ESPON

EUROPEAN SPATIAL PLANNING OBSERVATION NETWORK

ESPON project 1.4.4

Preparatory Study on Feasibility of Flows Analysis

Interim 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" is one of the last projects tendered in the ESPON 2006 Programme. The project belongs to the ESPON Priority 1 "Thematic projects" which address major spatial developments of European regions and cities. However, the main task of the study is 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 II.

The project commenced in spring 2006 and will be finalised at the end of this year. The Transnational Project Group consists of three partners:

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

In the second project phase four external experts will be engaged in order to cross-check and deepen the analysis in selected fields of flow analysis.

This report is the first and only Interim Report of the project. 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 for flow analysis to be elaborated in the second project phase.

The final report will be submitted at the end of October 2006. It will contain updates of the issues dealt with in this report, an introduction into methodologies 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 flow analysis and recommendations for future ESPON research with respect to flows.

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Part 1: Summary

1 Key messages and findings

> *"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 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 is 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 for ESPON.

The study "Preparatory Study on Feasibility of Flows Analysis" is designed as a feasibility and pilot study. Its main objectives areto 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 flow analysis.

This report is the first and only Interim Report of the project. 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 for flow analysis to be elaborated in the second project phase.

The work in this first phase of the project led to the following still tentative results:

- *Trade flows*, *financial flows*, *migration flows*, *transport flows*, *commuter flows*, *tourist flows*, *cultural exchange*, *information flows* and *environmental flows* are policy-relevant types of flow for spatial analysis.
- These types of flows have significant importance for the main goals of EU spatial policy competitiveness, territorial cohesion and sustainability.
- For each of these types of flows there exist *theoretical concepts* and feasible *analytical methods* for monitoring, analysing, assessing and forecasting flows at all spatial scales from the European to the local level.
- 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 certainly the case for transport and environmental flows and may be true for other types of flows.
- This will require the use of the results of existing models and efficient forms of *co-operation* with other research institutions and European agencies.
- *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.

The Final Report will be submitted at the end of October 2006. It will contain updates of the issues dealt with in this report, an introduction into methodologies 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 flow analysis and recommendations for future ESPON research with respect to flows.

The Final Report will include a critical review of the results obtained in the study and will give recommendations for further ESPON work with respect to flow analysis. The report will provide an assessment of the feasibility of flow

analysis with respect to the objectives of the ESPON programme and with respect to the added-value of flow analysis. Depending on the results of this assessment, draft terms of reference for in-depth research will be developed. Depending on the results terms of reference for one or more studies focussing on flow analysis or for thematic studies in which flow analysis is one relevant aspect will be developed.

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 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 is 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 II. The general objectives of this preparatory study are

- 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 EU 25+2+2 regions.
- to elaborate a proposal for a future applied territorial research covering the theme of flow analysis.

The project particularly addresses the following research questions and will provide information and guidance on these issues:

- *Which flows can be integrated into the ESPON analysis?* A wide range of different flow types will be 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 will be investigated and the problem of data availability and methodologies for estimating missing data will be addressed.
- *What are the implications of the integration of flow analysis?* A feasibility check will be made to get more insight on how flow analysis might work in practice and what problems might arise. For this purpose selected types of flows will be 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 will result in proposals for future policy-relevant research regarding flows in territorial analysis. Ideally this will turn out in a draft set of terms of reference for more detailed research projects dealing with flow analysis in ESPON II.

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

This report gives an overview on which flows are of interest to be studied by ESPON. For this, the political relevance of flow 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 flow analysis is indicated in Chapter 5. An outlook on the demonstration examples for flow analysis to be elaborated in the second project phase is given in Chapter 6. The report ends with first conclusions on the feasibility of flow analysis in ESPON research.

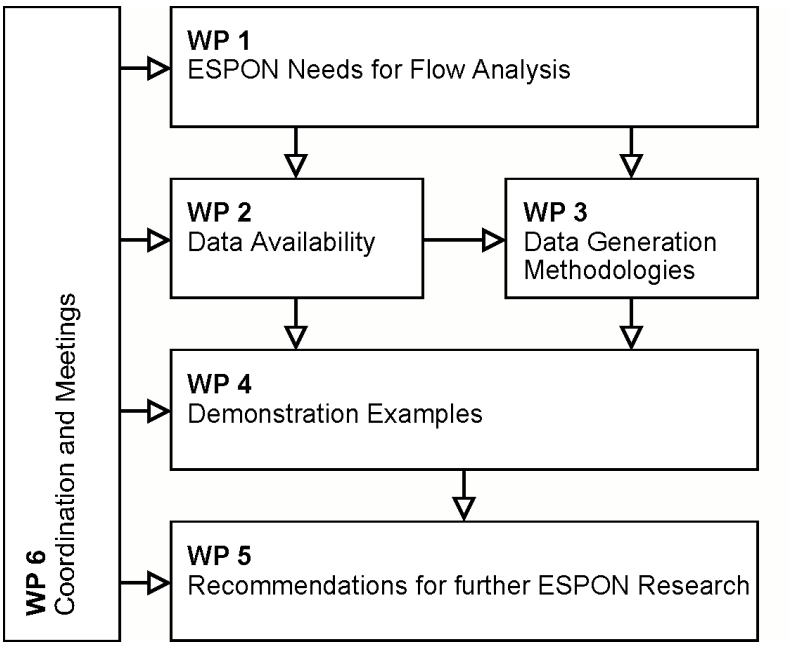


Figure 1 Project structure.

2 Political Relevance of Flow 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 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 is 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 for ESPON.

With the close linkage between trans-national and interregional flows for spatial development in mind, the political relevance of flow 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 will by examined with respect to existing and potential theoretical and empirical approaches to deal with them scientifically. In Chapter 5 the same types of flows will be assessed with respect to the availability of data for their analysis.

Trade flows

The ESPON projects to date have encompassed the entire space of the present European Union including the new member states. These projects analysed also the flows between those countries and regions (first of all ESPON 1.2.1 and ESPON 1.1.3). These analyses were, however, as a rule static, and concerned the situation before the enlargement of the European Union. Moreover, the quality of the data at disposal of the project teams was often different with respect to the old member states and the new accession countries. A lot of information was not based on data but on models in which not always up-to-date economic data were used.

Accession to the European Union brought about an abrupt increase of trade between the old and new member states. This necessitates a dynamic spatial analysis. Such an analysis would identify regions being the 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 and improvement of functioning of the respective enterprises, while increasing employment. There are practically no important obstacles that hamper investing and location of enterprises in any region of the integrating Europe. Yet, despite this, numerous less developed regions are still being omitted by the investors, which deepens interregional polarisation within the territory of the EU. The case study concerning capital flows will pay attention to this problem and will additionally emphasise it.

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

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 industry 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 continuously 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 tend to 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 the receiving countries. Spatially disaggregate demographic and economic forecasts therefore critically 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 regions 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 evidences of the inherent spatial nature of most social and economic activities. It is actually hard to imagine the life on a large continent like Europe without individuals and goods moving across the territory, both locally and on longer distances. Indeed, the growing integration of markets has recently given rise to an intensification of flows of passengers and especially freight, making transport one of the major inputs for the economic activity.

In the last years, transport has therefore deserved 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 1000 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 rises 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 territorial research 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 coming 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 those 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 going 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 and in particular tourist flows between the old and new member states and, equally important, also neighbouring countries, such as Bulgaria, Romania, Croatia, Turkey and Macedonia.

The analysis of statistical data should allow for answering the question whether and how the accession of the ten new member states had an impact on the general trends in tourism. Did tourist flow increase after the EU enlargement? What are their main directions? 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 will make it possible to identify the volumes of tourist flows and their structures (nationalities of tourists, numbers of visits, tourists using hotel infrastructure, 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, opening up of many of the labour markets in EU15 for residents of the new member states, and the vanishing of the barriers that had been constituted by the borders.

After the EU enlargement in 2004 the number and length of of border segments between the EU and third countries increased abruptly. Until then such a situation had existed only on the thinly populated areas of Scandinavia. Now the boundary of the EU with Russia, Belarus, Ukraine, Romania (until its eventual membership), Serbia and Croatia crosses the entire continent from the Baltic Sea to the Adriatic Sea. This process brings about a polarisation of the European border regime systems. 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 the rule) on the outer fringes of the EU.

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 (Romania, Bulgaria, Croatia and Turkey), but also to the remaining Balkan countries (Serbia, Montenegro, Macedonia and Albania) and the countries of Eastern Europe Ukraine, Belarus, Russia and Moldavia. The length of the present outer borders causes that omission of traffic crossing these borders deforms essentially the image of the existing interactions in all 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 ha 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 is now 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 does no longer matter 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 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 knows no boundaries. There is increasing transcontinental transport of air and water pollutants. There is growing awareness that trans-border air and water pollution is 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, NOx, VOCs and ammonia. Once the Protocol is fully implemented, Europe's sulphur emissions should be cut by at least 63%, its NOx 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 flows between countries and regions and create awareness about the most significant flows and the impact on quality of life an 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 degree that ESPON addresses intraregional and urban problems.

