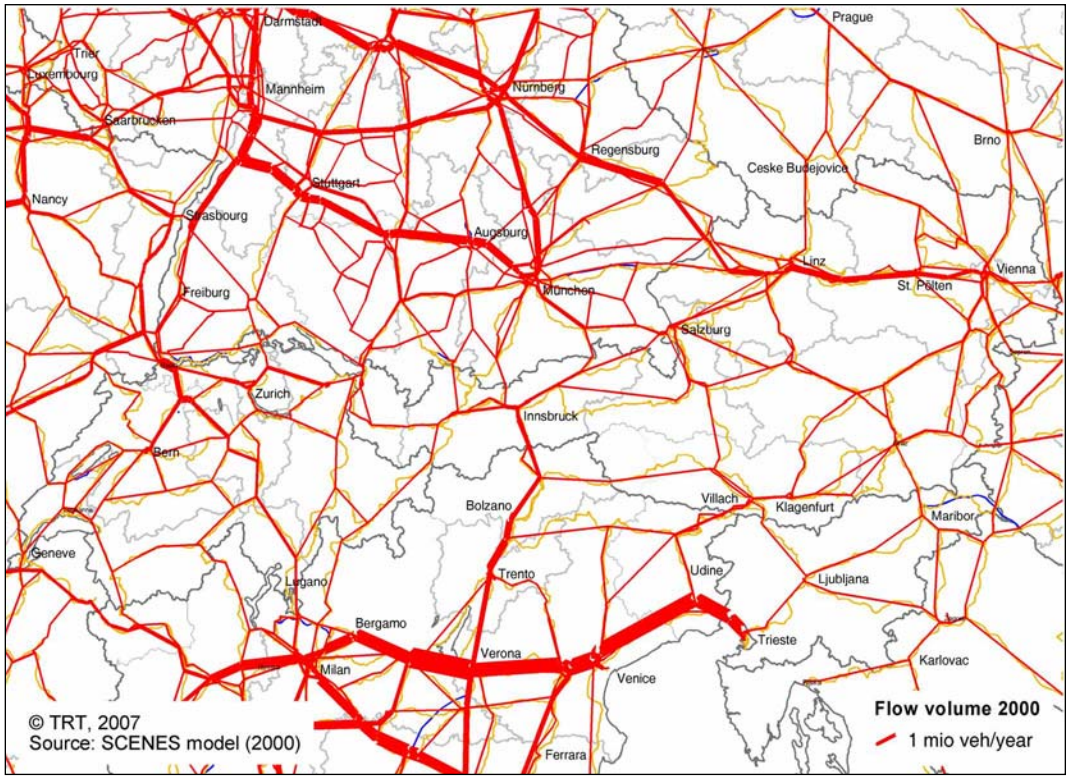


Figure 31 Road freight flows on the main network: Austria and Switzerland

Conclusions for ESPON

In terms of data for the time being only modelling estimations at the NUTS-2 level are available. Therefore, because NUTS-2 regions are of different size across EU countries, the quality of information available is not fully satisfying and there is room for improvements. Even if commuting is not considered, both for freight and for passenger travel short-distance shipments and trips constitute a large share of total flows, so more detailed data in geographical terms would be useful. From this point of view the TRANS-TOOLS model, which is being completed, will represent an enhancement as it provides data at the NUTS-3 level. Also, comparisons between modelled transport flows and other types of flows addressed in this study like trade or cross-border flows could help to improve the quality of data.

However, the available information on freight transport flows can make a significant contribution to the ESPON objectives. Transport flows are one of the main ways regions interact with each other; if trade links regions to each other in economic terms, freight flows are the physical translation of these linkages. The analysis of such physical linkages is also of great importance for assessing the sustainability of trade, as transport flows give rise to significant environmental effects and have a strong impact on energy consump-

tion. At the same time, transport can be regarded as a production factor the role of which has become more and more relevant as its cost has decreased. Monitoring the size of freight flows in comparison to other indicators, like the stock of infrastructure, can help to identify regions where infrastructure bottlenecks endanger regional competitiveness.

7.4 Passenger flows

Mobility is more and more a fundamental need for individuals. Most human activities require a trip to reach the place where the activity can take place. Even if a most individual trips are local (e.g. commuting), mobility of individuals between different regions and countries has grown with the political and economic integration of Europe. The continuous rise in car ownership, the emerging European high-speed rail network, the introduction of low-cost airlines and the extension of the air network to regional airports has made it possible for more and more persons to travel at low transport costs.

This demonstration example on passenger travel therefore aimed at showing how passenger flow data can be used to compute different indicators and how they can be interpreted to identify regional specialisations.

Data

Two data sources were used for the demonstration example. The main one has been the origin-destination matrix at the NUTS-2 region level provided by the ETIS-BASE database (see Section 5.4). The relevance of this source was already discussed with reference to freight flows (see Section 7.3).

As for freight, the ETIS-BASE database is not an exhaustive source for passenger trips. In addition to the lack of link flow data, the main missing information concerns the trip purpose. In the ETIS-BASE matrices only the total number of trips without segmentation is available. For that reason, the matrix of trips by purpose produced by the SCENES model was also used. The SCENES model was mentioned previously as one of the models forecasting transport demand at the European level. One of its best features is a detailed segmentation of passenger demand defined in a comprehensive way, including local trips. Therefore, shares of business trips and tourist trips were extracted from the SCENES model.

The main problems with the available data sources are the following:

- All data sources report models estimations rather than observed data. Therefore, the information include a inherent degree of uncertainty.

- The ETIS-BASE matrix has some gaps and inconsistencies, e.g. several regions (especially metropolitan areas) have no intraregional trips.
- Flows at the NUTS-2 level hide details of personal mobility as most passenger trips occur on very short distances.

Methods applied

The method used for the demonstration example on passenger transport flows was the same as for the demonstration example on freight flows.

Some available data sources were selected to compute several indicators. Original information was extracted from the sources and processed (e.g. comparing different data items, computing averages, etc.) in order to derive meaningful indicators. Indicators are represented in maps to provide a view of the EU regions. A graphical representation was adopted to show loads on road links on some parts of the European road network.

The aim of the demonstration example was to highlight the information potential of passenger flow data. For that reason a range of different indicators was developed, rather than to analyse a specific aspect of passenger flows. As for freight, the selection of indicators has favoured those using origin-destination data rather than regional data (e.g. the amount of trips attracted from external regions instead of just total trips attracted).

Main Results

Given the availability of data, this demonstration example focused on long-distance mobility of passenger. From this point of view, a relevant aspect is how attractive are regions, where 'attractive' means that a destination is chosen for trips generated in other regions. Attractiveness can be measured in different ways. A simple indicator is the number of trips attracted as shown in Figure 32. In the map, the attractiveness of metropolitan areas like London and Paris is clearly visible.

Even if the absolute number of trips attracted is a significant indicator, it can provide a biased perspective of regional attractiveness. For instance, other things being equal, a large and populated region will attract more trips than a small region. If the amount of population is used to divide the number of attracted trips, regions of different 'size' can be compared. The distribution of this relative indicator across the EU regions is shown in Figure 33. The hierarchy of regions is clearly different. Several regions with low population density show a significant attractiveness while the attractiveness of metropolitan areas becomes lower.

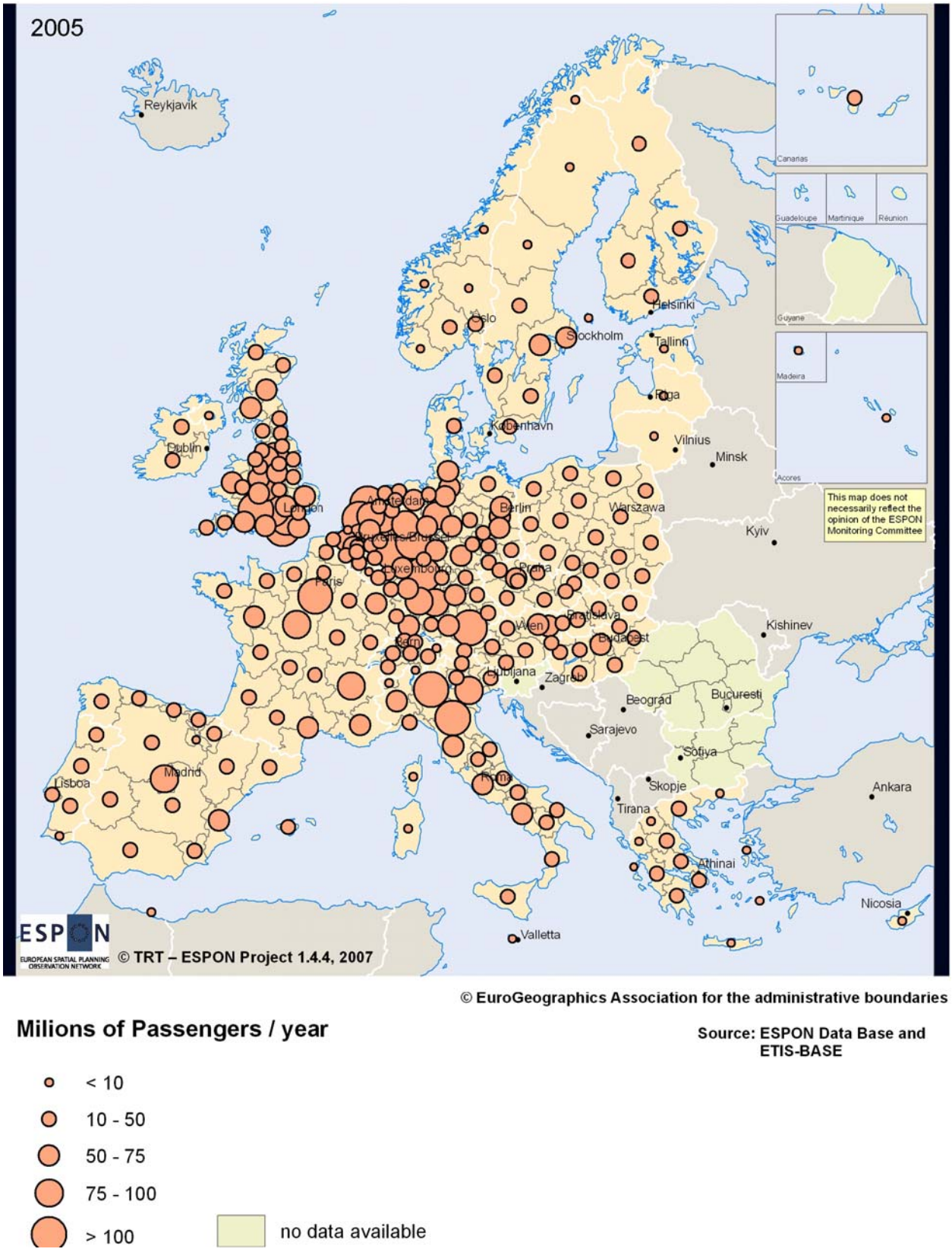


Figure 32 Absolute number of trips attracted from other regions

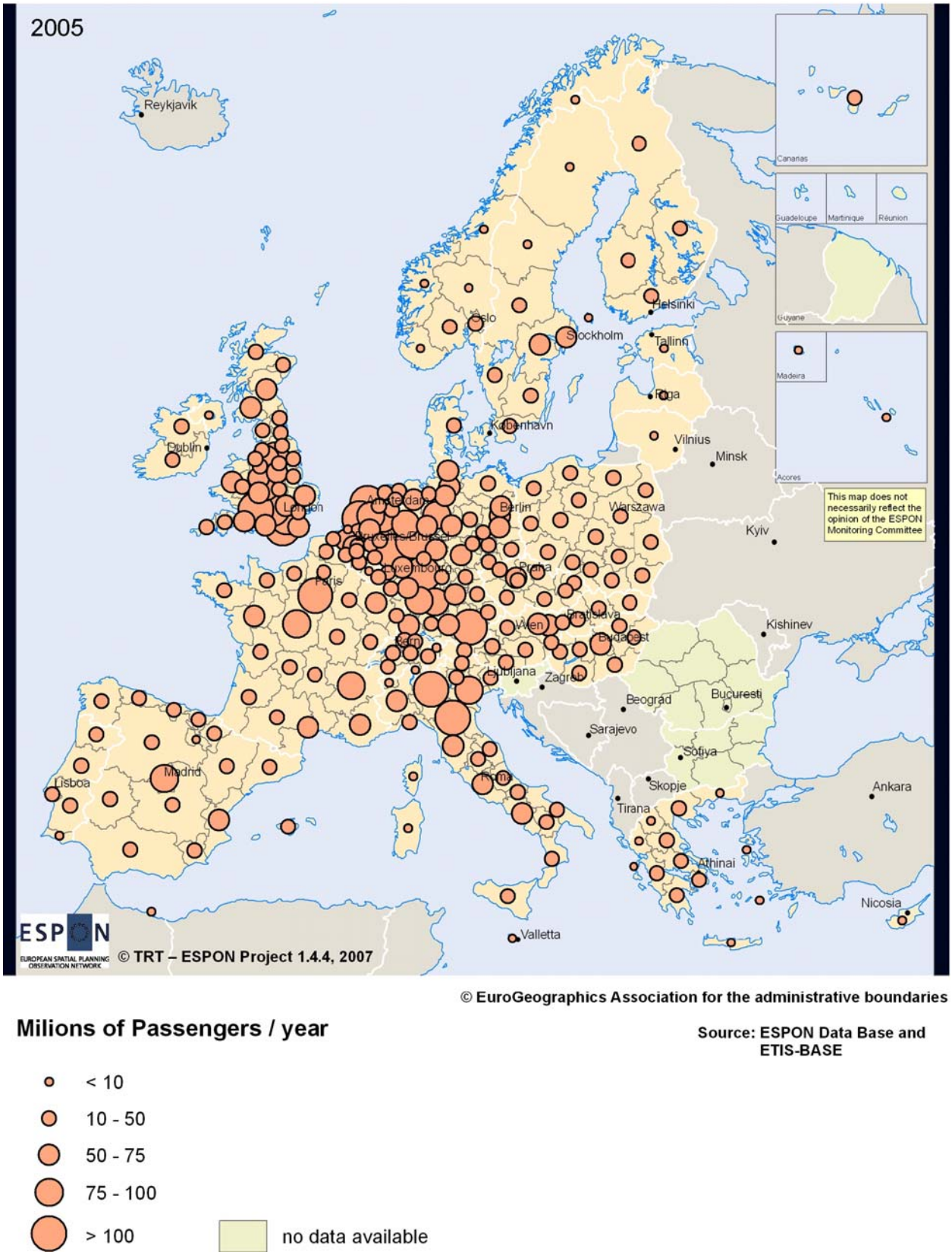


Figure 33 Number of trips attracted from other regions per unit of population

Another reason for being careful when comparing the absolute number of total trips attracted by regions is that regions have different specialisations. Maps in Figure 34 and Figure 35 illustrate the classification of European regions for the attractiveness of business and tourist trips, respectively. The patterns of the two maps are visibly different. Metropolitan areas are attractive especially for business trips, while other regions are in the top class for tourism. Regions in this group include both internationally renowned regions which attract tourists from several origins as well as regions which are mainly destinations for domestic tourism.

From another point of view, attractiveness of regions can be analysed in terms of trips incoming from foreign countries. Attracting trips from abroad is a sign of integration in the international community. Looking at map in Figure 36, where the share of trips incoming from foreign countries of all trips attracted to the regions is illustrated, it appears that the relative importance of international trips is especially high in border regions. This indicator demonstrates that often neighbouring zones exchange a large number of trips even if they belong to different countries. This can be regarded as a positive element from an integration point of view. At the same time, the maps show that international trips do not occur equally at all borders: many passengers cross the Alps and the Rhine while the figures for the Pyrenees or the border between Sweden and Norway are much lower. This specific type of passenger flows is addressed in more detail in the demonstration example about cross-border flows (see Section 7.6).

Passenger flows are the concrete manifestation of individual movements. For instance, tourist flows, which are addressed in a separate demonstration example in Section 7.5), mean people moving from one origin to one destination using one or more modes of transport. The analysis of the role of transport modes is one of the specific kinds of information data on passenger flows can supply. For instance, in Figure 37 the share of air travel of all trips attracted to each region. Not surprisingly, peripheral regions, and especially islands depend on air transport more than central regions. The absolute number of arrivals of air passengers in main metropolitan areas is much higher than in island and peripheral areas, but metropolitan areas also attract a large number of trips by car and rail from neighbouring regions, so the share of air is generally low.

Car traffic loads on roads are interesting indicators for appreciating on which links and therefore in which regions the personal mobility by road gives rise to traffic and contributes to congestion, air pollution, etc. Figures 38 and 39 provide some examples of the traffic loads on parts of the main European road network.

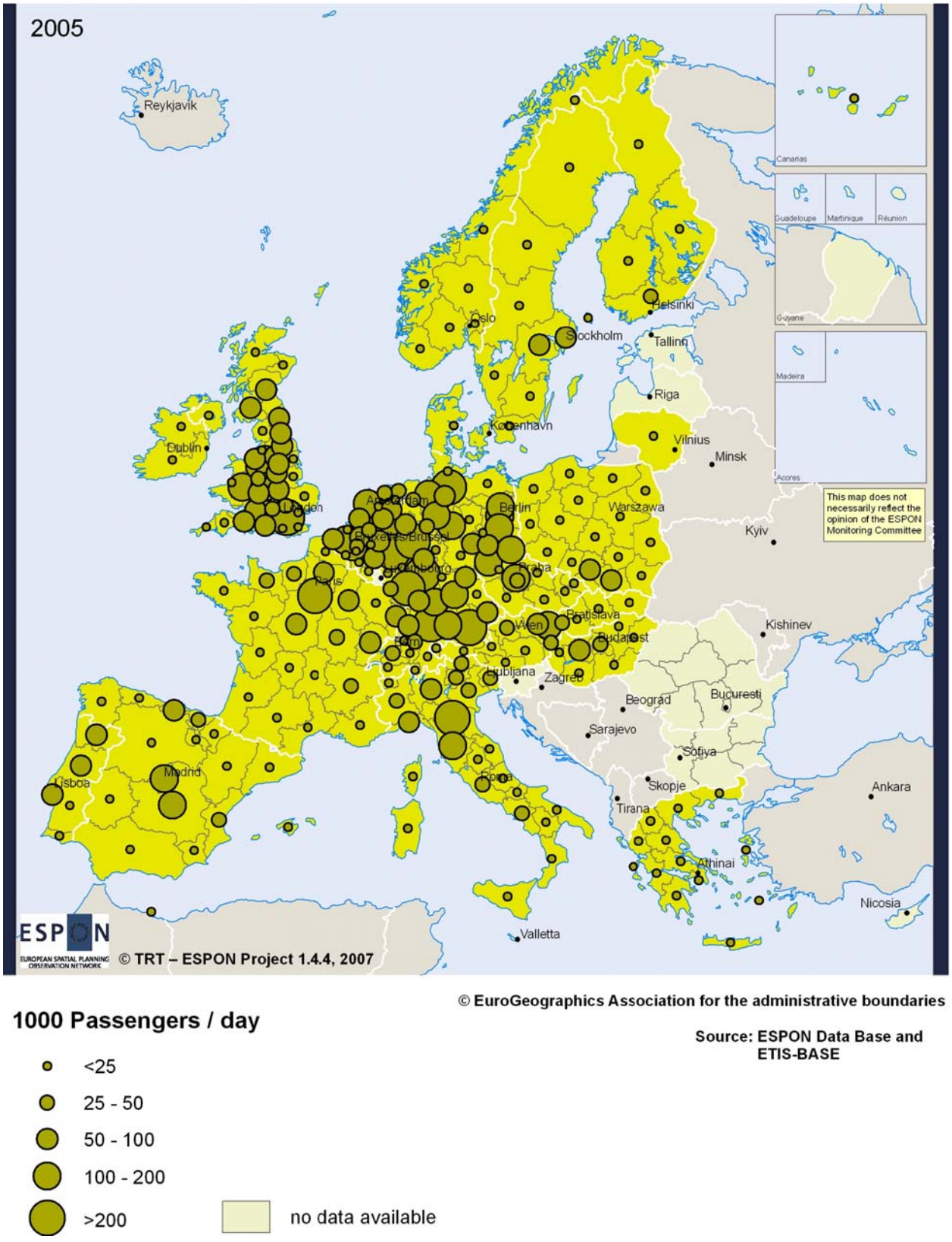


Figure 34 Business trips attracted from other regions

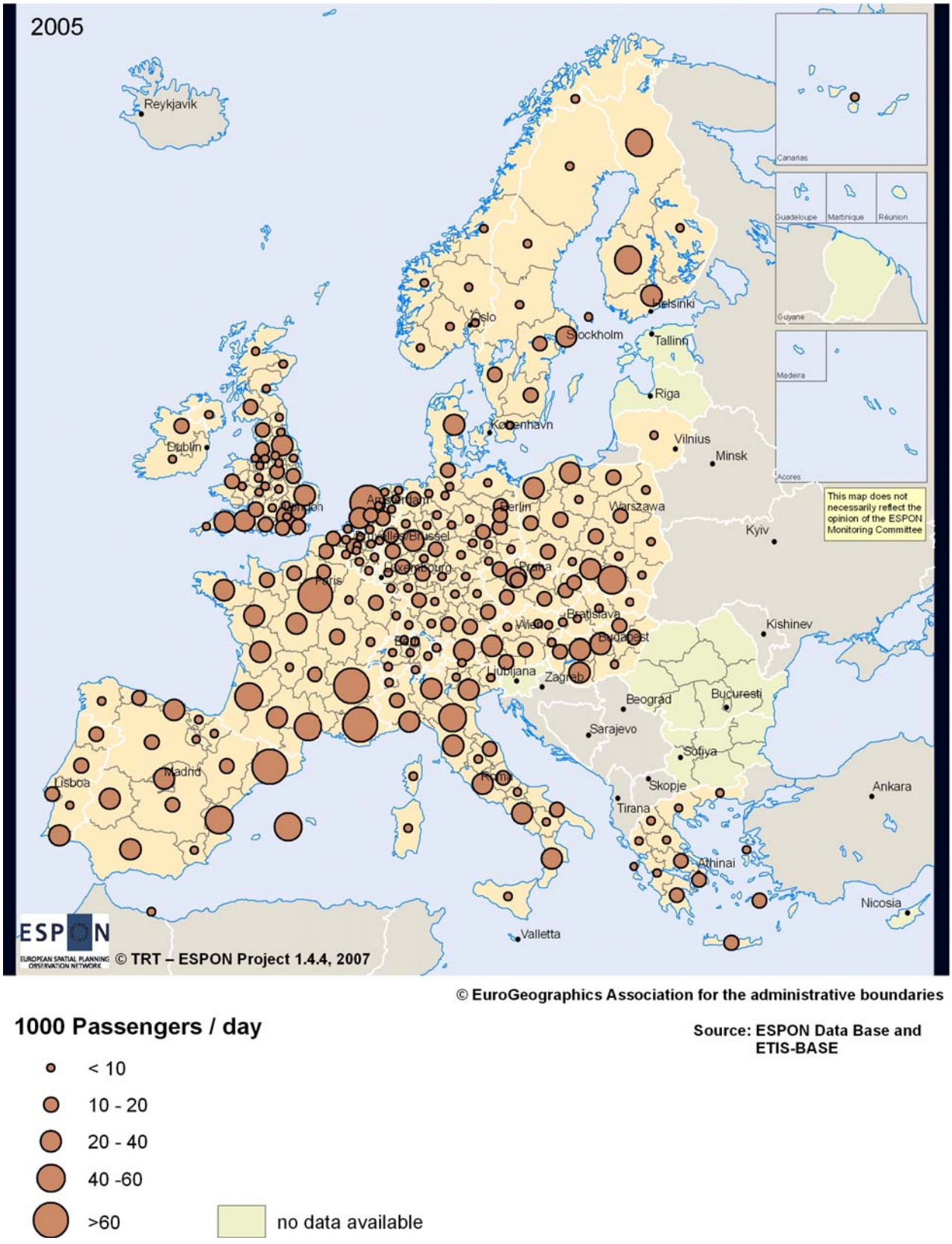


Figure 35 Tourist trips attracted from other regions

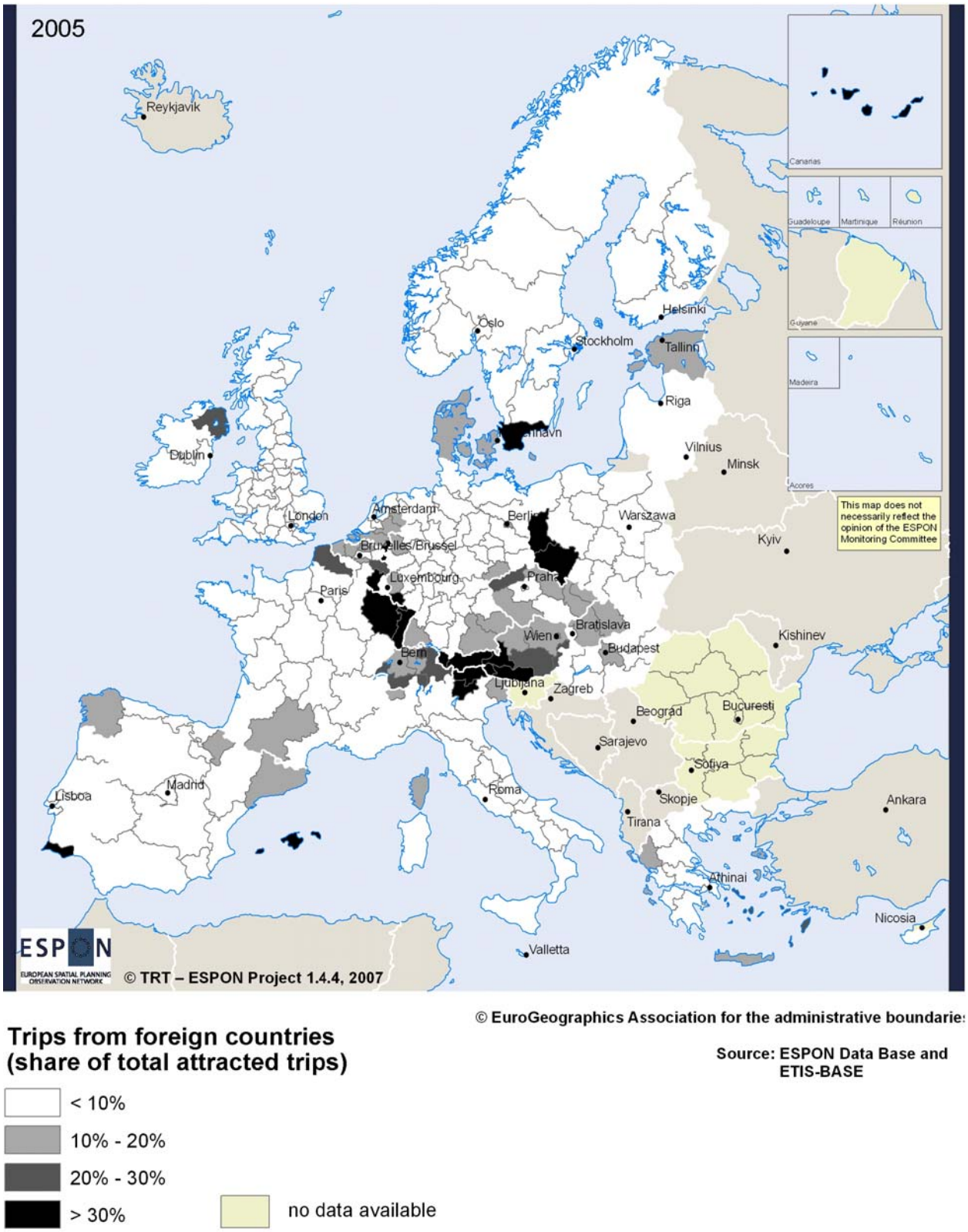


Figure 36 Share of trips from foreign countries of total attracted trips

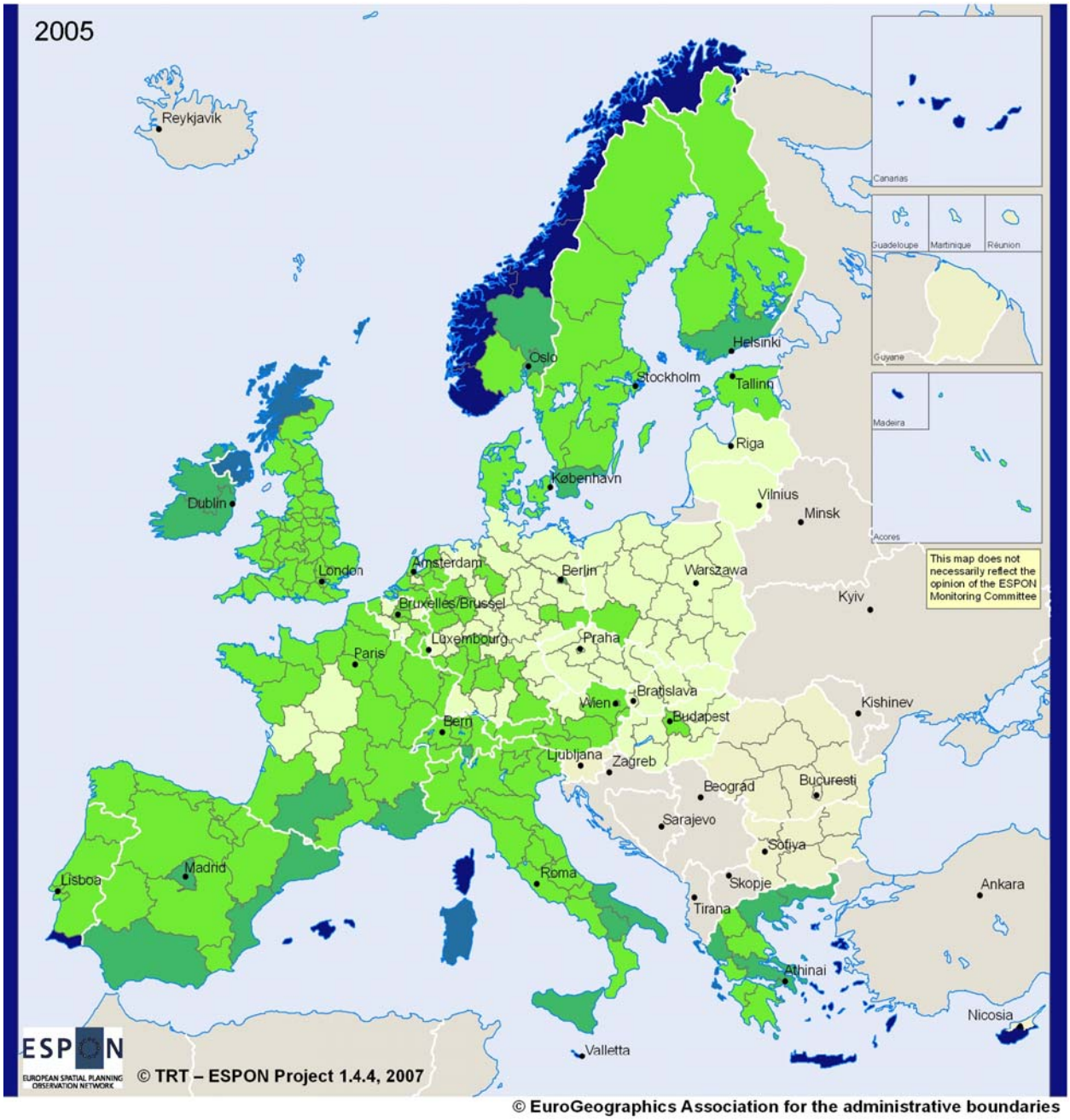


Figure 37 Share of air of trips attracted from other regions

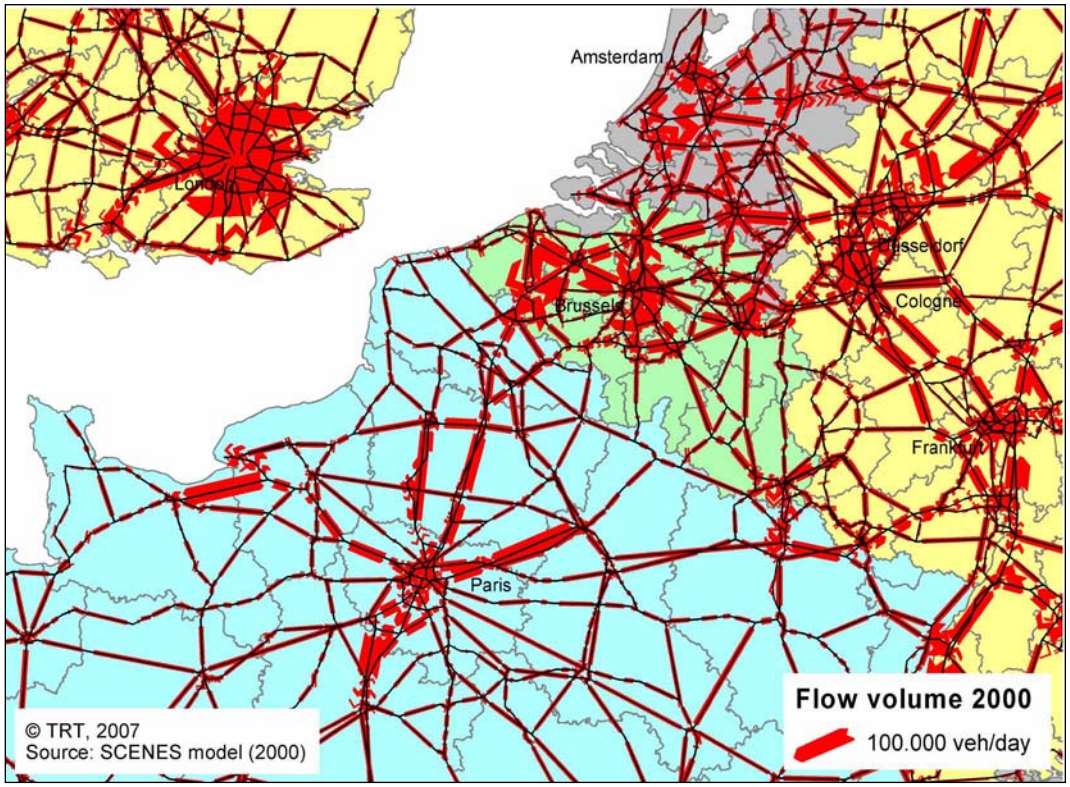


Figure 38 Road passenger flows on the main network: Southern UK and Benelux

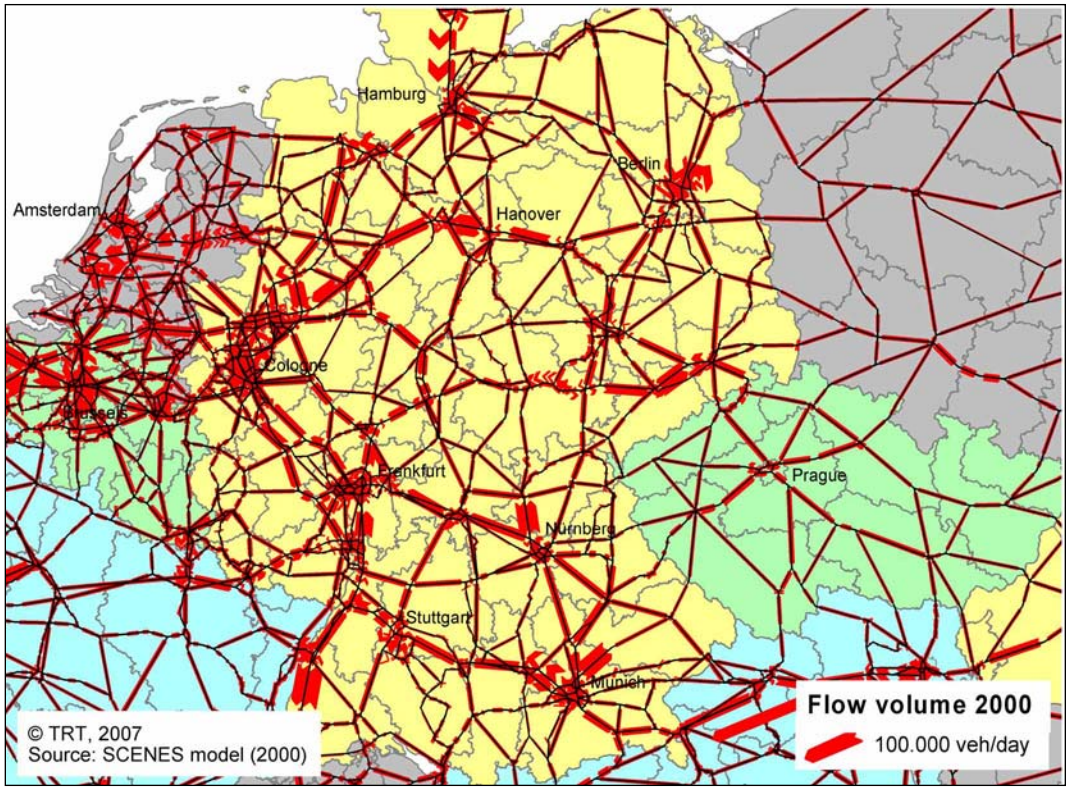


Figure 39 Road passenger flows on the main network:– Germany

Conclusions for ESPON

The main conclusions which can be taken from the demonstration example concerning passenger flows are the following.

In terms of data, as only information at the NUTS-2 level is available while a large part of personal mobility occurs below the average size of NUTS2 regions, an analysis at the European level is limited to a specific part of passenger flows: long-distance interregional trips. The TRANS-TOOLS model is expected to provide NUTS-3 level matrices. Extending the analysis to take into account the large amount of trips (even non-commuting trips) occurring within NUTS-3 regions would require to collect more detailed data, which can be a huge task. In all cases, passenger flows are only available as modelled estimations rather than observed data. Comparisons against other types of flow data addressed in this study, like tourist or cross-border flows could help to improve the quality of data.

However, the available information on passenger flows makes a significant contribution to the ESPON objectives, just like information of freight flows. If freight flows are the physical translation of trade, passenger flows are the concrete result of business, tourism, etc. Studying non-commuting passenger flows means monitoring the relationships between the activities of European citizens and space. For personal mobility the prominent role of some types of regions (e.g. metropolitan areas) is generally higher than for freight. This implies that the study of polycentricity at the European level needs to take passenger flows into account. Furthermore, the rapid development of new modes of transport, like low-cost airlines, can dramatically change the level of accessibility of peripheral regions. Monitoring the impacts of accessibility on competitiveness requires the consideration of passenger flows. Finally, as for freight, passenger mobility is not only a potential source of positive effects, but also a responsible for environmental impacts which reduce sustainability.