3 Analytical Framework for Flow 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 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 upon 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.

A. Wilson (1974) argues that spatial interactions and connections are expressed through transport, financial and information flows (the latter involving personal contacts, correspondence, telephone talks). J. C. Lowe and S. 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 themselves 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) according to regions (administrative units) of country A; (b) according to regions (administrative units) in country B; (c) according to directions of transport connections (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 processes is international trade (Wnorowski, 2002). At the same time, trade connections become less and less persistent in a spatial sense (Rogacki, 2001). Trade can no longer be analysed in abstraction from other kinds of connections, and especially capital interactions (foreign investments), but also to some extent the social ones (e.g. migrations).

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

In the domain of economic geography the theories of gravity and potential are used in description of flows of goods and capital. In the analysis of gravitational interaction an important role is played by the function of friction of 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 diminished perceptibly. Utility of this kind of models is sometimes questioned nowadays just because of the drastically decreasing role, in conditions of globalisation, of physical distance as the barrier to interactions in space and the factor shaping transport costs (Stryjakiewicz, 2002).

The gravity model is also often criticised for the assumption of full complementarity, a situation very rarely encountered in the real world (Ullman, 1957). Many authors think that the model describes correctly interactions between towns that are not far from each other. Its utility decreases already in the description of interregional 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 case of interactions crossing national borders (even when these borders are highly permeable) the jump-like change of the force of interaction 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 in conditions of Schengen area) gives rise to limitation of this kind of connection 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 (first of all 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 taking over of the interaction by a large centre (region) situated between the potentially connected areas. 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.

H. 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 spatial connections. The number of intervening opportunities increases, in particular, due to the integration process in Europe. At the same time, the globalisation process, which was 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 50 years after the principles of "Ullman's triad" were formulated, the role of complementarity and intervening opportunity in explanation of interregional connections increased, while the role of the factor of transferability decreased.

3.2 Financial flows

Financial flows are partly an element of the same setting of interactions with foreign trade flows. Movement of capital accompanies, namely, most often, by assumption, 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 (also at the "profiles" located between origin and destination), financial flows, based nowadays on telecommunication infrastructure, cannot be described in practice in similar geographic categories (having become similar with this respect to information flows).

Thus, in spatial studies we often concentrate on the effects of capital movement, and not on the financial flows themselves. Such effects are constituted by greenfield investments or those realised with funds of the European Union. Significant flows accompany also, on the other hand, the so-called portfolio investments (mainly done by the intermediary of 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 from the seasonal or permanent emigrants). These, however, are usually completely 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 cite as the firms with a share of foreign capital all those that have some foreign co-owners (even when their share is below 10%). Simultaneously, the agencies dealing with investments most frequently collect the 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 member states) will differ depending on the object of analysis, namely:

- spatial distribution of all 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 accession countries 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 professions in which there is a need for labour, or specific quotas for immigration from different origin countries. A special category are people applying for asylum for political reasons.

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.

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 migrate 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 at the origin region and the number of opportunities (e.g. jobs) at 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 constraint to immigration on the other, with the constraints being stronger.

3.4 Transport flows

As it will not be feasible to develop an autonomous transport modelling capacity in ESPON, the analysis of transport flows will concentrate 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, such indicators are unable to be 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).

Transport flows 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 at the basis of the need for transport indicators;
- the spatial dimension;
- the relevant aspects for a regional analysis of mobility;
- the segmentation of indicators.

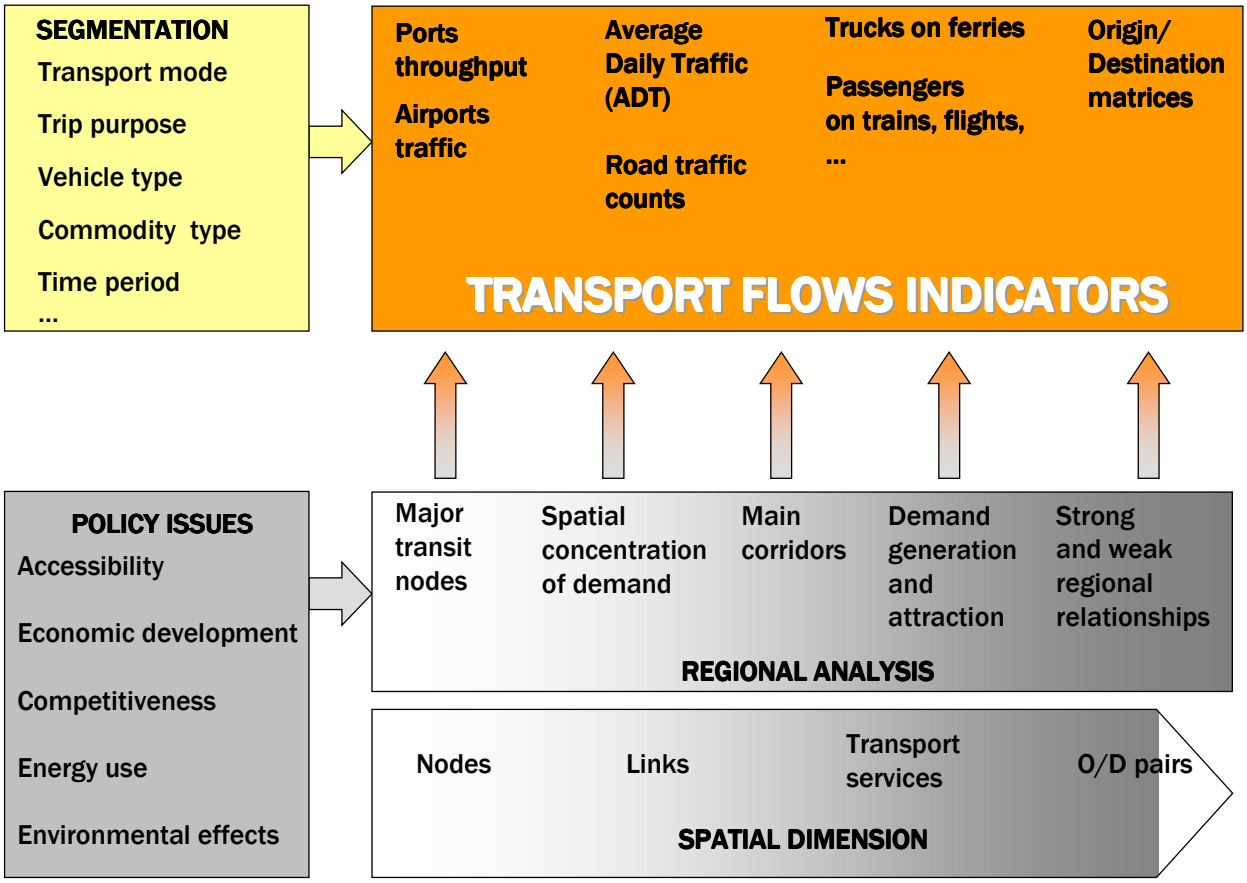


Figure 2 Analytical framework for transport flows indicators

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 individual, 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).

Transport models

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. Within the transport modelling practice, there are several methodologies to estimate flows matrices. We can distinguish two main categories of methodologies:

- numerical algorithms,
- algorithms based on generation and distribution models.

Numerical algorithms estimate flow patterns by making use of mathematical rules. An example of such techniques is the method consisting of estimating matrices starting from a set of observed traffic counts on a sample of links (Ortúzar and Willumsen, 1994). 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 a number of origin-destination pairs, whose demand uses that link. In Figure 3, for instance, traffic observed on link A is the result of flows from zone 1 to any other zone (and vice-versa), traffic on link B is the result of flows to and from zone 3, etc. If several counts are available on different links, mathematical relationships can be used to find the most likely origin-destination matrix within those that can give rise to the observed traffic data. 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). At the same time is necessarily a quite approximate technique and does not make reference to any theoretical model for explaining the configuration of transport flows in a study area.

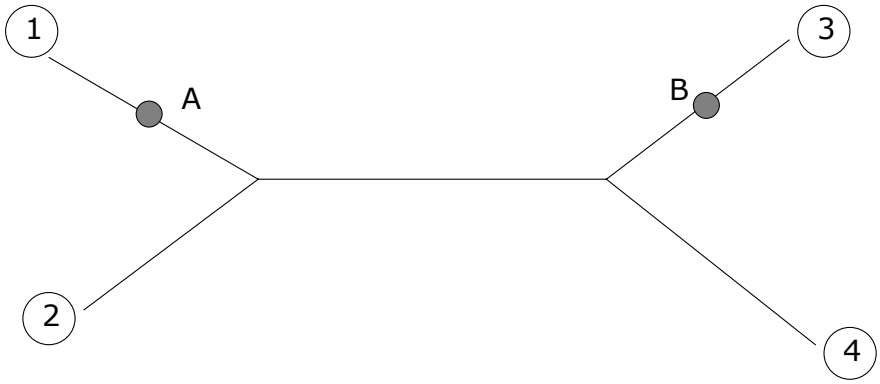


Figure 3 Estimating matrices from traffic counts (adapted from Ortúzar and Willumsen, 1994)

Other methods make use of some generation/attraction and distribution models. Generation/attraction models are used to defined total trips starting from and destined to each zone (Bates, 2000, Mc Nally, 2000). For instance, a very simple generation model consists of applying trip rates (number of trips per individuals) to the amount of population in each zone.