7.5 Tourist flows

Like in all parts of the world, tourism is rapidly emerging as one of the key sectors of the economy in a variety of European contexts. It has long been the major engine of economic growth in Alpine and other mountainous settlements, cross-border regions, coastal and insular regions, but also cities of varying sizes. The tourist sector has been credited with creating numerous jobs (directly and indirectly) and many observers believe it generates a significant income multiplier. In an era where many traditional activities such as agriculture, logging or manufacturing have witnessed substantial decline

in most regions, tourism has been boosted as one of the key sectors for economic restructuring (ESPON 1.4.5., 2006).

The enlargement of the European Union in 2004 resulted in significant intensification of tourist flows. One of the reasons was the rapid development of low-costs air traffic which not only has attracted people to destinations in the new member states, but as the same time has allowed people from there to travel abroad at reasonable costs.

Data

Tourist flow data for countries concerning tourist visits, overnight stays, accommodation infrastructure, are relatively easily accessible. Problems arise as the level of detail of the data sought increases. It is very difficult to obtain the data on the tourist visits by country of origin for the NUTS-2 and lower levels. Data from Eurostat allow to analyse the magnitude of flows, but without indication of their directions. The analysis of the intensity and flows of tourists between the old and new EU member states is possible only at the country level.

Information on tourist visits by country of origin for NUTS-2 regions is collected at some national statistical offices (e.g. Czech, Estonian, Danish and Polish). There are countries like Spain or France where data available are partial, i.e. record visits of tourists only from selected countries or groups of countries.

The data used to illustrate tourist flows between the countries of the European Union come from Eurostat, while the data for tourist visits in the Czech Republic, Hungary and Poland were produced by the national statistical offices of the respective countries. Lack of data on the structure of visits for the level of at least NUTS-2 in case of Hungary did not allow a detailed analysis of tourist flows from EU15 countries.

Methods applied

The analysis of statistical data made it possible to develop a detailed picture of tourist flows between the old and new EU member states. On the basis of data from Eurostat maps were prepared showing the magnitude and structure of tourist flows between the old and the ten new member states of 2004 and for selected countries (Czech Republic and Poland). The changes in the numbers of tourists in the years 2000-2005 (for the old member states) and in the years 2003-2005 (for the ten new member states) are presented in a dynamic setting on the maps.

Main results

A preliminary analysis of the tourist flows between the old and new EU member states for the years 2003-2004 shows for the majority of the new EU member states an increasing number of tourists travelling to the old member states. This was also confirmed by the analysis carried out for a longer time period, i.e. for the years 2000-2005. The largest percent increase was observed for the flows Slovakia-Luxembourg (300% though in absolute numbers this increase means just 920 persons) Slovakia-Finland (95%), Slovakia-Greece (76%), Slovakia-Belgium (71%), Hungary-Austria (70%) and Czech Republic-Greece (64%). These data, however, refer not to the entire flows, but only to persons using hotel accommodation. For the entire flows the directions of the highest increase would certainly be different (e.g. in case of Poland the trips to the United Kingdom would dominate). In the years 2000-2005 there has been a decrease in the numbers of Czech and Slovak tourists in Spain (by 41% and 22%, respectively) and of Polish tourists in Italy (by 20%). Determination of the rate of growth was impossible for countries for which incomplete statistical data exist (e.g. the United Kingdom).

In the reverse direction the biggest relative increase in the number of tourists took place in the direction from Portugal to Estonia (208%), from Austria to Latvia (176%), from UK to Latvia (170%), and from Austria to Estonia (169%). The biggest increase in the number of tourists in absolute terms took place in the years 2003-2006 from Germany to Poland (more than 320,000 persons), from UK to Czech Republic (244,700 persons) and from Germany to the Czech Republic (167,800 persons). The flow of tourists between the old and new EU member states using hotel accommodation, is shown in Figures 40 and 41.

The highest dynamics of tourist visits per 1,000 inhabitants is observed in the ten new member states. Among those countries the biggest increase was noted in the years 2003-2005 in Estonia by as many as 194 persons per 1,000 inhabitants. There has also been a significant increase in Latvia (88 persons per 1,000 inhabitants), the Czech Republic (80 per 1,000 inhabitants), and Slovenia (69 per 1,000 inhabitants). Only in the case of Cyprus there was a decline in tourist visits, by 59 persons per 1,000 inhabitants in the years 2003-2005. The dynamics of visits to the old member states is decidedly lower than in the opposite direction: the highest growth in visits in the years 2000-2005 was in Austria (42 per 1,000 inhabitants), Greece (25 per 1,000 inhabitants) and Luxembourg (24 per 1,000 inhabitants). Of the old member states only Spain noted a slight decrease in tourist visits (1 per 1,000 inhabitants). No data were available for Ireland, Portugal, Sweden and the United Kingdom (Figure 42).

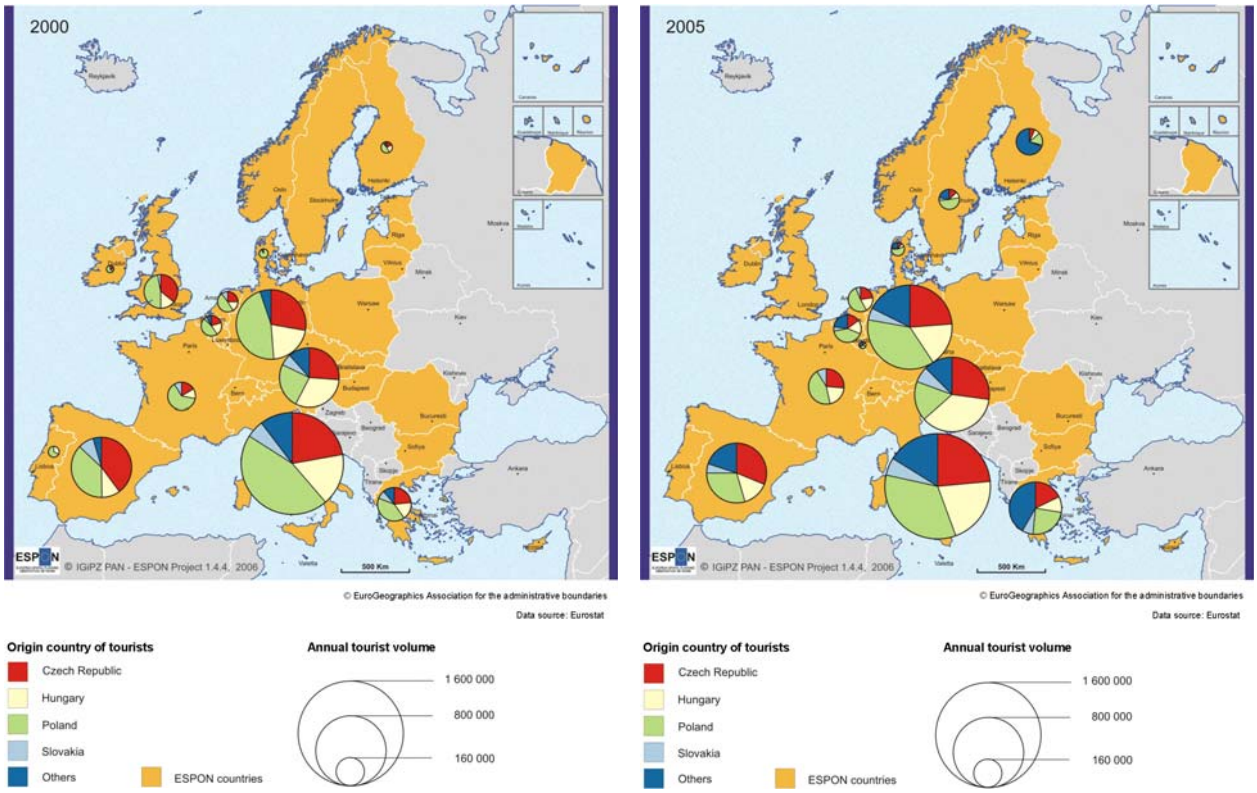


Figure 40 Arrivals of tourists from the new to the old EU member states accommodated in hotels etc. 2000 and 2005

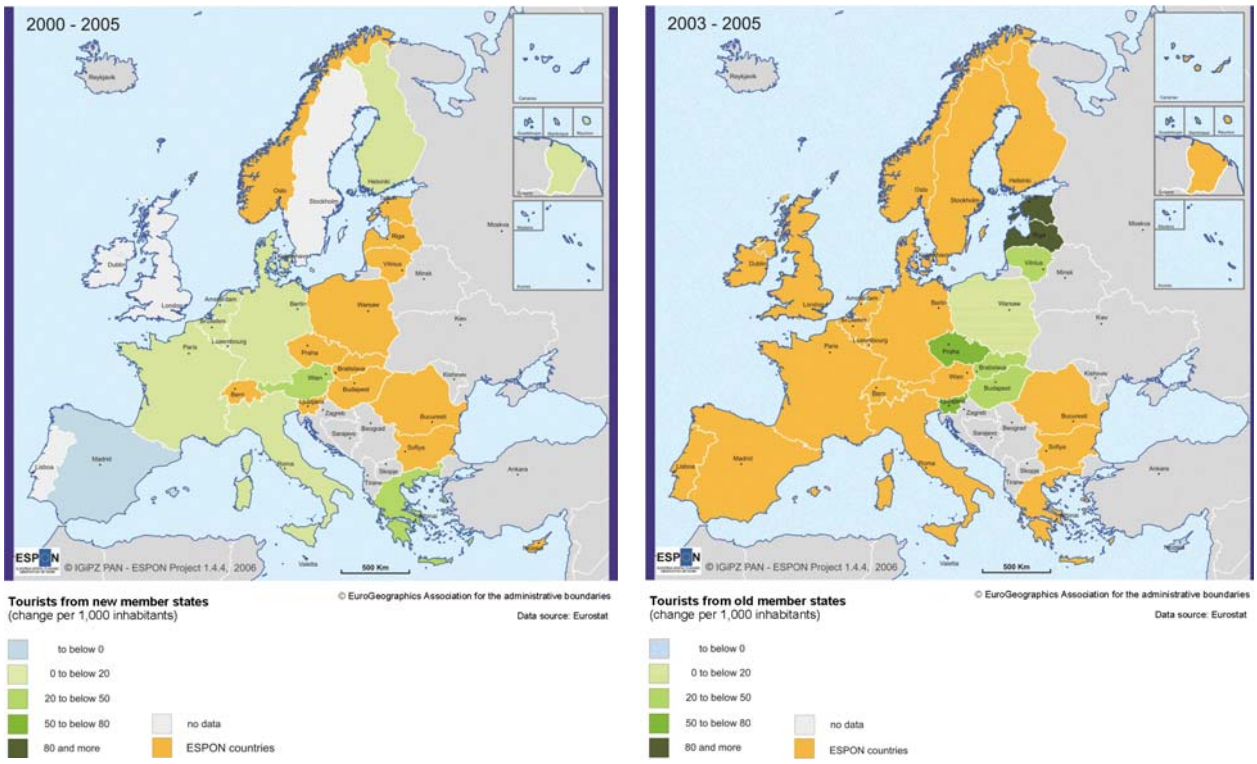


Figure 41 Change of tourist flows between old and new EU member states

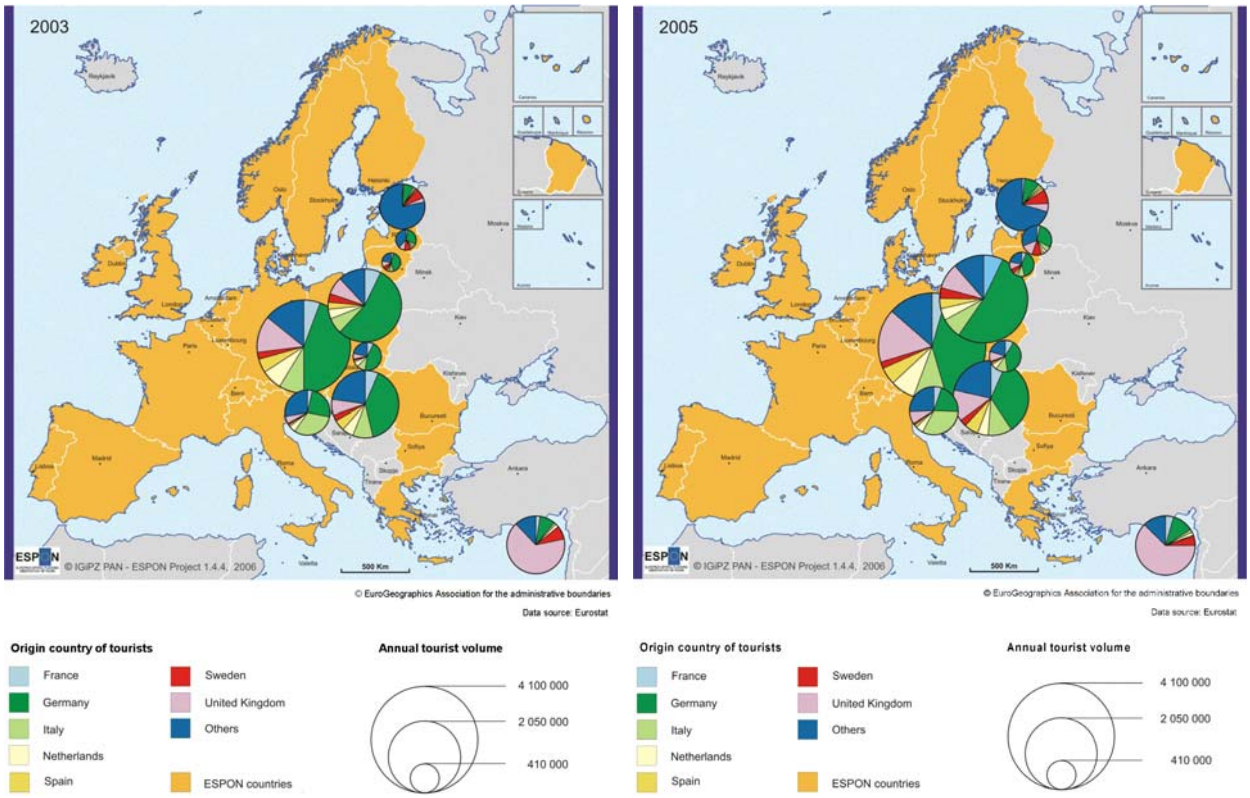


Figure 42 Change in composition and volume of tourist flows between the new and old member countries

Czech Republic

In 2004 the Czech Republic was visited by some 6,061,000 foreign tourists, who made use of the hospitality industry, and this number increases year by year. In comparison with the year 2000 the number of visitors from abroad increased by 27%. In the last year before the accession of the Czech Republic to the European Union, i.e. in 2003, this number was 5,075,800 persons. Thus, in the years 2003-2004 tourist visits increased by almost one million, that is by 19.4%. In 2004 the largest group of visitors came from Germany (1,569,000 persons, equivalent to more than one quarter of all the foreign tourists visiting the Czech Republic (Figure 43).

In the years 2000-2004 an increase in the number of visits was observed from 13 of the old EU member states, with the biggest increase from Ireland (498%), the United Kingdom (175%), and Greece (134%). In absolute numbers the biggest increase took place in the number of tourists coming from the United Kingdom (414,000 persons), Italy (158,000 persons) and France (95,000 persons). There was, on the other hand, a significant decrease of the number of tourists from Denmark (by 35%) and from the Netherlands (by 13%).

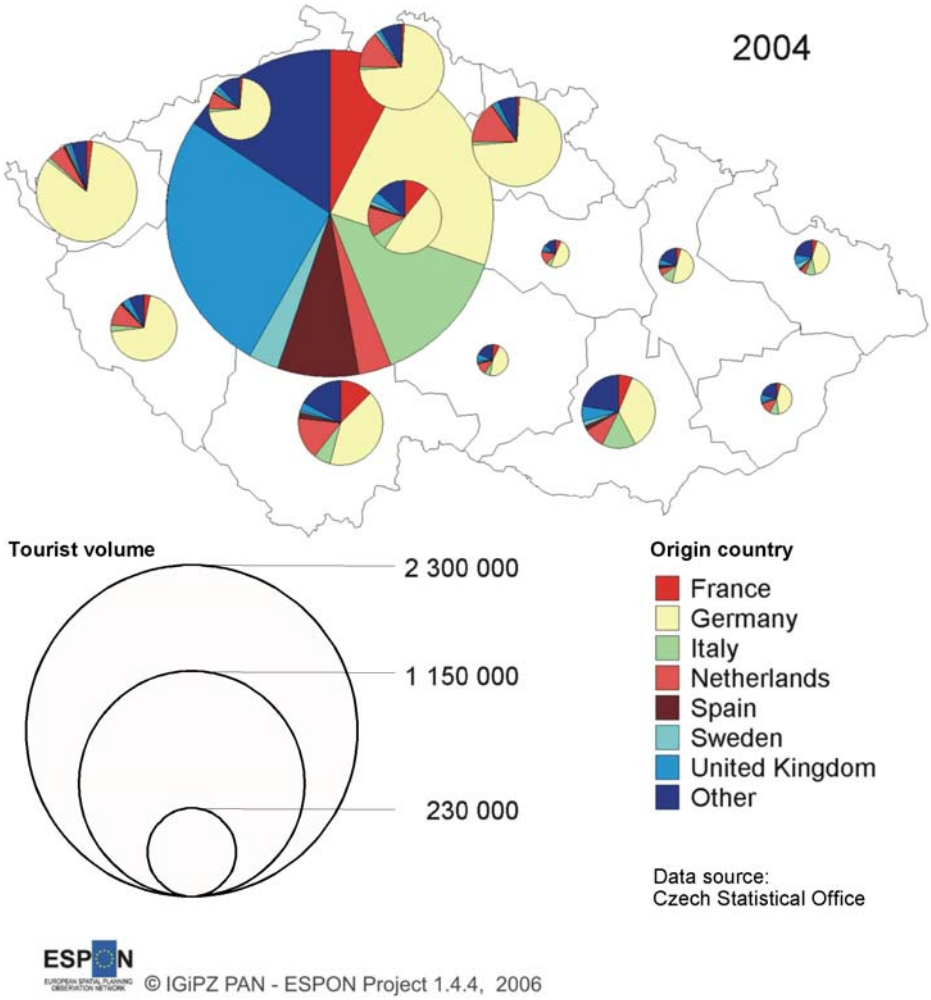


Figure 43 Foreign tourists in tourist accommodation establishments in the Czech Republic in 2004

Prague, the capital of the Czech Republic, is beyond doubt the most frequently visited place in the country. In 2004 more than half of all foreign tourists visiting the Czech Republic and using hotel accommodation, that is some 3,470,300 persons, visited Prague – an increase by almost 50% compared with the year 2000 and by 31% compared with the year 2003. The biggest group were the British (17.1% of all the foreign tourists), followed by the Germans (14.7%) and Italians (8.9%). In the years 2000-2003 Prague was visited, on average, by 1.5 million tourists per year from the old EU member states, while in 2004 the number of visitors increased by almost 720,000. One should emphasise the more threefold increase of the number of tourists from the United Kingdom, which in absolute numbers was equivalent to roughly 400,000 persons. A higher percent increase was noted only for visits from Ireland (565%), but in absolute numbers this was equivalent to not more than 34,000 persons.

The regions most frequently visited by foreign tourists include, besides Prague, the Karlovy Vary (Karlsbad) (389,000 persons in 2004 and 406,000 persons in 2005) the Southern Moravian region (349,000 persons in 2004) and the southern Bohemian region (317,700 persons in 2004).

In the case of the Czech Republic one can see repetitive annual or bi-annual oscillations of the numbers of tourists visiting the particular regions of Bohemia. The dominating position of Prague is the characteristic element of tourism in the Czech Republic. The capital city of Prague attracts a continuous increase of tourist visits and overnight stays. Prague is visited by more tourists than all the other regions of the country taken together. There are also regions with a constant decrease of the number of tourists since 2000 (e.g. Kraj Středočeský).

Hungary

In 2004 some 36.6 million foreigners visited Hungary according to border statistics. Of that number almost 33% came for tourist visits. In comparison with the preceding year the number of foreign visitors increased by more than 5 million. The largest group were tourists from Romania followed by tourists from Slovakia, Austria, Serbia and Montenegro, Germany, Ukraine and Croatia. The inhabitants of the ole EU member states accounted for almost 30% of all tourists visiting Hungary in 2004. Austrians were the largest group of tourists from the old member states (almost 49%) with Germans taking the second place (close to 29%). In the years 2003-2004 there was an increase in tourists from other European countries by 16% and from the old member states by 14%. The total number of tourists coming to Hungary increased in the same period by 16.3%.

In Hungary, similarly to the Czech Republic, the largest group of tourists from the old member states visit the capital city, Budapest. Although there are no detailed data on the destinations of tourist trips in Hungary, according to NUTS-2 data in 2004 there were almost twice as many foreign tourist visits to Budapest as to all the remaining regions together.

The regional distribution of tourist visits to Hungary is therefore as follows: Budapest is the engine of tourism in Hungary. In the years 2002-2004 the number of visits of foreign tourist to Central Hungary, the capital region, increased by 24.2%, whereas tourist visits to the entire country increased by 8.5%. In the remaining NUTS-2 regions the numbers of visits declined. It is interesting to note that the decrease of tourist visits concerns also the well developed and attractive region of the Balaton Lake (see Table 7).

Table 7 Foreign tourists in tourist accommodation establishments in Hungary (Source: Hungarian Central Statistical Office, 2005)

NUTS 2	2002	2003	2004	2002-2004 (2002 = 100)
Central Hungary	1,672,085	1 700,126	2,076,157	124.17
Central Transdanubia	256,216	233,213	227,866	88.94
Western Transdanubia	445,335	428,653	435,373	97.76
Southern Transdanubia	286,248	249,861	204,280	71.36
Northern Hungary	98,667	96,979	93,710	94.98
Northern Great Plain	141,709	133,696	124,867	88.12
Southern Great Plain	112,856	105,696	107,615	95.36
Total	3,013,116	2,948,224	3,269,868	108.52

Poland

According to the data of the border guards, 52,129,000 foreign visitors to Poland were registered in 2003 and 61,918,000 in the following year (+18.8%). In 2005 this number was 64,600,000, i.e. 4.3% more than in 2004 (see Table 8).

Incoming traffic increased at the border with Germany and decreased at the southern border. At the borders with the Russian Federation, Belarus and Ukraine the downward tendency of the previous years was stopped. Recent trends are uneven: there has been an increase of the number of visits from the old EU member states and non-European countries, while the number of visitors from the new member states decreased.

There is a concentration of one-day visitors across the eastern borders, largely for shopping, by inhabitants of Belarus or Ukraine but also of Poland. A similar phenomenon is observed at the border with Germany. The eastern border is also characterised by a high share of transit travellers through Poland.

Tourist traffic to Poland is characterised by a significant number of visits of the same person during a year, which means that the actual number of different persons visiting Poland is smaller than the number of visits. In 2005, the average number of visits during twelve months preceding a study by the Institute of Tourism, amounted to 3.4 per person. More than 50% of German tourists visit Poland two or three times a year, while for the remaining old member states this amounts to less than 40%.

Table 8 Arrivals of foreigners to Poland 2000-2004 by border (Source: Polish Central Statistical Office, 2005)

Border with	2000	2001	2002	2003	2004	2003/2004
	in 1,000					in %
Russia	1,210.0	1 042.0	853.3	620.0	672.0	108.4
Lithuania	1,390.1	1,373.4	1,314.1	1,327.6	1,504.3	113.3
Belarus	6,514.8	5,610.0	4,632.7	4,143.8	3,765.2	90.9
Ukraine	5,743.3	5,941.6	5,404.9	4,394.6	4,143.3	94.3
Slovakia	3,133.4	2,016.6	1,790.0	2,572.0	3,531.4	137.3
Czech Republic	16,803.2	13,442.4	12,073.5	12,353.2	13,127.4	106.3
Germany	47,046.6	29,606.5	22,339.2	24,190.8	32,874.6	135.9
Marine border	1,512.7	1,224.5	1,201.1	1,345.9	760.4	56.5
Airports	1,160.7	1,174.2	1,125.8	1,181.8	1,539.2	130.2
Arrivals total	84,514.9	61,431.3	50,734.6	52,129.8	61,917.8	118.8

In 2004 the biggest group of visitors were Germans (53.9% of 2,556,000 persons using hotel accommodation) followed at a distance by visitors from the United Kingdom (8.5%), Italy (7.2%), France (7.1%), the Netherlands (4.6%) and Sweden (4.0%) (Figure 44). The fewest tourists come from Luxembourg (0.2%), Greece (0.3%), Portugal (0.5%) and Ireland (0.7%). Compared to the year 2000 there has been an increase of visits from all old EU member states. The greatest increase of visits was recorded for Ireland (144.2%), Spain (136.3%) and Italy (68.2%), while in absolute numbers for Germany (more than 326,000), Italy (74,800), France (57,000) and Spain (45,000).

The visits of foreign tourists by province take the following pattern: the most frequently visited province is Masovia followed by Wielkopolska and Małopolska. Tourist visits by province constitute between 13 and 50% of all visits (in absolute numbers this means between 34,000 and 800,000 persons). The largest numbers of foreign tourists arrive in the provinces of Masovia, Małopolska, Pomerania, Wielkopolska and Lower Silesia. On the other hand, less foreign tourists come to the province of Świętokrzyskie and to the provinces of eastern Poland, especially to Podkarpackie and Lubelskie.

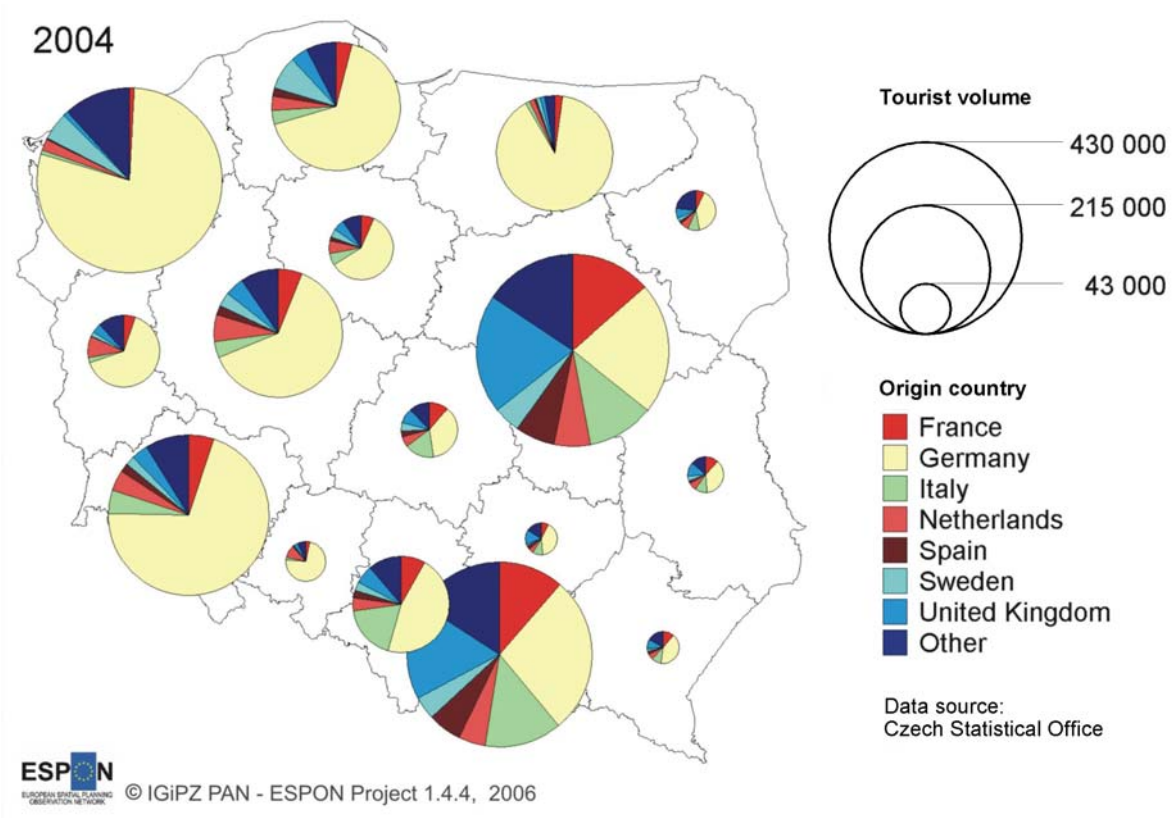


Figure 44 Foreign tourists in tourist accommodation establishments in Poland in 2004

In comparison with the Czech Republic and Hungary, where there is a clear domination of tourist visits to the capital cities of Prague and Budapest, the capital of Poland does not have such a dominating position. It is true that the province of Masovia, i.e. practically Warsaw, attracts the largest number of overnight stays of foreigners, but that number is comparable with those for the provinces of Małopolska (Cracow) and Western Pomerania.

The characteristic features of tourist flows between the old and new EU member states include:

- Tourists from Germany are dominant. In 2005 tourist from Germany to the new EU member states accounted for more than one third of all visits from the old to the new EU member states (of all EU countries Germans leave their country most often – 116 million trips in 2003).
- In many EU countries there is one dominant nationality among the tourists visiting that country, e.g. in Estonia some 67% of all tourists coming from old EU member states are Finns, on Cyprus the tourists from the United Kingdom dominate (roughly 62%), in Poland and in Lithuania

Germans (around 52% and 41%, respectively) and in Slovenia Italians (approximately 32%).

- The increase of tourists from the old to the ten new EU member states has been larger than in the opposite direction; an analysis of the entire population flow, both in terms of direction and magnitude of movement, would presumably yield different results.
- In the Czech Republic and Hungary the numbers of foreign visitors to the capital cities Prague and Budapest are several times larger than those to other tourist regions of these countries.
- The greater regional differentiation of foreign tourist visits in Poland may be the outcome of the better developed network of regional airports and connections by low-cost air lines than in the Czech Republic and Hungary. Travelling to Poland may take place without going through the capital, which in the Czech Republic and Hungary is almost impossible.
- Among the new EU member states only in Cyprus no significant increase in tourists from the old EU member states has been observed.

Conclusions for ESPON

The results presented here are based on incomplete statistical data. In many cases data for the old EU member states are lacking because these countries do not include detailed statistics for the new member states. Even greater gaps or even complete lack of data appear at the level of regions. In future studies efforts should be made to fill the gaps on the basis of data from national statistical services, previous studies and other sources. This would allow to answer a number of questions about, e.g. the directions of tourist flows at the regional level, their intensity and structure and whether they are different from those at the national level. Separate studies should be conducted for the new member states Bulgaria and Romania and the candidate countries Croatia, Macedonia and Turkey.

The major problem for the analysis of tourist flows lies in the incompatibility of the available data. Most data refer to the total number of visitors (arrivals of citizens of other countries at national borders). Travellers who stay overnight in hotels, pensions and other accommodations represent a proportion that differs considerably among the countries – in Poland, where the overwhelming majority of visits are one-day shopping trips, this share is less than 10 percent. Furthermore, users of hotel and related facilities include tourists, business visitors, family and friends visitors etc. Although for policy

analysis these data should be properly disaggregated, this is feasible on a limited scale only.

The analysis of tourist flows should therefore be undertaken within a wider context of international short-term population movement (as opposed to migration). Such an analysis would be extremely relevant for ESPON as it provides direct links to EU integration and territorial cohesion.

7.6 Cross-border flows

The increase in the level of cross-border passenger and freight traffic in the new member states since 1990 is without precedence in history. The economic and spatial dynamics are reflected in specific flow types.

This demonstration example looked more closely into the changes in cross-border traffic taking Poland as case study. One of the objectives of the demonstration example was to identify the changes in cross-border traffic at internal and external borders of the European Union after the introduction of Polish visas for east Europeans in 2003 and after the accession of the country to the EU in 2004. A detailed analysis was carried out of two border segments, between Poland and Germany (a new internal border of the EU) and between Poland and Ukraine (a new external border of the EU).

Data

For this purpose, the main data source used is the Polish border guard database. It contains the number of passengers and heavy goods vehicles and distinguishes between passenger transport between Polish citizens and foreigners crossing Polish borders. The data allow the analysis of cross-border movements between 1990 and 2005.

It is also possible to acquire data on border traffic by month (and in special situations even by). This was used in the estimation of changes in traffic during the crucial period between September 2002 and August 2004. On 1 October 2003 Poland introduced visas for the citizens of Russia, Belarus and Ukraine. In the first two countries the same was applied to Poles travelling to these countries, while Ukraine stepped down from the visa obligation for Poles. On 1 May 2004 the enlargement of the European Union took place. The monthly analysis allowed also the consideration of seasonal fluctuations in both passenger and goods traffic.

The database of the Polish border guards contains data on the entry of foreigners to Poland by nationality and borders crossed. This gives the possibility of assessing the magnitude of transit through Poland by citizens of third

countries, e.g. the Baltic States, most of whom are on transit to western Europe. The database does not contain, on the other hand, analogous information by country of origin of heavy goods vehicles (only vehicles with foreign registration are distinguished). Hence, it is not possible to analyse transit of heavy goods vehicles.

Other new EU member states collect similar data at their borders. They are fully available for Hungary and Slovenia. Yet, even there the complete time series from 1990 is not available. One can expect the termination of the collection of data on the border traffic across internal borders of the EU once the Schengen area is extended, according to current plans most probably in 2008. Thus, 2007 will most probably be the last year for which it will still be possible to carry out an in-depth analysis of traffic between the old and new EU member states and to compare its magnitude with the situation before the EU enlargement. The possibility of a detailed analysis will be preserved, though, at the external borders of the EU.

Besides the data from border guards, results of detailed studies on cross-border traffic at particular borders or border crossings are sometimes available. Such studies were carried out in Poland in the years 1994-2002 by the Central Statistical Office. They concerned the destinations of visiting foreigners and their expenditurs. These data are available in the form of publications for each year. Besides, the Institute of Geography and Spatial Organization of the Polish Academy of Sciences carried out studies on the structure of traffic at selected Polish-German border crossings, partly in collaboration with the Institut für Länderkunde in Leipzig in the West-Ost Axis Project (Rosner et al., 1998). The studies were based on the monitoring of registration plates of vehicles crossing the borders. Such studies provide a very precise image of the spatial reach of cross-border relations.

Methods applied

The existing material allows a dynamic analysis of traffic trends along particular border segments and crossings and allows their cartographic representation in the form of graduated symbols maps as well as an analysis of the degree of concentration of traffic across particular borders.

The analysis of border traffic constitutes also a method to verify the results of other studies on flows based on origin and destination matrices. As an additional cross-sectional profile it allows the estimation of routes linking countries and regions and may thus be an essential tool for the preparation and implementation of transport policy.

Main results

Previous analyses have shown that in the period 1990-1997 passenger cross-border traffic in both directions increased in Poland from 84.2 million to 273.9 million persons (Komornicki, 1999). This increase was followed by stagnation, and in the years 2000 and 2001 a decrease was observed. The traffic was dominated by one-day shopping trips to Poland. In 2003 altogether 181 million persons crossed the borders in both directions. In 2004 and 2005 there was a new increase associated with the accession of Poland to the European Union (Figure 45). This increase took place across all border segments except those with Russia and Belarus. On most border segments predominantly foreigners crossed the borders. This was most pronounced at the local Polish-German border crossings (neighbouring to bazaars, like Łęknica), and also along the borders with Belarus. There are border crossings on the eastern borders of Poland where the share of Polish citizens crossing the border does not exceed 5%. Poles dominate on the other hand at airports and on the Czech and Slovak borders.

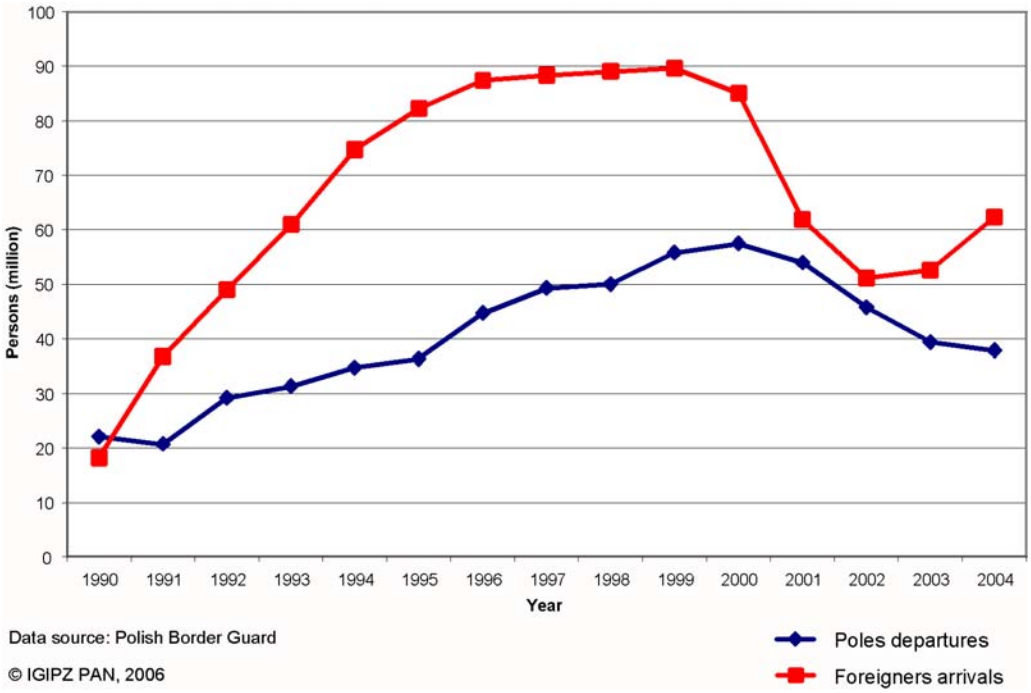


Figure 45 Cross-border passenger traffic in Poland 1990-2004

After 1990 two waves of rapid increase in air transport took place in Poland. The first one occurred in the years 1996-2000 and was associated with the rapid economic development (numerous business trips) and the increase in chartered tourist flights (mainly oriented at the Mediterranean). The second

wave was initiated by the accession to the European Union and the appearance of low-cost airlines. The gradual change of the fare policy of Polish Airlines LOT contributed to the increase in domestic flights. These two waves, in conjunction with market deregulation, brought about a systematic decentralisation of air traffic (Figure 46). In 2004 there was an abrupt increase in passengers at the airports of Kraków-Balice and Katowice-Pyrzowice where also the shares of low-cost airlines were highest, 46 and 70%, respectively (Czyczuła et al., 2005). In 2005 the rate of deconcentration was even higher. It is expected that the share of the regional airports in international traffic will further increase (Grzelakowski, 2005).