Once the total number of trips generated from and attracted by each zone (i.e. totals of the rows and of the columns of the origin and destination matrix) is defined, the origin/destination flows (i.e. the values of each cell of the matrix) can be appraised with different methods (see Figure 4):

- *The bi-proportional fitting (Furness method)*. This method consists in changing the values in the cells by applying correction coefficients computed such that the total of rows are replicated correctly, then applying new coefficients in order to replicated totals of columns, then correct again with respect to total of rows etc.. This iterative procedure is applied until a good approximation is reached both on rows and columns.

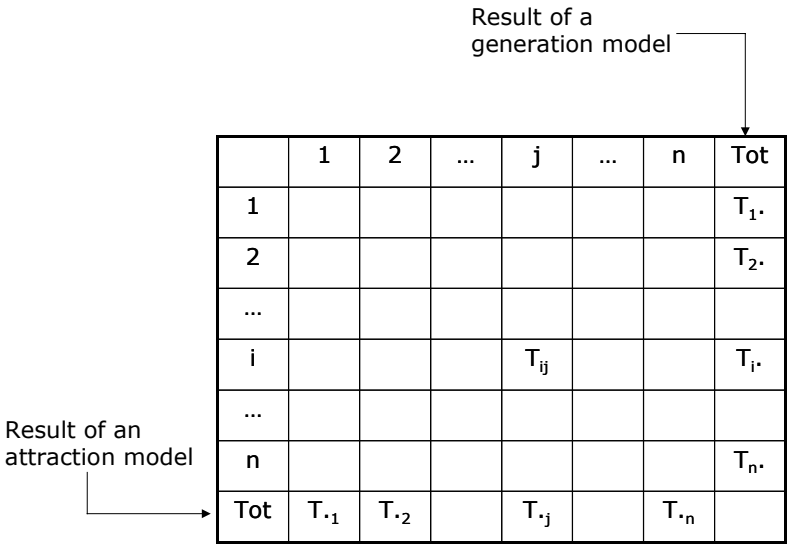
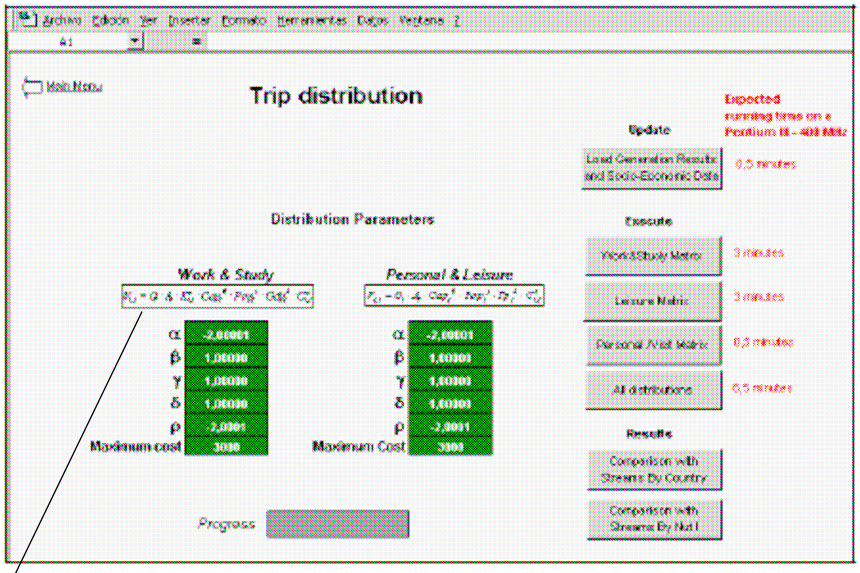


Figure 4 A generic trip matrix with totals of rows and columns estimated

- *Gravity models*. The Furness method is a purely numerical one. A more sophisticated methodology is based on distribution models, i.e. on synthetic explanations of the amount of flow between two zones. For instance, gravity models estimate the flow between two zones as a positive function of the total generation of the origin zone and total attraction of the destination zone and a negative function of the 'distance' between the two zones.

For a full detailed explanation of these and other methods see Ortúzar and Willumsen (1994).

A relevant example of the application of techniques for estimating transport flow data 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 metamodel 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 an European perspective. KTEN uses a passenger generation model based on trip rates to compute the number of trips generated from each NUTS-2 region, then applies a gravity-type distribution model to compute the matrix of origin-destination flows (see Figure 5).



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

Figure 5 Distribution model and interface of the KTEN passenger model (source: ESPON 3.2, 2006)

Origin-destination matrices can be also estimated through different types of models. For instance, in integrated land use and transport models the transport matrix can be derived as results of location and 'trade' choices (DETR, 1999). For instance, the European transport model SCENES (ME&P and TRT, 2001) has within its major features the endogenous estimation of the transport flow matrices. In particular, the freight flow matrix is obtained through

the application of a Regional Economic Model (REM) based on 'spatialised' input-output tables which produces information about the pattern of trade in commodities between regions within the modelled area (the internal zones) at the NUTS-2 level and to and from regions in the rest of the Europe (represented as external zones at the NUTS-0 level).

3.5 Commuter flows

The analysis of commuter flows in ESPON will be constrained by the same restriction that it will not be feasible to develop an autonomous transport modelling capacity in ESPON. Therefore the analysis of commuter flows will also concentrate 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" stems from the reduced or "commuted" fare paid for a rail season ticket (Wikipedia, 2006), i.e. reflecting 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 is across a municipal boundary, i.e. that place of residence and work are located in different municipalities.

Before 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. Since commencement of industrialisation commuting became a growing phenomenon (Ott and Gerlinger, 1992). The cause for the increase of commuter traffic was the spatial separation of residential and industrial or commercial areas induced by the specific location requirements of manufacturing and service industries leading to monofunctional residential areas at the urban fringe. 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 which is nearly independent from 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. Nowadays, a good fraction of students is not living in the university town but elsewhere, mainly at their parents' place, and is travelling by car or public transport to the university.

A second differentiation addresses the temporal aspect of commuting.

- Daily commuting is the prevalent frequency of commuting, i.e. leaving home in the morning to work and returning in the afternoon or evening.
- Weekly commuting or even less frequent commuting is another option chosen by a growing number of commuters. Those commuters have a second home or other forms of accommodation at their place of work or in the university town and are coming home to their main place of residence only for weekends.

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

- Commuters are counted as out-commuter at the origin, i.e. the place of residence. The out-commuter rate is the share of out-commuters in the total number of workers living in that municipality.
- Commuters are counted as in-commuters at the destination, i.e. the place of work or of education. The in-commuter rate is the share in in-commuters in the total number of jobs available in the destination city.
- Commuter which have both the place of residence and the place of work or education in the same municipality might be labelled as internal commuter.
- A commuter flow is the number of commuters travelling from one municipality to the same destination city.

All indicators are frequently 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 numerous jobs (directly and indirectly) and many observers believe that it generates a significant income multiplier. In an era where many traditional activities such as agriculture, logging or manufacturing have witnessed substantial decline, tourism has been boosted as one of the key sectors for economic restructuring.

Unfortunately, despite the obvious benefits associated with the 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 (one of the three prongs of sustainable development)?

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 both in the literature of the subject, 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 for job 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, other tourist objectives. Besides, the category of tourists may include also the "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 is constituted by the data collected at the state border. Then, however, the data include also the persons crossing the border when commuting to work and dealing with petty trade. On the other hand, the result-

ing category encompasses also the tourists visiting the neighbouring country for just a couple of hours and therefore are not registered in the overnight stay statistics. That is why the studies of tourist flows necessitate adequate precision in the use of available data and far reaching care in their 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 (see Section 2.7) 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 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.

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 flow analysis in ESPON

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 commences with projects in which flows are of potential value for the particular topic. Then, the analysis follows the thematic fields for flow 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. European-wide flows analysis, again with very few exceptions, is nearly lacking; 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 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 waived flows analysis more or less, 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 of ESPON 3.2 (2006). The assumptions on changing flows and the underlying causes made in ESPON 3.2 cannot be reported here. The transport model KTEN supporting the scenario work will be briefly described in Chapter 5.4.

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, 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, is also seen as ideal for measuring connectivity as one component of polycentricity. But the project 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

In the process of the enlargement of the European Union several flow pattern 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).