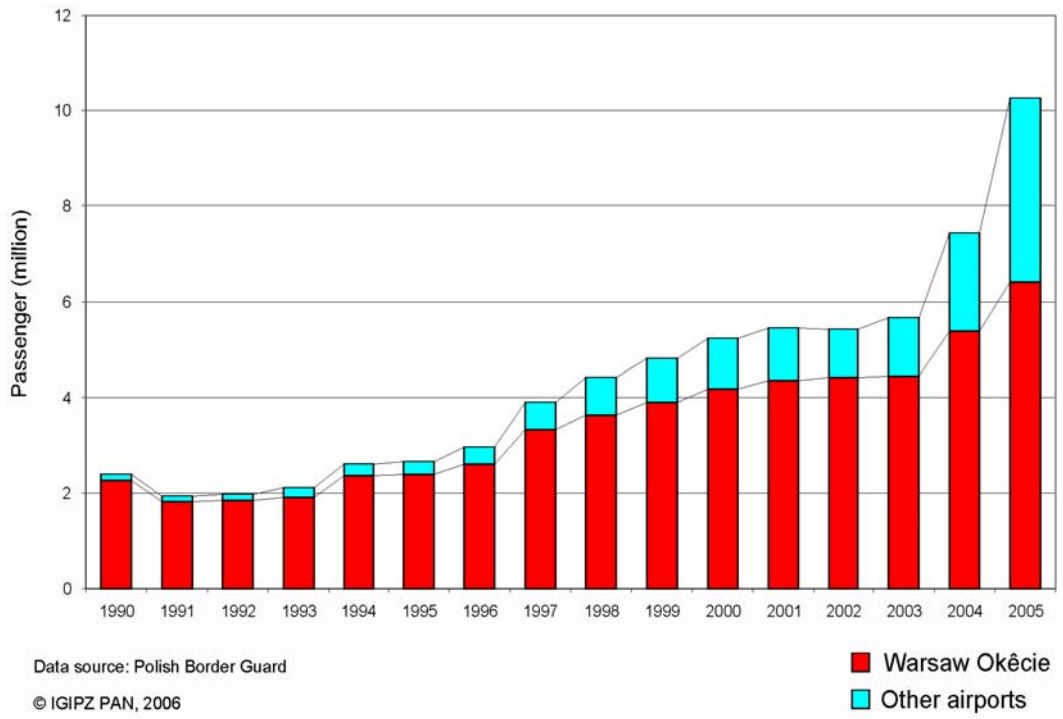


Figure 46 Development of air traffic in Poland

In freight transport the dynamic increase of heavy goods vehicles (HGV) traffic lasted over the entire decade and continues today. In 1980 all Polish borders were crossed in both directions by 295,000 HGV, by 1990 this number increased to 1.1 million and by 2003 to close to 6.2 million. During the entire decade lorry traffic across the Polish-German border was dominant. On the eastern side after 1998 Kukuryki was no longer the border crossing with the largest cargo traffic. Currently, the biggest intensity of truck traffic is observed in Budzisko on the Lithuanian border. The role of the Polish-Ukrainian crossings has relatively increased, especially at the crossing points in Dorohusk and Korczowa (see Figure 47).

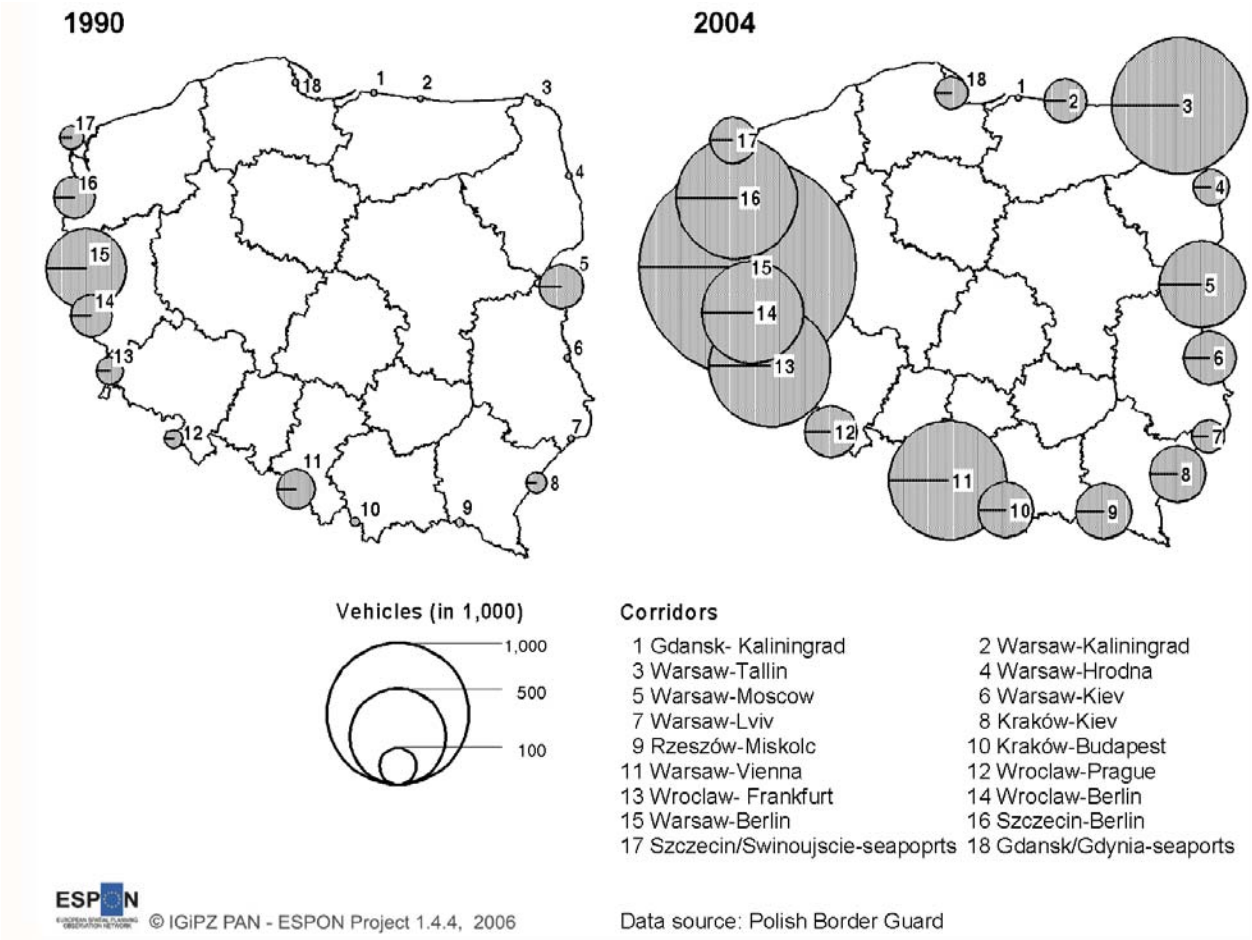


Figure 47 HGV border traffic by main transport corridors 1990 and 2004

But as it follows from other data sources (mainly on cargo turnover in seaports), there was at the same time a collapse of transit traffic through Poland in the north-south direction, mainly caused by the competition for the Polish seaports (and for the air cargo terminals) from Hamburg, Rotterdam and Trieste with respect to the Czech Republic, Slovakia and Hungary, which were previously served by the Baltic seaports of Gdańsk and Szczecin. Competition affected also the routes of Polish foreign trade. The evidence is seen in the 14% share of the total value of Polish imports from the United States taken by the border crossing on the route Warsaw-Berlin. In the east-west direction the route Moscow-Warsaw-Berlin lost the position of the most important transport route in car transport after 2000. Currently larger transit traffic through Poland is observed between the Lithuania, Latvia, Estonia and Finland and Western Europe (the "Via Baltica" route). There has also been a slight increase in transit from Ukraine.

Polish-German border

In the period of the highest border-adjacent prosperity (1994-1999) the traffic in both directions exceeded 130 million persons a year. This traffic was clearly dominated by German citizens. The breakdown in the intensity of traffic occurred after 1999 and concerned to a larger extent Germans than Poles. Its reason was the narrowing of the retail price gap between Poland and Germany, the emergence of large shopping malls on the German side of the border (competition for the Polish bazaars), and partly also lower travel activity of Poles. The analysis, carried out in the years 2002-2004 shows, however, that this tendency has stopped. The traffic increase noted in the first months of 2004 corresponds to the seasonal fluctuations of the preceding years. The increase in the number of foreigners, first of all Germans, however, was much larger after 1 May 2004 (Figure 48). Accession of Poland to the European Union intensified travel of the neighbours from across the Odra river to Poland. Moreover, since the end of the 1990s shopping visits were gradually replaced by visits to take advantage of services. This concerns, in particular, car repair and service stations, barbershops, dentists, and recently also more advanced medical services.

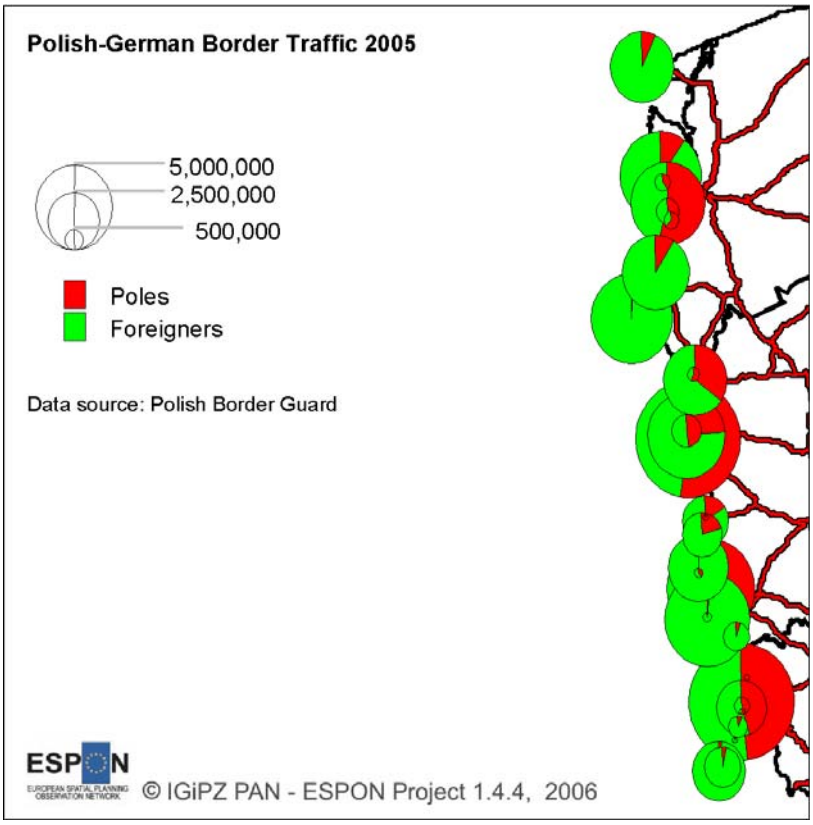


Figure 48 Polish-German border traffic by border crossings 2005

The statistics of border traffic has been differentiated by border crossings. At local crossings (especially those situated in the vicinity of small villages and towns) citizens of Germany dominate. On border crossings situated on the main transit routes Poles predominate. At these crossings traffic of third country citizens concentrates as well.

Unlike the fluctuating border traffic of persons, the Polish-German traffic of HGV increased over the entire period 1990-2005 (Figure 49) as the result of the rapid intensification of bilateral economic ties, and partly also as the effect of an increase in significance of transit over selected directions. Until 1998 the increase of traffic encompassed both vehicles with Polish and foreign registration. Between 1999 and 2003 the intensity of traffic in the category of foreign vehicles stabilised (at roughly one million per year in both directions). The traffic of HGV undergoes characteristic seasonal fluctuations (with the minimum at the beginning of the calendar year and the maximum in autumn and before Christmas). These fluctuations concern Polish vehicles more than foreign vehicles. In the period of accession the pattern of fluctuations was in principle preserved. Some differences appeared, however, in spring of 2004 (in the period immediately before and after 1 May). The traffic of Polish vehicles had been largest just before the date of accession (due to VAT regulations), to then drop in May, and return to a standard level in June. The traffic of foreign vehicles increased jump-like after the date of accession and remained in the following months at the level attained in May.

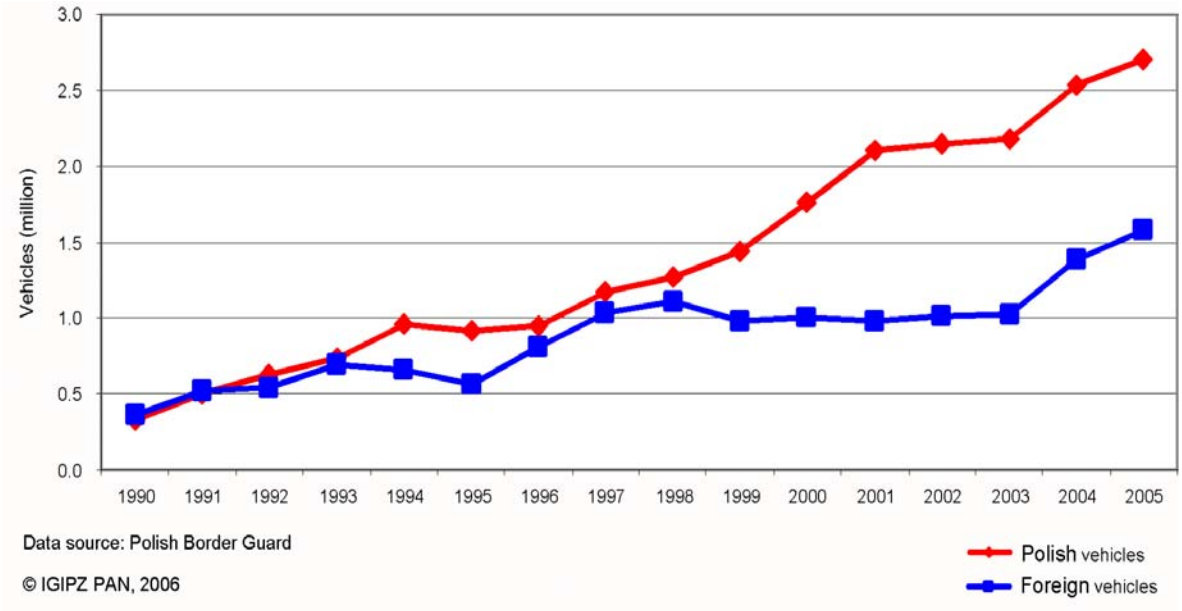


Figure 49 Polish-German HGV border traffic 1990-2004

Polish-Ukrainian border

The turn of the 1990s was a period of extremely dynamic increase of Polish-Ukrainian border traffic of both persons and vehicles. The traffic of persons reached its first peak in 1991 (that is before the establishment of the independent Ukraine), when the border was crossed in both directions by almost 7.4 million persons. This was the period just after the opening of the border for mass traffic. Price hikes in Poland, resulting from the transition to the free market economy, brought about the attractiveness of petty trade, consisting in importing cheap products of the collapsing Soviet industry and selling them on Polish bazaars. The subsequent years brought a slow decrease of traffic intensity. The primary cause was the worsening of the economic situation in Ukraine (separation from Russia, initiation of the economic reforms). Significant price increases of consumption goods in Ukraine took place. At the same time the situation in Poland was already gradually improving and the number of customers of the bazaars decreased. The years 1994-1997 were a period of a renewed intensive traffic increase, involving however, mostly foreigners. The direction of cross-border trade changed. Ukrainians started to visit Poland to do their shopping there. The second breakdown of traffic intensity took place in 1998 owing to the Russian economic crisis, which encompassed the entire area of the former Soviet Union, partly due to the introduction of the Polish Law on Foreigners. Traffic dwindled to the level of 1995.

The subsequent wave of development of cross-border trade took place in the years 1999-2001. Simultaneously, there was a renewed increase of the number of Poles travelling to Ukraine (higher number of official business trips, and intensification of tourism, including the use of health resorts). In 2001 the border was crossed in both directions by the record-breaking number of close to 12 million persons.

The analysis of traffic in the period of 24 months (September 2002 to August 2004; see Figure 50) shows a characteristic seasonal cycle with a distinct summer maximum and a drop in the winter months. This cycle was disturbed by a breakdown associated with the introduction of visas on 1 October 2003. The delay, after which the fluctuations of traffic returned to the earlier rhythm, was, however, quite short. Already in December 2003, the intensity of border traffic corresponded to the level of the preceding year. This was partly due to the increase in travel of Polish citizens (occurring exactly just after the introduction of visas, perhaps denoting the temporary takeover of a part of trade activity from the Ukrainians).

In 2005 there was a dramatic increase in the share of Polish citizens of the border traffic. This was first of all linked to the increase of fuel prices in Po-

land, which motivated the inhabitants of the border regions to buy fuel in Ukraine. Another factor may be the more rigorous procedures applied by the Polish Border Guards with respect to the citizens of Ukraine. Even if they had a visa, they were frequently denied admission due to the suspicion that they might take up an illegal job in Poland. This had not happened in the preceding years.

The changes in traffic described here apply only to road traffic. Traffic at railway border crossings has decreased quite evenly over the entire period. In 1992 the share of border crossings by rail was 40% and decreased to 4.5% by 2003. Initially, this share was bigger for foreigners (this was the transport means of petty traders), while later on and still today more Poles cross the border by train. Ukrainians shoppers travel by car or by coach. For Poles travel by train has the advantage of avoiding waiting at the border.