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 analysis on flows. In particular, 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 3.2 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 are 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 pattern 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 territorial research: "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 of the processes of convergence/divergence within EU29" (ibid., 31). The project did quantitative scenarios in which the current regional fer-

tility 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, as it will be discussed in Chapter 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 at origin regions, trips attracted at 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 in-

clude 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 the tourism function. However, no flow data were used, 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 expressed 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 in interaction 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 examines 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 are used for the indicator. It is 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 flow analysis

As for any other territorial analysis the availability of data of good quality with appropriate spatial resolution is crucial for flow 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 already 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 6):

- 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 pupils 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 from a certain place. Examples are the number of jobs or students available in 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, where does it come from?

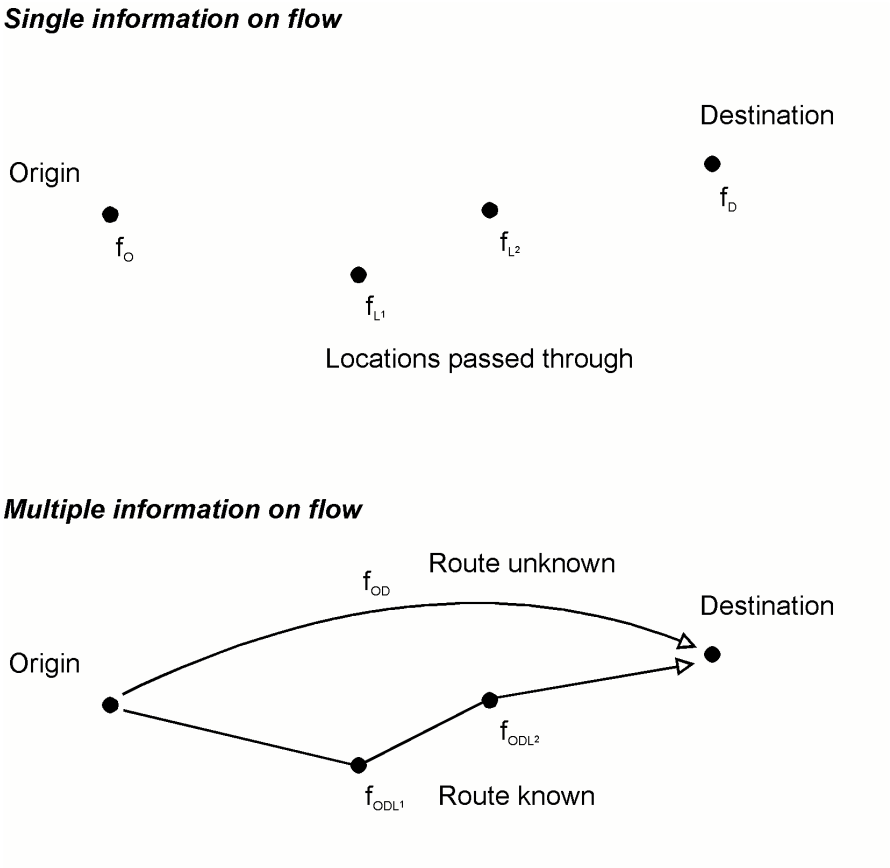


Figure 6 Measurement options of flows.

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 alignment 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 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 form a complete image 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 according to regions (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 according to products and countries, but without more precise information concerning directions of flows. The most recent information dates back to 2004.

Data of the 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 European external trade 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 Community legislation. Statistics on trade with non-EU countries are based on Council Regulation (EC) 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, 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 the statistical copy of the customs declaration. 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 according to groups of reporting member states, partner countries and products (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 according to products, etc.) is contained in the data collected by the national statistical offices of individual member states.

5.2 Financial flows

In the category of financial flows one should consider as particularly important the acquisition of data in the domains of foreign direct investment (FDI), the EU structural funds as well as transfers carried out by natural persons. 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 23 EU member countries (data for Cyprus and Malta are missing), as well as Bulgaria, Croatia, Norway, Romania and Switzerland. Data are aggregated according to the geographical criterion (locations of origin, two-way flows) and the structural criterion (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 disposes also of data on financial flows at country level (for the majority of EU countries, for groups of countries like EU25, EU15, Euro zone countries, as well as for Bulgaria, Croatia, Turkey and Romania). It should be noted that 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 on 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)

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 serv-

ices. The Bank uses its close relationship with governments in the region to promote policies that will bolster the business environment

EBRD makes available data for the years 1991-2005 on direct investments in 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 base is possible according to years and countries. 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 programs, carried out in the years 2000-2006. Querying is possible with the geographical criterion (countries and regions) and the thematic criterion (nature of programme, detailed thematic scope). Data in question encompass all EU member states as well as Bulgaria, Romania and Turkey. The database contains detailed 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 in particular 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 the 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 (ECFMR), 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 substantive 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 (outmigrants) of a country without specification of nationality or origin (destination) country,
- immigrants (outmigrants) 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 outmigrants 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 county
- 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. There is also data on migration balances of NUTS 2 regions without specification of country of origin or destination.

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 methodologies. 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 fitting. In these approaches the rows and columns of a matrix are iteratively adjusted so that the row and column totals match exogenous given migration origins and destinations. A variant of this methodology 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 fitting 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 6.2) therefore an attempt will be 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.

5.4 Transport flows

In the field of transport there are both existing European-wide harmonised databases and well-established methodologies 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, spot 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 the table 5.x a summary of the most representative sources covering different kinds of transport flows data is provided. In the table references are given for data, 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 1 summarises the most important existing databases on European transport flows. The Internet addresses referred to in Table 1 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.

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 methodologies 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 (2004).

As far transport flows are concerned, ETIS-BASE data includes origin-destination matrices for both passengers and freight covering the EU 25 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 treatments of freight consignment as multi-modal chains. Therefore not only origin and destination regions are indicated in the database, but also transhipment regions are. This information is especially important to analyse the role of regions in the freight transport chains (ETIS BASE, 2005).

Table 1 Main transport flow data sources at the European level

Source name	Main data and segmentation	Methodology	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 andtotal 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 methodologies	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 surveyed 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 1 (continued) Main transport flow data sources at the European level

Source name	Main data and segmentation	Methodology	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.

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 report 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. Finally, annual data is available since 1999 (and 1988 for EU15 countries) and therefore a large amount 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 is 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 are 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 1)

Both the ETIS-BASE and EU trade database have been already used within the ESPON project 3.2. In particular, data from such sources entered on 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 within the research Framework Programmes have estimated matrices. 1 reports reference 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 the EU wide modelling exercises. In particular, 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 transhipment regions like in the ETIS-BASE freight matrix.

For other types of data, Table 1 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 E-road networks, from which Average Daily Traffic is computed. Alpine countries organises every some year a sampling survey to collect data about Alps crossing traffic by road and rail.

In addition to European source, also national sources exist. Each member country collect some transport data in a homogenous way according to Eurostat directives and such a data are then included in the EUROSTAT database. Then, each country has also its own procedure to collect other transport data. However, as far as we know, 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 for European territorial research would be at the municipality level, i.e. LAU 1 or LAU 2.

Table 2 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 given. Because commuting data can be easily aggregated to higher NUTS level, only the lowest available spatial level is given in the table.

Table 2 Commuter flow data (Source: 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

Table 2 shows that there are huge data gaps regards commuter flow data. For many countries, it is also unclear from the nomenclature whether the data is 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 relates 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 this. On the other hand, the information from the ESPON Data Navigator seems to underestimate commuter flow data availability. For many more countries such data does exist, but access to it might be more difficult than in other countries or it exists only for parts of the country or parts of the work force or the costs for purchasing such data is 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 the journey to work traffic is responsible for a good portion of transport volumes.

In any case, the development of a European-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 an enormous value for territorial research. However, the development of such a data base 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

The general data for the 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 according to the country of origin for the NUTS 2 and lower levels.

Eurostat conducts detailed statistics for all EU25 countries (and for Bulgaria, Norway and 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 for analysing 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. The detailed data needed for respective analyses may be found only in the national statistical offices.

The UN World Trade Organisation (WTO) collects data 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, Norway and Switzerland and Bulgaria and Romania. 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.

To the extent that a definition following the NUTS classifications 2 and 3 is applied, data is available from Eurostat, NACE and the ESPON database for the following categories:

- The capacity of collective tourism accommodation (hotels, campsites etc.) for which data is 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 required monthly for the country as a whole (ESPON 1.4.5).

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 disposes of the most recent (though not always complete) data, mainly with respect to visits of tourists taking advantage of accommodation infrastructure. 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 according to the country of origin for the NUTS-2 level is at the disposal of only some national statistical offices (e.g. the Czech, Estonian, Danish and Polish statistical offices). There are cases, such as Spain and France, where data available are partial, i.e. concern visits of tourists from selected countries or groups of countries. A detailed listing of accessibility of data concerning tourist traffic in the statistical offices of particular countries (based on an Internet search) is shown in Table 3.