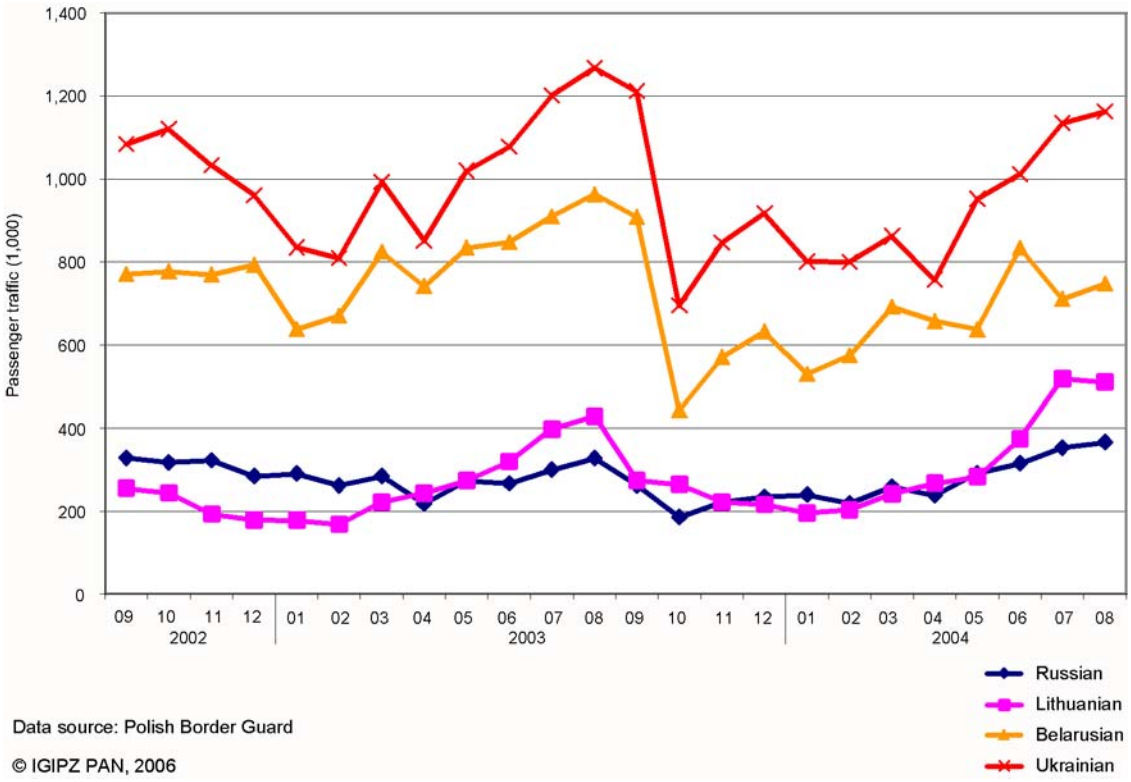


Figure 50 Passenger traffic at the Polish Eastern border 2002–2004

HGV traffic across the Polish-Ukrainian border increased continuously since the downfall of the Soviet Union (the years 1990-1992), until the year 1997. In the years 1998-1999 there was a short breakdown followed by a continued rapid intensification. Similarly as in passenger traffic, the breakdown of the year 1998 was less than on the Belarusian border.

The opening of subsequent border crossings resulted not only in the de-concentration of goods traffic. There were also shifts of traffic between the crossings associated with the lengths of queues, the severity of inspections or the installation of control facilities (especially vehicle weighting). In the period of 24 months analysed in detail (September 2002 to August 2004), HGV traffic was subject to standard seasonal fluctuations with a peak at the end of the calendar years and a more pronounced minimum in January. The influence of the introduction of visas for Ukrainians on the intensity of traffic is not perceptible. The spring increase in 2004 was observed earlier than in the preceding year, which allows the assumption that either the accession of Poland to the European Union had no influence on the volume of traffic or that this impact was positive. In these terms the situation is different from the one observed on the Belarusian border, where a decrease of traffic was observed in May 2004.

The increase of traffic of heavy goods vehicles in the years 2004-2005 took place first of all at the border crossing of Korczowa along the direction of route E-40 (Dresden-Cracow-L'viv) (see Figure 51). In the previous years the biggest flows of goods were observed along the direction of Kiev-Warsaw-Berlin. The change may have been caused by a relative advance of the construction of the Polish motorway A-4 (the segment between Cracow and Bolesławiec, some 40 km from the German border).

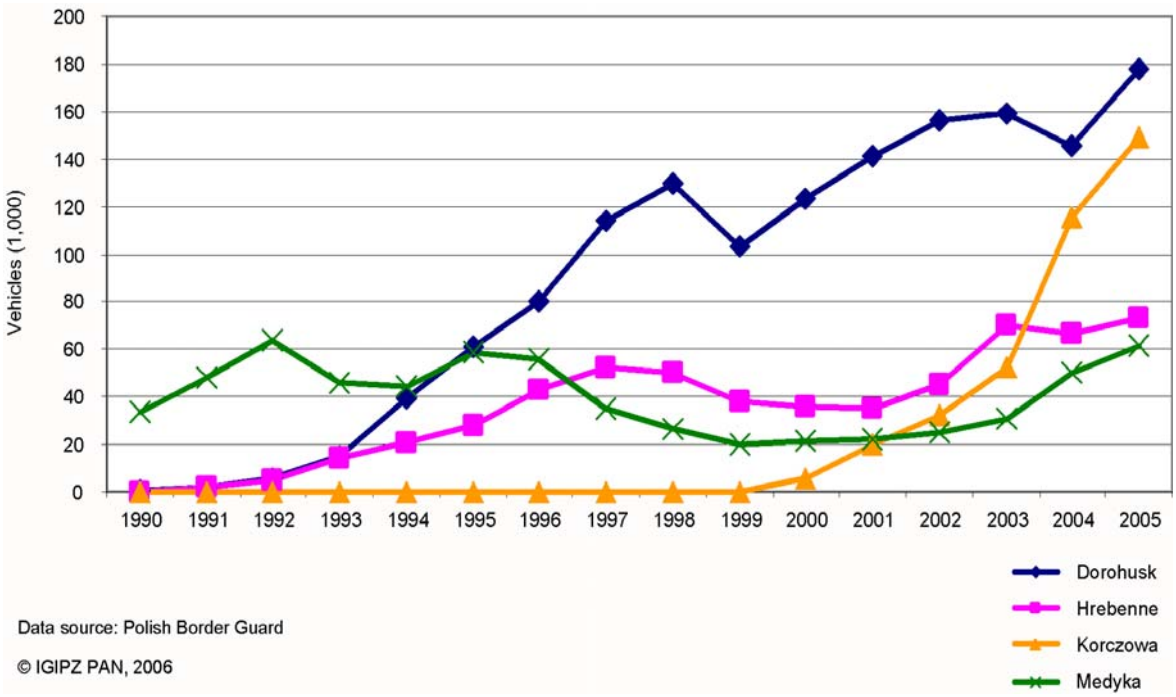


Figure 51 Polish-Ukrainian HGV border traffic by border crossing 1990-2005

Conclusions for ESPON

The analysis carried out allowed the formulation of the following conclusions concerning the transformations of the Polish border traffic of people and goods connected with the enlargement of the European Union in 2004.

- The EU enlargement of 2004 caused an increase of border traffic both across the new internal borders of the European Union, and the external ones (except for the Polish-Belarusian border) both in passenger traffic and goods traffic.
- The structure of traffic underwent a transformation as well. The increase at the internal (Polish-German) border took place mainly on the basis of the increase in the number of foreigners coming to Poland, while Poles participated primarily in the increase at the external (Polish-Ukrainian) border.
- There was also a significant increase in the diagonal direction of movements in the transport of goods from the north-east (the Baltic states) to the south-west (the Czech Republic).
- The deregulation of markets and the appearance of low-cost airlines caused a rapid increase and decentralisation of air traffic.
- The previously existing specialisation of the individual border crossings in terms of traffic structure was preserved. Poles dominate in the traffic in the directions of the old EU member states at the large transit crossings (that is in long-distance traffic), while foreigners (mainly Germans) dominate in local traffic.
- First effects of the changes in the intensity of heavy goods vehicle traffic caused by the investments made in roads in Poland and the Czech Republic can be observed.

In conclusion, the analysis of border traffic is an essential complement for the analysis of flows based on origins and destinations. It may provide verification, especially for studies, in which the data are just estimates or model outputs. Difficulties appear if it is attempted to link the data on trade with data on heavy goods traffic. This is possible only at the external borders of the European Union, where the data on trade flows continue to be based on customs clearance and so it is feasible to determine the origin of goods.

The data on border traffic may also be use to verify data on international tourism. It is possible to relate the numbers of persons of a certain nationality crossing the border of a given country or region to and the number of tourists being serviced by the hospitality industry. The share of the latter is usually small in the case of neighbouring countries. Drawing up a balance of

inward and outward trips of the citizens of a country may also contribute to the correct estimation of migration data. Despite numerous reservations, border traffic may therefore be the starting point for an integrated analysis of flows between two countries or regions. Of particular interest are studies on cross-border flows between the old and new EU member states and across the external borders of the European Union.

In addition, the analysis of cross-border flows provides the opportunity for determining the development potential of border regions. It allows the estimation of demand for trans-border transport infrastructure and traffic-related services. Especially important in this research is the identification of concentration of flows on selected routes and border crossings.

Under a broader perspective, the analysis of the evolving intensity and structure of cross-border flows between the EU member states offers insights into the process of territorial cohesion. Conversely, flows across EU external borders reflect important relations between the EU as a whole and its neighbouring countries, while their observed fluctuations may be associated with particular policies, such as changing visa regulations, changing severity of inspections etc. The impact of alternative future policies could be simulated over a longer time perspective.

7.7 Commuter flows

Many passenger flows are occurring below the spatial resolution usually applied in ESPON research, i.e. below the NUTS-3 level. Commuter trips occur mostly within one municipality or between nearby municipalities, i.e. within or between LAU-2 areas that belong to one NUTS-3 region. But at the same time, daily commuting patterns reflect also the spatial pattern of cities and urban-rural relationships, i.e. the degree of polycentricity of urban systems. In this way, an analysis of commuter flows has significant relevance for European spatial development. The focus of the demonstration example is on the spatial pattern of commuter flows in the light of spatially relevant issues, such as polycentricity and urban-rural relationships and of dynamics over time.

Data

In the demonstration example commuter flows in the state of North-Rhine Westphalia in Germany are analysed using a database compiled by the Statistical Agency of North-Rhine Westphalia (LDS, 2005). The database contains all commuter flows for working and education between the almost 400

municipalities or LAU-2 areas in North Rhine-Westphalia for the years 1987, 1998, 2000 and 2002. Most of the data are based on labour force and university registers, parts of the database, for instance for self-employed persons, have been estimated by the agency in order to provide a complete data set. Thus the data allow insights into spatial interaction patterns of two important domains of daily life, working and education, over time. In addition, figures from previous work on commuter pattern in Germany are used for this demonstration example.

Methods applied

No specific methods are applied in the demonstration example on commuter flows. In most cases, only the raw commuter data were transferred into indicator values, e.g. the number of out-commuters was recalculated into the percent of out-commuters of all workers of a municipality. Besides that, experiments with innovative cartographic representations of flows are part of the case study. Besides common choropleth maps showing commuter at the place of origin and destination, some attempts were made to display the flows between trip origin and destination in the form of lines or three-dimensional surfaces.

Main results

The main results of this analysis are presented in a series of maps showing different aspects of commuting in North-Rhine Westphalia and other parts of Germany. First, the spatial patterns of commuter flows by municipality and their dynamics in recent years are discussed. Then, spatial interaction patterns are analysed under the viewpoint of the spatial organisation of agglomerations in Germany. The next subsection addresses the question of the appropriate spatial resolution of analysing commuter flows.

Spatial patterns of commuter flows

Very distinct spatial structures of commuter flows emerge for the state of North-Rhine Westphalia. Figure 52 shows the share of workers of a municipality that are going to another municipality for work, i.e. the out-commuters. Figure 53 presents the percentage of employees of a municipality that are coming from a different municipality for work, i.e. the in-commuters.

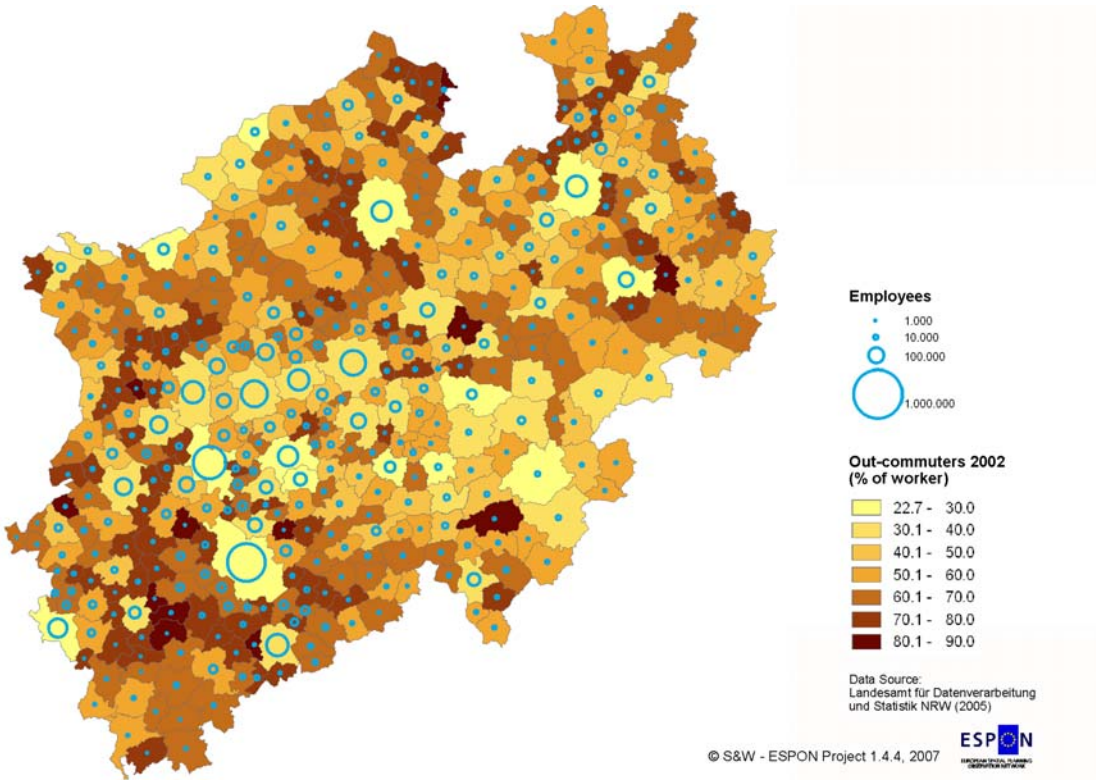


Figure 52 Out-commuters, North-Rhine Westphalia (NUTS 5), 2002

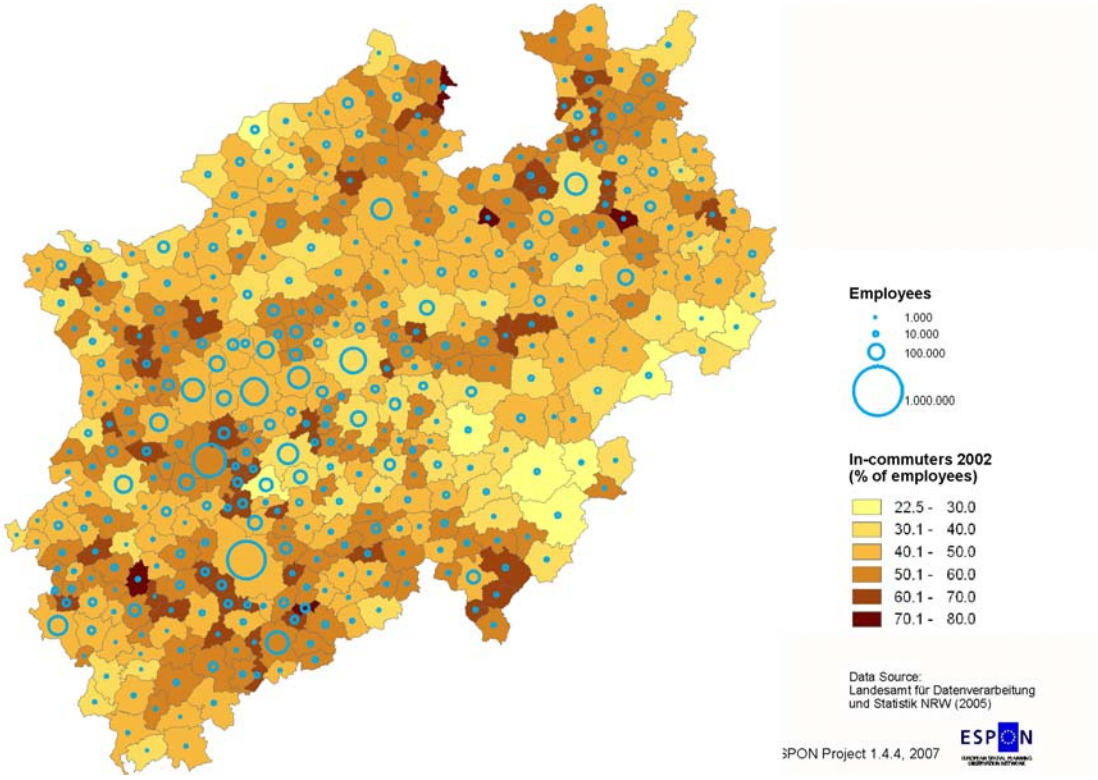


Figure 53 In-commuters, North-Rhine Westphalia (NUTS 5), 2002

The lowest shares of out-commuters are in the core cities of the agglomerations. In absolute terms, these cities offer a high number of jobs to their working population, of which therefore only few are forced to travel to other municipalities for work. The highest shares of out-commuters are in the municipalities surrounding these core cities. Here, the process of suburbanisation of population has led to commuter life styles in which the places of residence and work differ. In North-Rhine Westphalia, there are two areas that do not follow this overall pattern. On the one hand, the Ruhr area in the centre of the state has a band of cities that offer large number of work places with the consequence that the share of out-commuters in those core cities is much higher than in other core cities. On the other hand, the rural, south-eastern parts of the state do not show high percentages of out-commuters. This area seems to be so far away from the influence of the labour markets of the agglomerations that relatively many persons still work in the municipality in which they live.

The pattern of in-commuters is less clearly pronounced. The core cities are offering many jobs, but most of them are occupied by their residents so that the share of in-commuters is relatively low. Higher shares are visible in the suburban municipalities. Seen together with the high shares of out-commuters, the commuting intensity in the suburbs is rather high. The rural parts in the south-east have also low shares of in-commuters, i.e. the overall commuting intensity is low.

Spatial dynamics of commuter flows

Due to the mobility of persons on the labour market and to changes of their places of residents, the dynamics of commuter flows are rather high. Figures 54 and 55 show to what degree the spatial pattern of commuting has changed between 1998 and 2002, i.e. in a period of four years only. The figures display the change of the share of out- and in-commuters in terms of percentage points, i.e. if for example the share of out-commuter rises from 55 to 60 percent the change in percentage point is five.

The overall trend in commuting is growth. More and more people travel to other municipalities for work. Whereas the number of jobs increased by 4.4 percent between 1998 and 2002, the number of out-commuters rose by fourteen percent in the same period.

Highest rise in the share of out-commuters is visible in the peripheral locations in North-Rhine Westphalia. This is followed by a large increase in the core cities, mainly in the Rhine corridor. That means that out-commuting is not only a feature of suburban locations, but is becoming also important for large cities that offer a large number of jobs for their own residents.