5.7 Cultural exchange

As it is 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 one of the reasons why in Section 3.7 concentration on initially three kinds of cultural exchange flows is 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.

Table 3 Tourist data availability by country

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 countries in 2000-2004	X			X	
	Number of overnight stays: by countries 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, months 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 residents and non-residents) in2003	X	X	X		
	Nights spent in collective accommodation establishments (by residents and non-residents) in 2003	X	X	X		
Hungary	Nights in public accommodation establishments (by residents, non-residents) 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 establishments	X				
	Tourist nights in public accommodation establishments by country	X				
	Tourist nights in hotels and in spa hotels by country	X				
	International arrivals by countries and by months	X				
	Passenger traffic data of border relations in 2002-2005	X				
Italy	Arrivals of non-residents in 2002-2003	X		X		

Table 3 (continued) Tourist data availability by country

Country	Description	NUTS level				
		0	1	2	3	4
Latvia	Persons crossing Latvia's border by purpose of the 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 countries	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 countries of origin in 1990, 1995, 2000-2004	X				
	Tourist arrivals and overnight stays by municipalities, countries and types of tourist accommodations in 2003, 2004					X
	Arrivals of tourists by countries of origin in 1990, 1995, 2000-2004	X				
Spain	Arrivals of tourists by countries 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				

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 Internate Sources). A preliminary survey was carried by the Council of Europe out in spring 2005 among member states to obtain an overview of the curricula used at national or regional level to teach the 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 ten 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 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, which 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 Outlook on demonstration examples

The second phase of the project will be concerned to a large extent with the development of a set of selected demonstration examples showing the potentials and also limitations of introducing flow analysis into ESPON.

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 case studies is to give an impression of the potentials of flow data analysis, i.e. the case studies should show high potentials for bigger studies in ESPON II and what type of results could be obtained in a larger project. In this way the case studies will complement the findings of WP 1 on ESPON needs, WP 2 on data availability and WP 3 on data generation methodologies and be a key input for WP 5 for recommendations and the development of terms of reference for one or more substantial studies on flow analysis.

Seven case studies will serve as demonstration examples for the feasibility of flow analysis. Table 4 gives an overview on the planned demonstration examples including their geographical coverage and spatial resolution. Not all case studies address Europe-wide flow data, some focus on smaller territories. Most of the demonstration examples are based on data available from public authorities or agencies, however, some of them will include also data generation methodologies. Because of data limitations, case studies can not always be based on NUTS-3 regions, and because of budget and time restrictions not all thematic fields discussed in the previous chapters can be accompanied by a demonstration example. In some of the case studies experiments will be made with different forms of visualisation of flow data in form of maps and diagrams.

The subsequent sections of this chapter present the planned demonstration examples with more detail on what will be done with what type of data. The outcomes of the demonstration examples will be presented in the Final Report of ESPON 1.4.4.

Table 4 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. in Poland: - NUTS-2 for past data - NUTS-3 for 2005 else NUTS-0
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

6.1 Trade flows

The exchange of goods with other regions is the essential base 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 an territorial 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 performances, relationships and dependencies of regions.

This demonstration example is dealing with the Polish foreign trade. Trade exchange with Poland constitutes around 50 percent of the whole exchange between the old and new EU member states. The database to be used are matrices for the years 2000 and 2006 covering 372 Polish counties (LAU 2) versus all European countries. Figures comprising the amount of imports and exports are given for each relation and are expressed in tonnes as well as in US dollars based on information from SAD and INTRASTAT.

The data for 2000 have already been analysed; some first results are given below. The material for the year 2005 has been acquired recently and is currently being analysed. The demonstration example will encompass also the dynamics of the phenomenon between 2000 and 2005, i.e. before and after Poland joined the EU.

In 1991 Poland signed the Association Agreement with the European Community, which determined the directions of trade in subsequent years. Classic effects of the creation and shifting of trade ensued. Where the status of main trading partner for Poland was concerned, the place of the Soviet Union (which accounted for 31 percent of exports and 33 percent of imports in 1980) was taken by the reunified Germany (32 percent of exports and 24 percent of imports as of 2003). The 24 other current member states of the EU accounted for 81 percent of Poland's exports and 77 percent of its imports in the year 2003. Leaving aside Germany in its dominant position, the other large trading partners for Poland (current EU member states plus the USA) represent a rather diverse structure. The most important roles in trade are played by Italy, France, the UK and the Netherlands. Russia maintains a high position in the ranking mainly on account of imports of crude oil and natural gas.

Poland is characterised by a very uneven regional breakdown when it comes to exports (see Figure 7). These mainly derive from Warsaw and the western part of the country, in which almost all poviats (counties) participate in trade. In contrast, in eastern Poland, trade is concentrated almost uniquely within the largest centres. The main areas of the absolute concentration of exports nationwide are: (a) the Warsaw agglomeration, (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 larger concentration is to be noted for imports.

There are some areas in Poland in which belts of enhanced significance as regards international commercial exchanges have taken shape. These most often relate to elements of transport infrastructure. Thus, belts of this kind have come into existence along the Berlin-Wrocław-Kraków-Ukrainian border route, the Warsaw-Lublin-Ukrainian border route, and along the seacoast between Szczecin and Gdańsk. The beginnings of a belt-like concentration of trade relations can also be observed along the "Via Baltica" route or the corridor leading from Warsaw to the border with Lithuania.

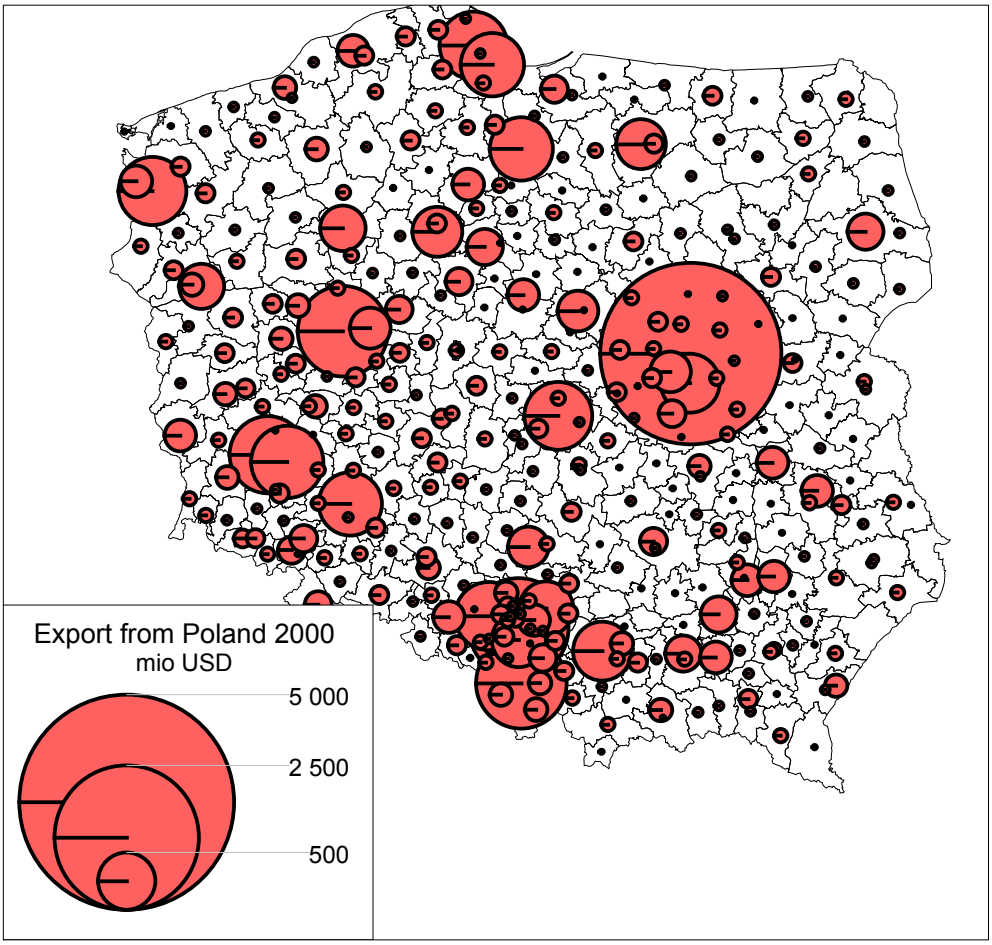


Figure 7 **The regional breakdown of Polish exports in 2000 (Komornicki, 2003).**

The importance of the EU as a destination for exports declines steadily as one moves eastwards through Poland, its place gradually being taken 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 tends to increase towards the east, as EU markets come to be augmented by more significant roles for partners in eastern Europe. There are even certain industrial centres in the Podkarpackie voivodship which enjoy links with the USA as well.

The presence of outside investors appears to be the decisive element for the intensity of foreign trade in numerous smaller and medium-sized centres. The key factor is, though, not the very volume of investment, but rather the position of the investor (most often an international corporation) on world markets. Distance from the borders and from the elements of international transport networks has regional significance. Both factors can be observed

when analysing the trade turnover with particular neighbouring countries. The neighbourhood of Germany (including the enormous 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 took shape along the transport routes leading towards the eastern border.

The expected results of this demonstration example will be an analysis of changing international trade patterns of Polish regions over time. It is expected that the analysis will enhance the understanding of different economic and spatial dynamics of the Polish regional system as one example for the developments in the new member states of the EU. The analysis will be supported by maps and diagrams showing trade developments, i.e. amounts and relationships, over time.

6.2 Migration flows

The feasibility of estimating interregional migration flows by fitting interregional migration flows predicted by an interregional push-and-pull migration model to national origins and destinations or migration balances of countries (see Section 5.3) will be demonstrated by refining and re-calibrating the migration submodel of the SASI regional socio-economic model.

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, 2004).

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 8 shows the structure of the SASI model with the migration submodel highlighted.

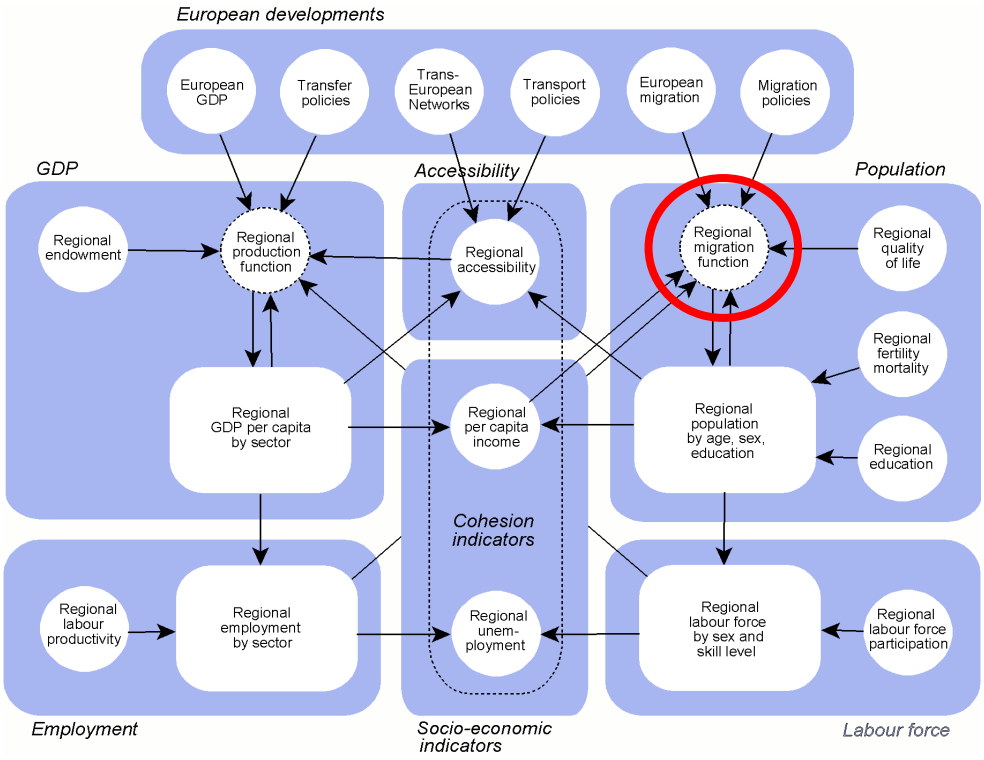


Figure 8 The SASI model

In the demonstration example, the migration submodel of the SASI model will be used to generate synthetic migration flows between NUTS-3 regions as a function of push variables (e.g. unemployment) of origin regions and pull variables (e.g. job opportunities) 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:

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

The attractiveness of a region as a place of employment is expressed as the ratio of regional GDP per capita $q_r(t–3)$ and average European GDP per capita $\overline{q}_r(t-3)$. The attractiveness of a region as a place to live is expressed as the ratio of the regional quality of life $v_r(t–3)$ and average European quality of life $\overline{v}(t-3)$. 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 will be explicitly modelled using an interregional push-and-pull migration model in which the push and pull factors will be the same as the ones used in the net migration model shown above. Specific assumption will be 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. It will be important to make assumptions about the age composition of migrants to take account of characteristic age structures of job-oriented and retirement migration flows.

The migration flows so generated will be compared with existing interregional migration flows from countries in which such data are available and with international immigration and outmigration statistics. The experience gained in these comparisons will be used to improve the migration model and forecast future interregional migration trends and to formulate recommendations for the application of migration flow estimation techniques in other contexts.

However, because of the magnitude of the task to develop an ESPON-wide model of interregional migration and the large volume of country-specific information that would have to be collected in a real application, the demonstration example will have a strictly exploratory character and not produce final results.

6.3 Freight flows

Goods transport is one of the most important flow types in Europe. With growing political and economic integration in Europe, freight flows have significantly increased during the past decades and are expected to grow in the future. Therefore, it is of great importance to monitor the evolution of freight flows and analyse their impacts at the regional level.

The case study on freight transport will aim at showing how transport flow data can be used to compute different indicators and how they can be interpreted. The data source for the case study will be the origin-destination matrix provided by the ETIS-BASE database (see Section 5.4). The reason for using this matrix is 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 transhipments take place (see ETIS-BASE, 2005).

The ETIS-BASE matrix reports freight flows between NUTS-2 regions, so the analysis will be limited to this level of spatial detail. The case study will discuss where more detailed data would be helpful to obtain a better understanding of the flows investigated.

The ETIS-BASE data will be used to analyse freight flows from different perspectives. A first issue considered will be how "transport-intensive" the economy of the European regions is. This question will be addressed looking at the total amount of freight originated and attracted in each region in comparison to a measure of the economic activity in the regions themselves. So indicators will be computed like:

- total tonnes generated / regional value added,
- total tonnes attracted / regional value added.

Further specifications could be added looking at tonnes by mode of transport or by commodity type, etc.

A second aspect investigated will be the role of regions as transhipment areas. Here the question is: how many tons attracted by a region are actually destined to the region itself? Or, from a opposite point of view, which is the relevance of transhipment on the total freight flows attracted by a region? Useful indicators will be, for instance:

- tonnes attracted for transhipment / total tonnes attracted,
- total tonnes generated / tonnes generated from transhipment.

Additional detail will be added by looking at the same indicators by commodity type, in order to highlight regional specialisations in terms of transit point. Furthermore, the share of tonnes subjected to modal change during the transhipment will be also considered.

A third issue analysed with the ETIS-BASE information to demonstrate the potential use of freight flows data will be the geographical pattern of flows for the regions. For instance, indicators will be computed like the followings:

- the share of intra-regional tonnes,
- the share of tonnes attracted from (destined to) neighbouring regions,
- the share of tonnes attracted from (destined to) other regions of the same country,
- the share of tonnes attracted from (destined to) foreign regions.

The same indicators will be computed both on the total tonnes and on the transhipped tonnes.

Finally, as the ETIS database also reports a matrix forecast for the year 2020, an example of analysis of how freight flows change over time will be carried out by computing indicators like

- growth rate of total tonnes attracted (generated) by region
- growth rate of tonnes transhipped by region.

Such indicators will be computed also distinguishing freight flows by mode and by commodity type.

6.4 Passenger flows

Interregional passenger transport is growing everywhere in Europe. The continuous rise in car ownership, the emerging European high-speed rail network and the introduction of low-cost airlines and the extension of the air network to regional airports make it possible for more and more persons to travel between regions at fairly low transport costs.

For the passenger flows case study three main data sources will be used, namely:

- the ETIS-BASE database,
- the SCENES passenger matrices.

The reason for using different data sources is to exploit the specific strength of each one. The ETIS-BASE will be used for extracting the total amount of flows, as this source is considered the reference for passenger demand at the European level. On the other side, the SCENES model supplies matrices with details on trip purpose so adding a relevant dimension to the analysis.

Data will be used to show how transport flow data can be used to investigate the relationship between passenger demand, population and transport infrastructure existing in the regions as well as the development of demand over time. Given the level of geographical detail of both data sources, the analysis will be carried at the NUTS-2 level. The results will be used also to highlight that the chance of working with more detailed data (NUTS-3) would permit a more insightful analysis.

The first step of the analysis will consist in identifying the main attractors of passenger demand. To take into account the differences between regions in terms of size and population, relative indicators will computed like:

- total trips attracted / total population,
- total trips attracted / regional value added.

The term "attracted" is used here to identify those trips generated *outside* the region considered, i.e. attraction is considered net of intra-regional trips. This share of trips can only be identified using matrix data while they could not be recognised using aggregated data of the type existing currently in the ESPON database. These indicators will be used to classify regions according to relevance of interregional personal mobility. The indicators will be computed distinguishing different modes of transport to extend the analysis to the role of the different alternatives in interregional transport.