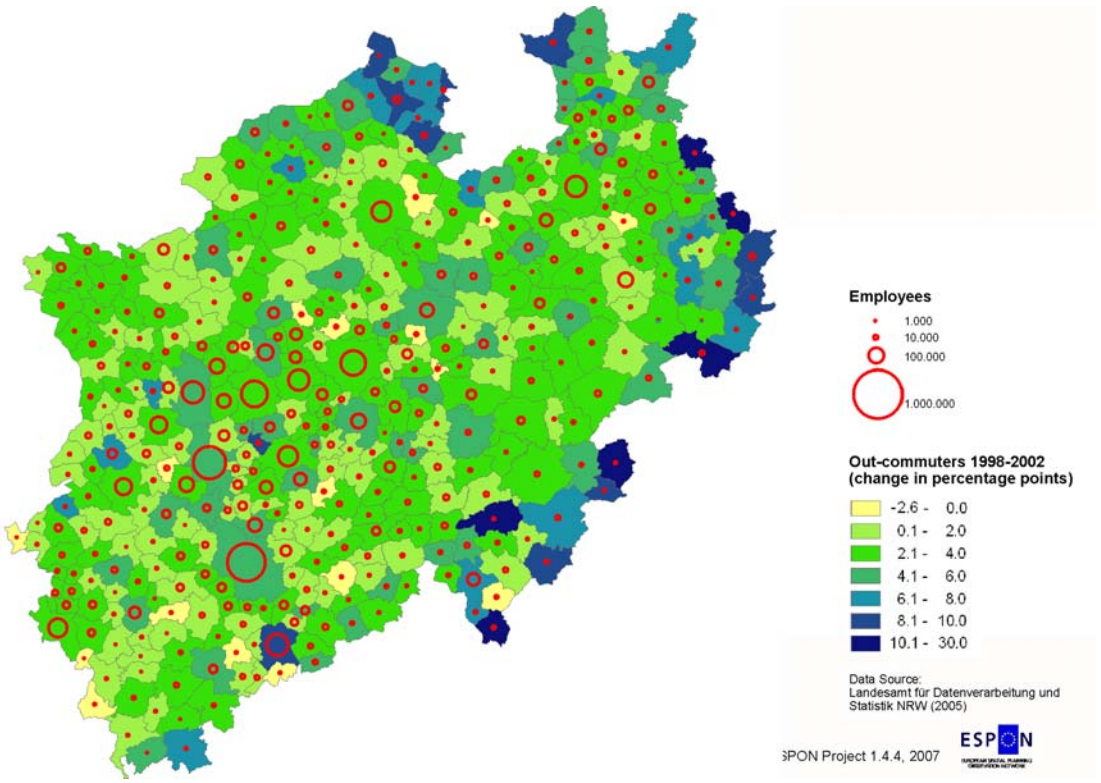


Figure 54 Out-commuters, North-Rhine Westphalia (NUTS 5), change 1998-2002

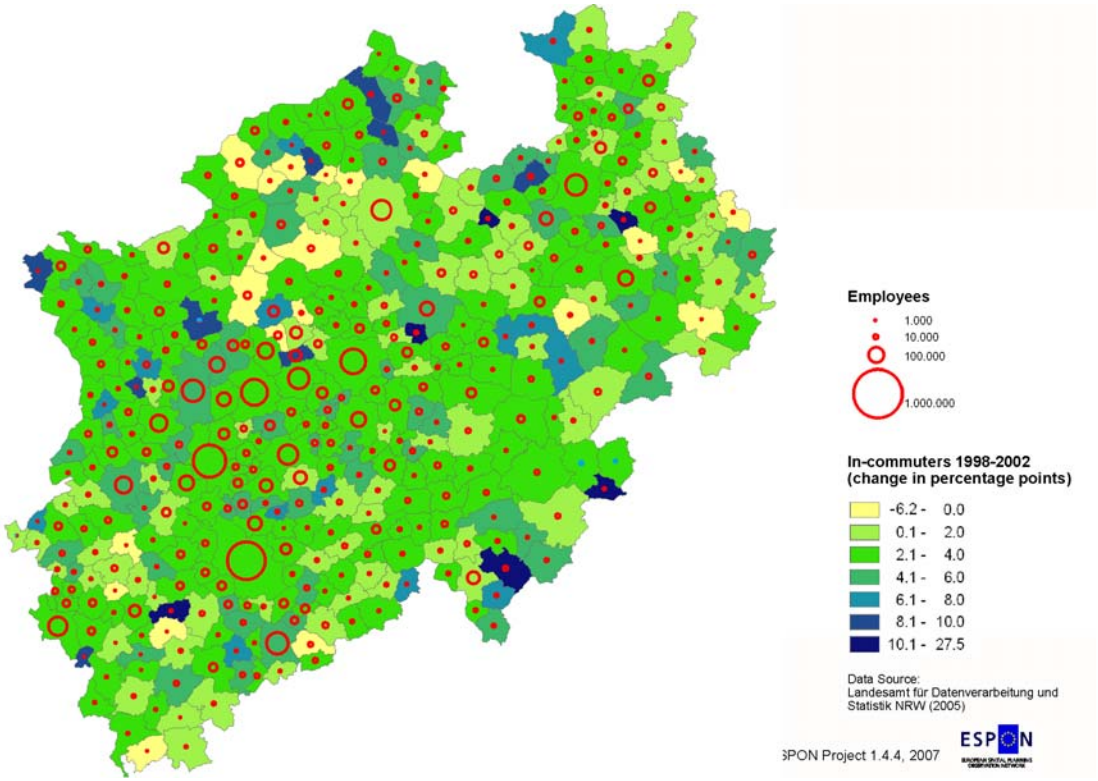


Figure 55 In-commuters, North-Rhine Westphalia (NUTS 5), change 1998-2002

For the change of in-commuters, the spatial pattern is less clear. There are smaller cities in rural locations that have low increases, other display the highest increases in North-Rhine Westphalia. The same is true for the core cities. Some of them have clearly pronounced growth in in-commuting, others only moderate increases.

Spatial interaction patterns of commuter flows

Commuter flow data are an ideal data set to analyse the spatial organisation of agglomerations and their relation with rural areas. This is done here by visualising spatial interaction patterns of commuter flows. Figures 56 to 58 show maps of commuter patterns of three different agglomerations in Germany based on a different data set, i.e. a subset which contains only workers subject to social security insurance. The maps show the number of jobs in each municipality, the commuting balance (blue: negative, red: positive) and the actual size of commuter flows between municipalities.

The maps display the spatial interaction pattern for the three German agglomerations Munich, Rhine-Main and the Ruhr area. Very distinct spatial settings become visible.

Figure 56 shows the commuter pattern of the Munich agglomeration in the south of Germany. Munich is the prime example for a rather monocentric urban region. The core city offers the majority of jobs in the agglomeration. The overall direction of the commuter flows is directed from suburban locations towards the core, i.e. a star-like flow pattern emerges. There is only very little interaction between the cities in the suburbs; most of them have a negative commuter balance. However, it is also visible that the city of Munich has already grown over its administrative boundaries. Some of the neighbouring municipalities offer a substantial number of jobs and have like Munich a positive commuter balance.

The commuter flows in the Rhine-Main agglomeration are displayed in Figure 57. The urban region appears to be rather polycentric. Frankfurt acts as a dominating core city with the highest number of jobs attracting a high volume of commuter flows and leading to a clear positive commuter balance. The city of Frankfurt is supported by a number of smaller centres which also offer a substantial number of jobs leading to significant shares of commuter flows in the region and a positive commuter balance. Major commuter flows are visible between these regional cores. The smaller cities have net commuter losses. Clearly visible is that Frankfurt, but also the secondary core cities in the region, have developed their own area of influence in which workers commute from a ring of smaller municipalities to the centres.

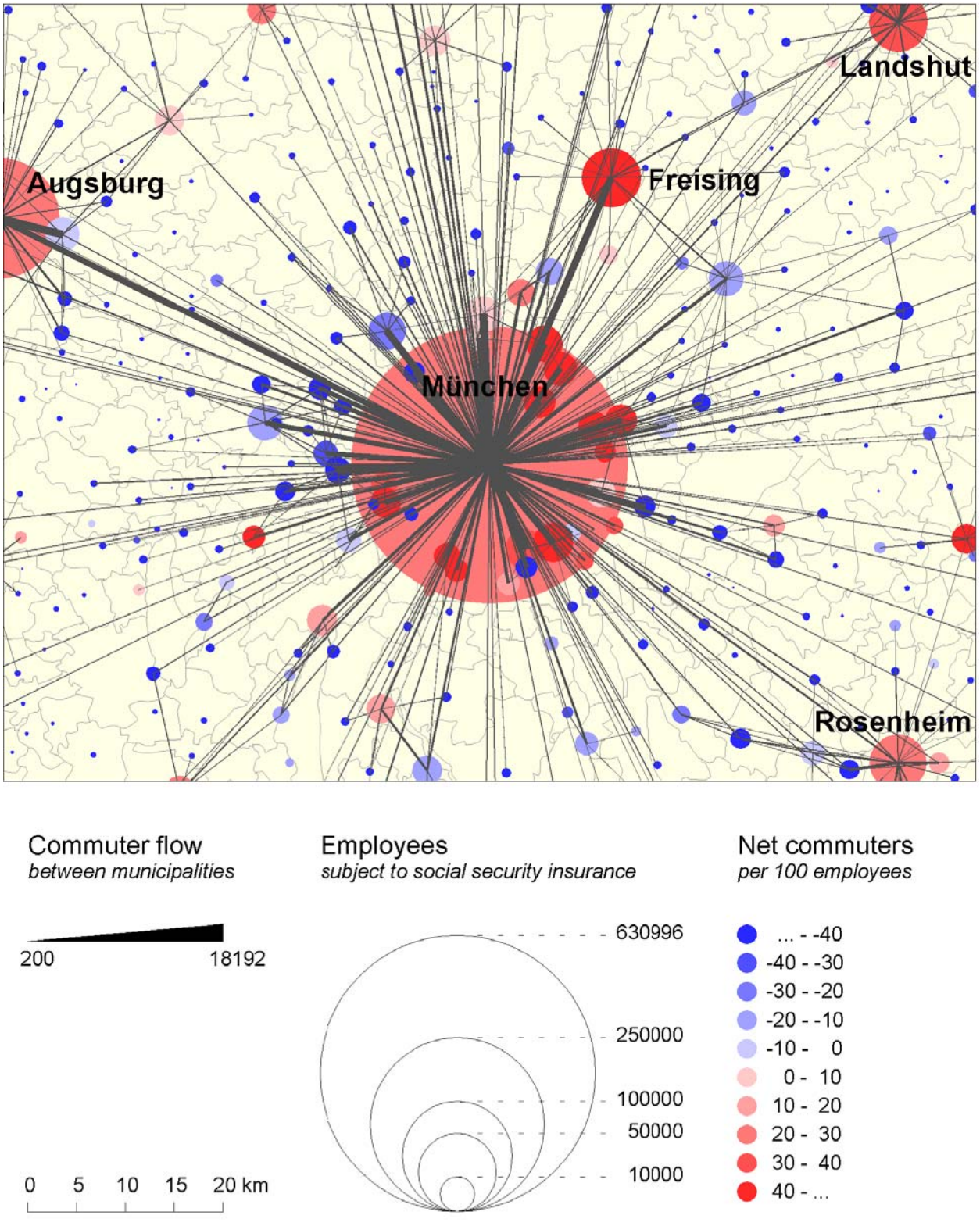


Figure 56 Commuter flows in the Munich agglomeration (Bade and Spiekermann, 2001)

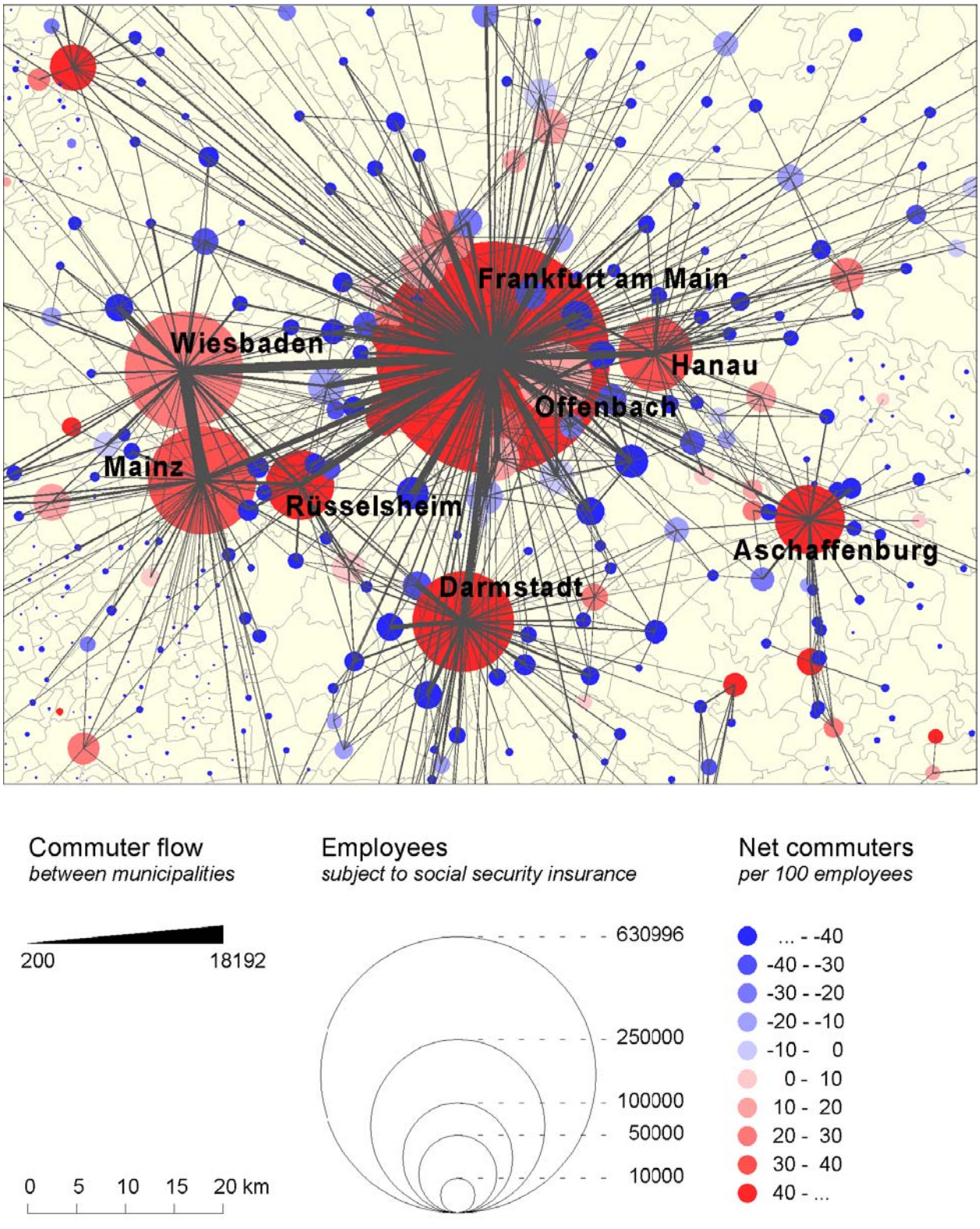


Figure 57 Commuter flows in the Frankfurt agglomeration (Bade and Spiekermann, 2001)

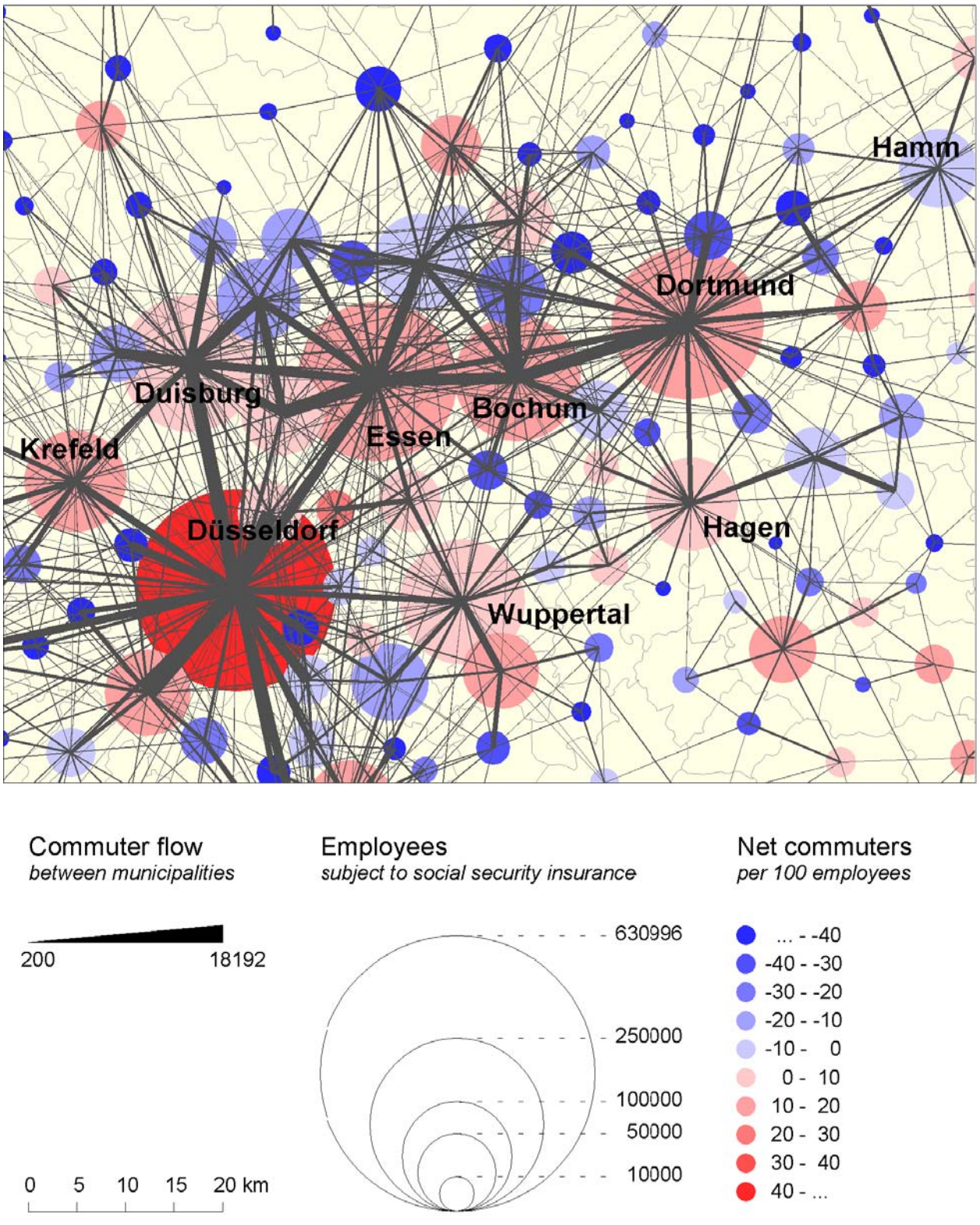


Figure 58 Commuter flows in the Ruhr area (Bade and Spiekermann, 2001)

The map in Figure 58 shows the commuter pattern of the core area of North-Rhine Westphalia, the Rhine-Ruhr metropolitan region ('Ruhrgebiet').The map reveals the overall spatial pattern of the agglomeration which can be seen to be somewhere between a polycentric and a dispersed urban region. The pattern of commuter flows is rather complex, but with some significant flows along two major axes. Apart from the five largest cities, the commuter balance does not correlate with city size: larger cities may have a negative balance, smaller cities a positive one.

Spatial aggregation of commuter flows

Commuter flows have been presented so far based on municipality flow data, i.e. at the LAU-2 level. This is the spatial resolution necessary to analyse issues related to the urban system and the internal and external spatial interactions of agglomerations. If one would aggregate commuter flows to NUTS-3 regions, most of the flows would disappear as they occur within a region. However, there might be good reasons to work with such aggregated commuter flow data. On the one hand it might be easier to develop a comprehensive picture of commuter flows for instance for a whole country, on the one hand aggregate commuter data might be linked with other data available only at NUTS-3 level such as GDP.

In Figure 59 an attempt has been made to visualise commuter flows in Germany based on NUTS-3 flow data. In the three-dimensional map the intensity of commuter flows through areas is represented by the height of the surface. Admittedly, the detailed information given in the previous maps is lost, however, the basic characteristics of commuting in Germany become visible. The urban agglomerations and their areas of influence can be depicted through the commuter catchment areas. Also visible is some long-distance commuting, e.g. between Frankfurt and Munich or from Berlin to several major cities. These corridors apparently reflect non-daily commuting which is recorded in the underlying database as well.