Still looking at the relevance of interregional mobility, but from a different perspective, another analysis will concern the classification of regions as "attractors" or "generators" of interregional trips. Here the difference between the trips generated with destinations in other regions and trips attracted from other regions will be computed in order to identify regions in which attracted trips exceed generated trips and vice versa.

Thirdly, the question will be addressed whether regions are more or less attracting specific types of trips. Building on the matrices distinguished by trip purpose available from SCENES, it will be possible to identify whether the composition of trips attracted from other regions is similar or different across the EU. Here, relevant indicators will be:

- the share of business trips attracted,
- the share of holiday trips attracted.

Another issue addressed in the demonstration example will be the analysis of the distribution of the origins of attracted trips in order to classify the regions as local, national and international attractors by the indicators

- the share of trips attracted from neighbouring regions,
- the share of trips attracted from other regions of the same country,
- the share of trips attracted from foreign regions.

Finally, like for freight, the ETIS-BASE and SCENES matrices forecast for the year 2020 will be used to show how interregional trips evolve over time in the regions, also taking into account different trip purpose and different transport modes.

6.5 Tourist flows

The enlargement of the European Union in 2004 resulted in significant intensification of tourist flows to the new member states. After a decline at the beginning of the decade (particularly after the 11th September 2001), there was an increase in the number of tourists visiting the new member states. One of the reasons was the rapid development of low-cost 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 go abroad at reasonable costs.

This demonstration example will analyse tourist flows to and from the new member states. It is focused particularly on the area of the Czech Republic, Hungary, Poland, Slovakia and Slovenia. The study is based on published data on accommodation facilities provided to foreign tourists.

A first analysis of the tourist flows between the new and the old 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 EU member states. The largest percentage increase was observed for the flows Slovakia-Sweden (285 percent, though in absolute numbers this increase means just 2,800 persons), Czech Republic-France (113 percent), Hungary-United Kingdom (111 percent), Slovakia-United Kingdom (78 percent), and Poland-France (60 percent. These data, though, refer not to the entire flows, but only to persons taking advantage of the hotel infrastructure. For the entire flows the directions of the highest increase would certainly be different (e.g. in case of Poland trips to the United Kingdom would dominate). It is interesting to note that there has been a significant decrease of the numbers of travels to Spain from the Czech Republic and Slovakia (the biggest decrease in percentage terms), as well as from Poland and Hungary.

In the reverse direction, that is from the old EU member states to the new member states, a significant increase of tourist flows is observed as well. This concerns first of all the trips by British, Italian, German and Spanish tourists. The highest percentage increase of visits of tourists from the old member states was observed in Lithuania (almost 47 percent) and in Estonia (23.3 percent). In the case of Lithuania this is the effect of an important increase of visits of German trourist, and in the case of Estonia of Finnish tourists, whose number grew in the years 2003-2004 by more than 137,000 persons. The Czech Republic saw an increase of the number of tourists from the old EU member states by 22 percent, Poland by 20 percent, Slovakia by 16 percent, Slovenia by 11 percent, and Hungary by 10 percent The largest numbers of tourists visiting the new member states come from Germany, the United Kingdom, France and the Netherlands. In Hungary, Slovenia and Slovakia, Austrians constitute also an important part of tourists.

An essential information, which can be derived from the analysis of the total flows of tourists, is the indication of the main destinations of trips from various countries of the European Union (and so the shares of particular components in flows of people), and the indication of areas which attract true-to-life tourists, business travellers and the so-called one-day tourists, etc. It

can be stated on the basis of materials already collected that the most frequently visited province in Poland is the province of Mazowieckie (in practice: Warsaw), followed by the provinces of Wielkopolskie and Małopolskie (Cracow). Visits having typical tourist character account, depending upon the province, for between 13 and 50 percent of all the visits (in absolute numbers this corresponds to between 34,000 and 800,000 persons).

In the case of the Czech Republic there are 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 features a continuous increase in tourist visits and overnight stays. Prague is visited by more tourists than all other regions of the country taken together. There are also regions which note since 2000 a constant decrease of the number of tourists (e.g. Kraj Středočeský). In the regional setting in the years 2000-2004 the number of tourists from some countries of the old member states decreased remarkably (e.g. Denmark by roughly 80 percent), while at the same time there has been an increase of the number of visits for the entire area of the Czech Republic. A deeper analysis of the subject will try to look at the underlying causes for these different developments.

The final outcome of the demonstration example will be an assessment of the main directions and magnitude of tourist movements in both directions between the old and the new member states. It is expected that the analysis will contribute to an enhanced insight into international movements of persons and into the question from where tourists come and what the most important destinations are. The final analysis will be supported by maps and diagrams showing tourist flows between countries and regions of the old and the new member states of the European Union.

6.6 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 thus visible in a specific flow type.

This demonstration example will therefore look more closely into the changes in cross-border traffic taking Poland as case study. One of the objectives of the demonstration example is 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.

For this purpose, the main data source utilised will be the Polish border guard data base. It contains the number of passengers and heavy goods vehicles and distinguishes for passenger transport between Polish citizens and foreigners crossing all Polish border crossings. The data allow to analyse the dynamics of cross-border movements as it covers the years 1990 to 2005.

Previous analysis shows that in the period 1990-1997 the 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 a period of stagnation, and in the years 2000 and 2001 a decrease was observed. The traffic was dominated by the persons doing their shopping in Poland. In 2003 altogether 181 million persons crossed the borders in both directions. In 2004 there was a new increase associated with the accession of Poland to the European Union (Figure 9). This increase took place across all the border segments except for those with Russia and Belarus. On most border segments predominantly foreigners cross the borders. This is most pronounced at the local Polish-German border crossings (neighbouring to the bazaars like Łęknica), and also along the borders to Belarus and the Ukraine. There are border crossings on the eastern borders where the share of Polish citizens crossing the boundary does not exceed 5%. Poles dominate on the other hand at airports and on the Czech and Slovak borders.

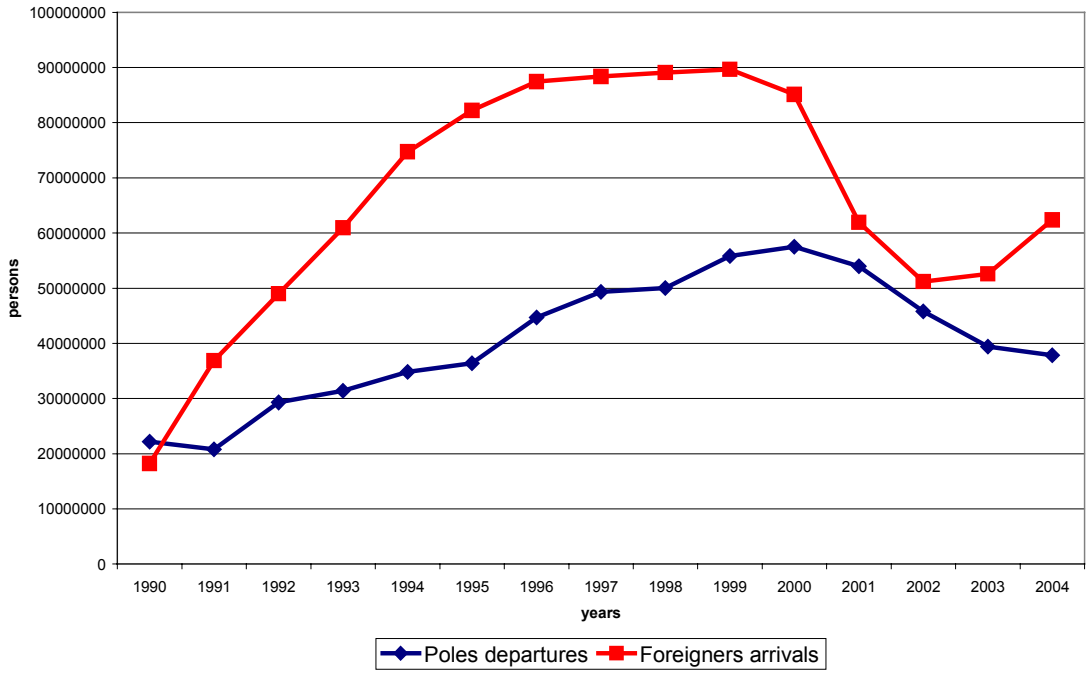


Figure 9 Passenger cross-border traffic in Poland 1990-2004.

For freight transport the dynamic increase of heavy goods vehicle (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 dominating. On the eastern side after 1998 the border crossing in Kukuryki was no longer the one 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 point in Dorohusk (see Figure 10).