Conclusions for ESPON

The demonstration example on commuter flows differs from the other demonstration examples through the utilisation of spatially detailed flow data at the LAU-2 level. This has two implications for further ESPON research. Firstly, there is no Europe-wide commuter flow database available neither at the most appropriate spatial levels of LAU-1 or LAU-2 nor at the less useful level of NUTS-3. Secondly, it has been demonstrated that commuter flow analysis would enrich the insight into spatial development processes in Europe.

Figure 59 Commuter flows in Germany based on NUTS-3 data (Spiekermann,1997)

The conclusion for further ESPON research is that more attention should be paid to commuter flow analysis. It would contribute to a deeper understanding of spatial development processes through the inclusion of important issues of spatial interaction. Given the variety of thematic topics which would benefit, commuter flow analysis should not be an isolated theme of one project, but an integrated part of several projects dealing with the European urban system, urban-rural relationships, economic and social development etc..

However, reflecting the data situation, a decision has to be made whether to invest in the establishment of a harmonised Europe-wide commuter flow data base with appropriate spatial resolution based on national commuter flow data bases and amended by generated commuter flow data through spatial interaction modelling, or whether projects with commuter flows should base their analyses on case studies in countries for which commuter flow data are available.

8 Conclusions

The study "Preparatory Study on Feasibility of Flows Analysis" was designed as a feasibility and pilot study. Its main objectives were, building on existing work in ESPON, to give an overview on existing research, analytical concepts, indicators and data sets which are relevant for flows analysis in ESPON, to demonstrate suitable research methods for flows analysis and to elaborate a proposal for future applied spatial research covering the theme of flows analysis.

8.1 Added value of flows analysis

Based on the review of the state of the art of flows analysis, existing data sources and relevant application fields, the main results of the project can be summarised as follows:

The project identified ten types of flows as of particular importance for ESPON: *trade flows*, *financial flows*, *migration flows*, *transport flows*, *commuter flows*, *tourist flows*, *cultural exchange*, *information flows* and *environmental flows*. It was found that these types of flows are indispensable ingredients of a holistic analysis of spatial development and of direct relevance for EU policies, such as economic policy, regional policy, transport policy, agricultural policy, technology policy and environmental policy.

These types of flows have significant importance for the main goals of the European Union, economic competitiveness, territorial cohesion and environmental sustainability. Financial, trade, tourist and transport flows have direct impacts on the economic performance of regions, migration flows, information flows and cultural exchange flows play a significant role for the economic and social cohesion between regions and countries, and transport flows and environmental flows in the form of air and water pollution are relevant for the achievement of sustainability objectives.

8.2 Feasibility of flows analysis

The project reviewed the state of the art with respect to each of these types of flows and found that there exist *theoretical concepts* and feasible *analytical methods* for monitoring, analysing, assessing and forecasting them at all spatial scales from the European to the local level.

However, because of the *complexity* of the forecasting models required, not all types of flows are suitable for establishing a forecasting capability in ESPON. This is the case for transport and environmental flows and may be true for other types of flows.

Because of this it will be necessary to use the results of existing models and efficient forms of *co-operation* with other research institutions and European

agencies. For other types of flows, where no expertise exists, original innovative work by ESPON is required.

Data on spatial flows are in general incomplete or entirely lacking. Data on flows between NUTS-2 or NUTS-3 regions, the main levels of interest of ESPON, exist mostly only within one country. Where trans-national flow data are available, they suffer from insufficient spatial resolution or lack of standardisation.

Methods of bridging data gaps or generating synthetic interregional flow data from spatially more aggregate flows or even origin and destination data are therefore major challenges of flows analysis.

Table 9 gives a final assessment of the different flow types considered. For most flow types, NUTS-3 is the appropriate spatial level of analysis, but some flow types need a higher spatial resolution. For some flow types, an analysis at the NUTS-0 level is probably more feasible and might bring already some additional knowledge. Flows analysis would potentially contribute to the analysis of major European policy objectives and spatial development issues. However, it has also to be stated that there are major restrictions for flow analysis which mainly stem from the unsatisfactory data situation, but which can be overcome by the development and application of data generation methods.

8.3 Recommendations for future ESPON projects

Considering the complexity and high degree of specialisation of the different types of spatial flows and application fields, the research team decided not to propose one single future ESPON project on flows analysis. Such a project would be too large and would require the simultaneous specialisation in too many fields which do not necessarily require co-operation.

Instead it was decided to propose six projects in which flows analysis plays a major role: three projects on specific flow types and three projects on the integration of flows analysis into spatial analysis:

8.3.1 Projects on specific flow types

The first three projects should deal more intensively with specific types of flow than it was possible in this pilot and feasibility study:

Migration flows

The objective of this project is to develop and test a model of interregional and international migration flows in Europe. Such a model is indispensable for a holistic view of regional development and a necessary complement of regional demographic or demo-economic analyses and projections.

Table 9 Final assessment of flow types for analysis in ESPON

Flow type	Appropriate spatial levels of analysis	Potential contribution for analysis of	Restrictions and information gaps
Trade flows	- NUTS-0 - NUTS-3	- Economic competitiveness - Economic and social cohesion - Territorial cohesion	- Harmonised trade data at regional level not available - Intranational trade data lacking - Data generation methods required
Financial flows	- NUTS-0 - NUTS-3	- Economic performance - Economic and social cohesion - Territorial cohesion	- Harmonised financial flow data at regional level not available
Migration flows	- NUTS-0 - NUTS-3	- Population development - Economic and social cohesion - Territorial cohesion	- Regional migration flow data for ESPON space not available - Data inconsistencies and gaps for international migration - Data generation methods (models) required
Transport flows	- NUTS-2 - NUTS-3	- Economic performance - Environmental sustainability	- Relatively good data situation, but few observed data, mainly model estimates - Modelling capacity outside ESPON
Commuter flows	- NUTS-3 - LAU-1 - LAU-2	- Urban system / polycentricity - Urban-rural relationships - Regional welfare	- Harmonised data not available; many data gaps - Major effort required to generate European commuter flow database
Tourist flows	- NUTS-0 - NUTS-3	- Economic performance - Environmental sustainability	- Incomplete flow data, place of origin often missing, regional data often missing - Data include often other trip purposes
Cultural exchange	- NUTS-0 - NUTS-3	- Economic and social cohesion	- Heterogeneous data sources - No full data coverage of cultural exchange
Information flows	- NUTS-2 - NUTS-3	- Economic performance - Economic and social cohesion	- Data availability at regional level - Limited data access because privately owned
Environmental flows	- NUTS-3	- Environmental sustainability	- Relatively good data situation, but few observed data, mainly model estimates - Modelling capacity outside ESPON

The research in the project should include a review of the state of the art of interregional and international migration modelling and of existing national and international migration data, the development of methods to harmonise data from different countries based on different definitions of migration, the development, calibration and validation of the model and its application for a number of policy-relevant scenarios of different immigration policies in EU and non-EU countries. The model should be designed to forecast migration flows between NUTS-3 regions that can be aggregated to higher levels.

Expected results of the project are advances towards a harmonised database of interregional and international migration in Europe, the provision of very important indicators, such as interregional and international migration flows by age, sex and nationality, and the results of exploratory scenarios of the impacts of different immigration policies of different groups of countries for the social and economic development of the regions in Europe.

The results of the project would support the policy discussion on global migration flows and their impacts on the European Union and its regions and would also support the policy objectives related to a balanced spatial development of the European territory.

The project would last about 30 months and require a budget of about 600,000 Euro.

Freight flows

The objective of this project is to improve the description of mobility of goods by using different types of flow data, such as trade flows, freight flows or cross-border flows. Different types of data which provide alternative points of view on the same activity (freight transport) can be exploited to fill information gaps, correct inconsistencies, validate estimations, etc.

The project should improve existing indicators rather than develop new ones. The project should collect, check and harmonise freight flow data, compare data from different sources and produce revised and coherent indicators at different levels but with the main objective of improving transport flow data availability and analysis at the *meso* level (flows between regions). Important tasks of the project should also be to connect origin-destination matrices with observed transport data (e.g. cross-border and road traffic data) to obtain the observed flow information for selected transport corridors, to connect it with previous model estimations, to classify regions according to their economic interaction and finally to prepare recommendations for European transport policy, in particular transport infrastructure policy.

Such indicators would help to monitor the development of patterns over time, i.e. to identify the evolution of linkages between regions and their contribution to the cohesion in the EU space. Goods flow indicators should be treated both as direct object of the study and as indicators of national and international economic interaction between the regions of the ESPON space.

In policy terms, comparing the pattern of intensity and structure of goods flows by mode of transport with other indicators already existing in the ESPON framework (like e.g. environmental or economic performance indicators) would be relevant for both sustainability and competitiveness objectives. For instance, it would allow to study the relationship between goods flows and sustainability (e.g. impacts of goods vehicles traffic on the air quality of regions) or competitiveness of EU regions (e.g. correlation between regional development and freight transport growth).

The project would require about 24 months to be completed; the necessary budget is in the range of 250,000 – 300,000 Euro.

Passenger flows

The objective of this project is to improve the description of mobility of individuals by using different types of passenger flow data – tourist flows, passenger flows and cross-border flows. Different types which provide alternative points of view on personal mobility can be exploited to fill information gaps, correct inconsistencies, validate estimations, etc.

The project should improve existing indicators rather than develop new ones. The project should collect, check and harmonise passenger flow data, compare data from different sources and produce revised and coherent indicators. Indicators could be produced at different levels, but the project should be especially focused on improving passenger flow data availability and analysis at the *meso* level (flows between regions). Important tasks of the project should be to connect origin-destination matrices with observed transport data (cross-border and road traffic data) to obtain observed flow information for selected transport corridors, to compare it with previous model estimations, to classify regions according to their interaction with other regions of the ESPON space and beyond and finally to prepare recommendations for European transport policy, in particular transport infrastructure policy.

The enhanced set of indicators would allow to gain a deeper knowledge of the pattern of passenger flows at the regional level in the EU. In particular, different regional specialisations could be studied in more detail: in geo-

graphical terms (preferred destinations and origins), in economic terms (tourist, business, etc.) and in transport terms (modes).

As far as policy objectives are concerned, the indicators would help to monitor the development of patterns over time by identifying the evolution of linkages between regions and their contribution to cohesion in the EU. Comparing the pattern of passenger flows with other indicators already existing in ESPON (e.g. environmental, economic or infrastructure indicators) would be relevant to study the relationships between different types of passenger flows and sustainability (e.g. impact of mass tourism on regional environment) and competitiveness (e.g. contribution of tourism to regional development) of regions.

The project would require about 24 months to be completed; the necessary budget is in the range of 250,000 – 300,000 Euro.

8.3.2 Projects on flows and spatial development

The second group of projects should pick up project themes addressed already in ESPON 2006, review their results in the light of flows analysis and extend and enhance their results by bringing in the dimension of flows which was largely neglected in them.

Polycentricity

The objective of this project is to review and extend the results of ESPON 1.1.1 (2004) and ESPON 1.4.3 (2006) with respect to the dimension of flows. In both projects it was not possible to adequately deal with interactions between cities in space because of lack of data. However, interactions between cities, such as information flows, service flows or networks of cooperation etc. are central for the theoretical foundation of polycentricity.

The project should devise innovative methods of data collection on tangible and intangible flows in the "space of flows" (Castells) linking individuals, companies, cities and regions. The tasks of the project will include the development and test of extended indicators of polycentricity at the European, national and regional level taking better account of interactions and networks between cities and regions and analyse the historical patterns and scenarios of future development of polycentric urban systems in Europe. For a range of data and indicators the project should address the LAU2 level for data collection and analysis.

The expected results of the project are a better understanding of the meaning and added value of polycentricity of regional, national and European ur-

ban systems for EU goals, such as competitiveness, spatial cohesion and environmental sustainability.

Such a project would require about 30 months and a budget of about 600,000 Euro.

Urban-rural relationships

The objective of this project is to review and extend the results of ESPON 1.1.2 (2006) with respect to the dimension of flows. In the project it was not possible to adequately deal with interactions between city and countryside because of lack of data. However, interactions between city and countryside, such as commuter flows, information flows and service flows are central for sustainable urban and rural development.

The project should devise innovative methods of data collection on tangible and intangible flows linking cities with their hinterland. The tasks of the project should include the development and test of extended indicators of urban and rural relationships, such as functional urban regions or commuter catchment or retail service areas, with special emphasis on intangible flows, such as telework and e-commerce, and analyse the historical and scenarios of future development of selected urban systems. For a range of data and indicators the project should address the LAU2 level for data collection and analysis.

The expected results of the project are a better understanding of the relationship between cities and their hinterlands and their added value for EU goals, such as competitiveness, cohesion and sustainability.

Such a project would have a duration of 30 months; a budget of about 600,000 Euro should be foreseen.

Enlargement and beyond

The objective of this project is to review and extend the results of ESPON 1.1.3 (2006) with respect to the dimension of flows. In the project it was not possible to adequately deal with interactions between cities and regions in the new member states and between the new and old member states because of lack of data.

The project should devise innovative methods of data collection and analysis on tangible and intangible flows in the new member states and between the old and new member states. The tasks of the project would include the development and test of extended indicators of polycentricity and cohesion in the new member states compared with the old member states and analyse their historical development and scenarios of their future development. Particular attention should be paid to the analysis of flows across two different

types of borders, i.e. the borders between the old and the new member states and the new external borders of the EU, particularly the eastern borders of Estonia, Latvia, Lithuania, Poland, Slovakia, Hungary, Romania and Bulgaria. For both border types a dynamic analysis comparing flow dimensions before and after enlargements of 2004 and 2007 shall be carried out.

The anticipated removal of border control on borders between the new and old EU member states when joining the Schengen Treaty in 2008 provides a compelling argument for undertaking this study because the year 2007 might be the last year for which it is possible to carry out analysis based on a complete data base gathered by border services.

The expected results of the project are a better understanding of the meaning and added value of polycentricity for overcoming the gap in economic development, spatial cohesion and environmental sustainability between the old and new member states. The project would be the first study investigating the new flow patterns, spatial and functional linkages as well as cohesion effects as a consequence of the EU enlargements in 2004 and 2007. In addition, the results of the flow analysis between old and new member states as well as across the external EU borders may throw a new light on the current investment priorities in road, rail, air and telecommunication infrastructure. Therefore, the project could become the base for other ESPON projects focusing on development of transport networks and linkages in the field of new technologies. Seen from a broader perspective, the project would stimulate the necessary discussion about the feasible and desirable degree of closure or openness of the EU as an economic, political and social system.

The project would require 30 months and a budget of 600,000 Euro.

Part 3

Annexes

1 Indicators developed and datasets provided

In the context of the demonstration examples ESPON 1.4.4 developed and applied a number of indicators which are listed in Table A1.

Table A1 Indicators developed and applied in demonstration examples

Flow type	Indicator	Spatial scale	Spatial coverage	Year(s)	Data source
Trade flows	Regional export differentiated by destination	NUTS 3	PL	2000 2005	Polish Ministry of Finance
	Regional import differentiated by origin	NUTS 3	PL	2000 2005	Polish Ministry of Finance
Migration flows	International migration by origin and destination country	NUTS 0	All European countries	2002	SASI model
	Regional immigration by origin region	NUTS 3	ESPON space plus Western Balkan	2002	SASI model
	Regional outmigration by destination region	NUTS 3	ESPON space plus Western Balkan	2002	SASI model
Transport flows	Transported tonnes by region	NUTS 2	EU15, 8 NMS, CH, NO	2005	ETIS-BASE
	Freight transhipment by region and commodity type	NUTS 2	EU15, 8 NMS, CH, NO	2005	ETIS-BASE
	Intraregional freight transport by region	NUTS 2	EU15, 8 NMS, CH, NO	2005	ETIS-BASE
	International freight transport by region	NUTS 2	EU15, 8 NMS, CH, NO	2005	ETIS-BASE
	Road freight flows by transport link	Road links	ESPON space	2000	SCENES model
	Total trips attracted from other regions	NUTS 2	EU25, CH, NO	2005	ETIS-BASE
	Business trips attracted from other regions	NUTS 2	EU25, CH, NO	2005	ETIS-BASE
	Tourism trips attracted from other regions	NUTS 2	EU25, CH, NO	2005	ETIS-BASE
	Share of international trips attracted	NUTS 2	EU25, CH, NO	2005	ETIS-BASE
	Share of air transport attracted from other regions	NUTS 2	EU25, CH, NO	2005	ETIS-BASE
	Road passenger flows by transport link	Road links	ESPON space	2000	SCENES model
	Cross-border passenger traffic by nationality and border	NUTS 0	Borders of PL	1990-2004	Polish Border Guard

Flow type	Indicator	Spatial scale	Spatial coverage	Year(s)	Data source
	HGV border traffic by main transport corridors	Border crossings	PL	1990 2004	Polish Border Guard
	Border traffic by border crossing	Border crossings	Border PL/DE	1990 2004	Polish Border Guard
Commuter flows	Out-commuter by municipality	LAU2	North-Rhine Westphalia	1998 2002	Statistical Agency NRW
	In-commuter by municipality	LAU2	North-Rhine Westphalia	1998 2002	Statistical Agency NRW
	Commuter flows between municipalities	LAU2	North-Rhine Westphalia	1998 2002	Statistical Agency NRW
Tourist flows	Arrival of tourists from ten new member states in EU15	NUTS 0	EU15	2000 2005	Eurostat
	Arrival of tourists from EU15 in ten new member states	NUTS 0	EU10	2003 2005	Eurostat
	Foreign tourists in tourist accommodation by region	NUTS 2	HU, PL	2004	National statistical offices

As a preparatory and feasibility study, ESPON 1.4.4 was not meant to provide datasets for the ESPON database.

2 Indicators to be further developed

Because the indicators mentioned in Annex 1 were developed only in the demonstration examples of this feasibility study, all indicators have to be further developed in ESPON 2013 in the context of research projects dealing with flows analysis.

3 Missing data

It was shown in Chapter 5 of the report that for none of the thematic fields of interest for ESPON a complete Europe-wide set of flow data at NUTS levels 2 or 3 exists. Even in the field of transport, which is most advanced, the analysed data sources (that claim to provide complete data) showed problems with respect to spatial coverage, thematic completeness, quality and reliability. In other thematic fields, for instance commuting, data exist in many countries, however, no attempt has been made so far to harmonise definitions and collection methods, i.e. the data are only to a certain degree comparable.

In future, the situation might even get worse. Deregulation of the transport sector and further European integration with free markets and free movement of people and goods will lead to a further reduction of regularly collected flow data.

In consequence, any further ESPON project dealing with flow data has to develop reasonable solutions to overcome the data problems and has to be equipped with enough resources for obtaining, harmonising, completing and/or generating the flow data required.

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6 Publications of TPG members

Because of the short duration of the project no publications by TPG members on the subject of the study have been prepared so far.

7 Performance indicators

Table A2 Number of performance indicators achieved

Number of spatial indicators developed: - in total - covering the EU territory - covering more than the EU territory	 26 - 19
Number of spatial indicators applied - in total - covering the EU territory - covering more than the EU territory	 26 - 19
Number of spatial concepts defined	0
Number of spatial typologies tested	0
Number of EU maps produced	18
Number of ESDP policy options addressed in that field	35