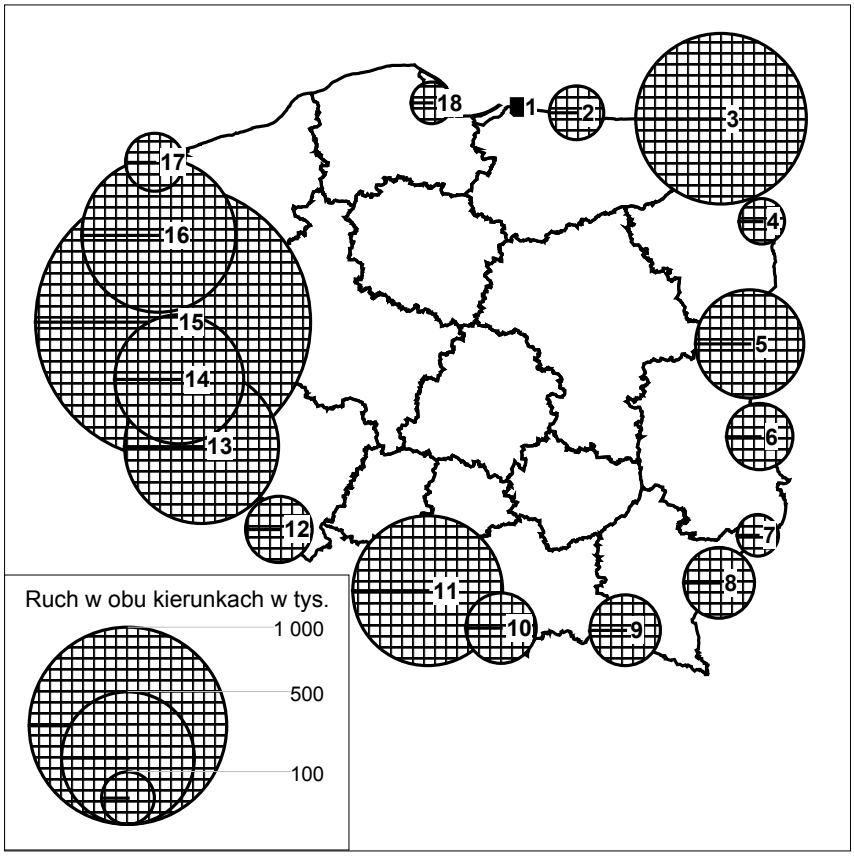


Figure 10 HGV border traffic by main transport corridors (2004; thousands of vehicles both direction)

But there was at the same time a collapse of transit traffic through Poland in the north-south direction was 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 percent share taken by the border crossing on the route Warsaw-Berlin in the total value of Polish imports from the United States. 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 Baltic states (Lithuania, Latvia, Estonia as well as Finland) and western Europe (the "Via Baltica" route). There has also been a slight increase in transit from Ukraine.

The outcome of the demonstration example will be an analysis of changing cross-border flows to and from a new member state of the European Union. As an example of flow analysis at border crossings, it is expected that the analysis will contribute to the question how the European integration is developing by measuring and analysing spatial interactions. The analysis will be supported by maps and diagrams showing cross-border flows at border crossings between Poland and neighbouring countries.

6.7 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.

In this demonstration example commuter flows in the state of North-Rhine Westphalia in Germany will be 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 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.

Figure 11 shows a sample map for commuter pattern in North-Rhine Westphalia based on a different data set, i.e. a subset which contains only workers subject to social security insurance. The map shows the commuter pattern in the year 1998 of the core area of North-Rhine Westphalia, the Rhine-Ruhr metropolitan region ('Ruhrgebiet').

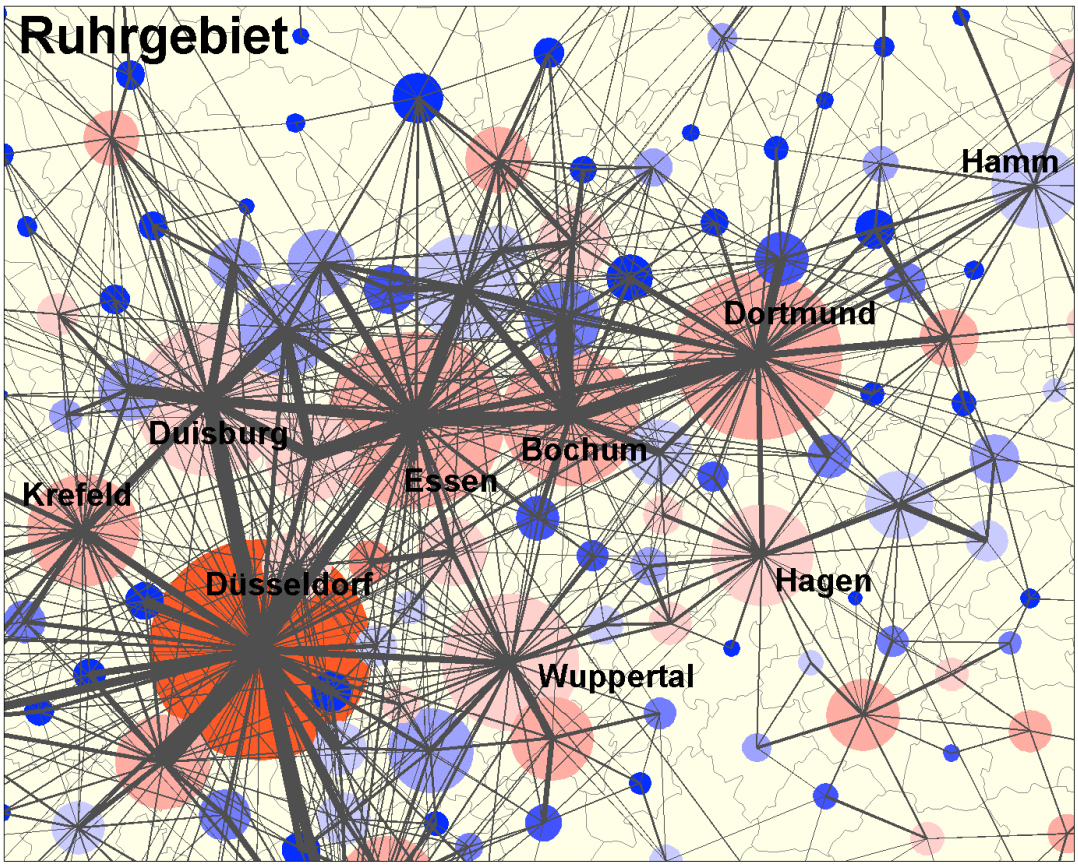


Figure 11 Commuter flows in the Ruhr area (Bade and Spiekermann, 2001)

The map in Figure 11 shows the number of jobs in each municipality, the commuting balance (blue: negative, red: positive) and the actual size of commuter flows between municipalities. 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 at least some significant flows along two major axes. Apart from the five largest cities, the commuter balance does not correlate with city size: larger cities might have a negative balance, smaller cities a positive one.

The demonstration example will go into more detail and will in particular address the dynamic of commuting patterns over time. The outcome will be an analysis of commuter flows at the municipality level within a German NUTS-1 region. The focus of the analysis will be on the spatial pattern of commuter flows in the light of spatially relevant issues such as polycentricity and urban-rural relationships. Some experiments with innovative cartographic representations of flows will be a part of the case study.

7 Conclusions: Feasibility of Flow Analysis

The study "Preparatory Study on Feasibility of Flows Analysis" is designed as a feasibility and pilot study. Its main objectives are, 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 flow analysis.

This report is the first and only Interim Report of the project. 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 for flow analysis to be elaborated in the second project phase.

The work in this first phase of the project led to the following still tentative results:

- *Trade flows*, *financial flows*, *migration flows*, *transport flows*, *commuter flows*, *tourist flows*, *cultural exchange*, *information flows* and *environmental flows* are policy-relevant types of flow for spatial analysis.
- These types of flows have significant importance for the main goals of EU spatial policy competitiveness, territorial cohesion and sustainability.
- For each of these types of flows there exist *theoretical concepts* and feasible *analytical methods* for monitoring, analysing, assessing and forecasting flows at all spatial scales from the European to the local level.
- 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 certainly the case for transport and environmental flows and may be true for other types of flows.
- This will require the use of the results of existing models and efficient forms of *co-operation* with other research institutions and European agencies.
- *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.

The Final Report will be submitted at the end of October 2006. It will contain updates of the issues dealt with in this report, an introduction into methodologies 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 flow analysis and recommendations for future ESPON research with respect to flows.

The Final Report will include a critical review of the results obtained in the study and will give recommendations for further ESPON work with respect to flow analysis. The report will provide an assessment of the feasibility of flow analysis with respect to the objectives of the ESPON programme and with respect to the added-value of flow analysis. Depending on the results of this assessment, draft terms of reference for in-depth research will be developed. Depending on the results terms of reference for one or more studies focussing on flow analysis or for thematic studies in which flow analysis is one relevant aspect will be developed.

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