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Agglomeration in Europe in the Context of Socio-Ecological Transition

Izabela Styczyńska
Constantin Zaman

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CASE-Center for Social and Economic Research on behalf of CASE Network
al. Jana Pawla II 61, office 212, 01-031 Warsaw, Poland
tel.: (48 22) 206 29 00, 828 61 33, fax: (48 22) 206 29 01
e-mail: case@case-research.eu
http://www.case-research.eu

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Izabela Styczynska, Ph.D. *is an economist and author of publications in the fields of labour economics, social policy and health economics. She holds a MA degree in economics from Warsaw University, Master in Economics at the CORIPE Piemonte in Turin and she has obtained a Ph.D. at the University of Turin. She has worked for CASE-Center for Social and Economic Research since 2005, participating in its numerous projects including: NEUJobs (Emplyment 2025: How will multiple transitions affect the European labour market), ANCIEN (Assessing Needs of Care in European Nations) or AIM (Adequacy of Old-Age Income Maintenance in the EU). She is fluent in English and Italian and has a working knowledge of Russian language.*

Constantin Zaman *is Associate Researcher with CES (Centre d'Economie de la Sorbonne) and CASE (Center for Social and Economic Analyses). He holds a Ph.D. in Economics from the University of Sorbonne. He has worked as a social expert, public finance specialist and expert evaluator for the European Commission (DG Employment, EUROPEAID, ETF Torino, DEVCO D3, DG Research), as well as in various research and technical assistance projects financed by EU, UNESCO, World Bank, UNDP, and ILO. He has also carried out research with CEPREMAP, and ROSES in Paris, CERGE-EI Prague, CSSR and BCI Chisinau, The Institute for National Economy and The Romanian Institute for Prognosis in Bucharest, and GVG Koln. He is member of the editorial board of Romanian Journal for Economic Forecasting and Management of Sustainable Development Journal. He has been teaching courses in Macroeconomics, Microeconomics and Intercultural Management at the University of Sorbonne and University Paris XIII – Marne la Valée.*

Abstract

This paper analyses the spatial distribution of economic activity in the European Union at NUTS2 level over the 2001-2010 period. The aim of the study is twofold: (i) to provide descriptive evidence of the agglomeration distribution in Europe and its evolution over time across countries; (ii) to identify the nature of agglomeration and the factors that determine its level, with particular attention paid to the socio-ecological transformation occurring in Europe.

Our study concludes that: a) the changes in agglomeration are sensitive to demographic transformations taking place; b) the ecological transformation has a mixed effect, depending on each country; c) significant differences are observed between new and old Member States; the crisis has had a significant influence on agglomeration but only in Western Europe.

1. Introduction

The agglomeration of economic activities in few locations has been a distinctive feature of the world economy for many years. On the one hand it has been proven that agglomeration offers several advantages in the context of cost minimisation for industries by providing a pool of multifarious labour, input suppliers and access to know-how and ideas. On the other hand, it has been argued that agglomeration is one of the territorial factors that increases spatial inequalities in terms of wages, productivity and quality of life (see for example Krugman, 1991; Ciccone, 1992; Krugman et al., 1995; Fujita et al., 1996). The latest Cohesion Report (2010) reveals striking regional disparities ranging from differences in productivity to infant mortality rates and vulnerability to climate change. Many of these disparities have diminished over the past decade, some of them relatively fast, but overall a wide gap between less developed and highly developed EU regions still persists. Consequently, understanding the determinants of agglomeration is important for securing economic and social convergence among the Member States, which is a key goal of the European Union.

The theoretical work in this area has demonstrated that agglomeration economies can arise from labour market pooling (Helsley et al., 1990), input sharing (Goldstein et al., 1984), and knowledge spillovers (Glaeser, 1999). The empirical literature suggests that spatial concentration might also be influenced by several plausible mega-trends that we observe in Europe (for example EC, 2008). They include energy transition, climate change, demographic changes or the move towards a knowledge-based society, knowledge diffusion and growing use of ICT. Despite the fact that a huge part of the literature analyses these phenomena separately, we have not found any study that attempts to jointly analyse changes in agglomeration economies in the context of the so-called socio-ecological transformation for Europe or for a specific European country. In our view, it is essential to look at the joint impact of these trends, as their influence could change the overall agglomeration dynamics.

This paper bridges the theoretical literature and the empirical evidence observed in the EU in this domain using the agglomeration index. The objective of this study is twofold. First, we measure the distribution of spatial concentration among European NUTS2 regions during the

last decade (2001-2009). Second, by matching the geographic concentration measures with data on regional characteristics, we seek to explain what might be the potential impact of socio-ecological transformation on agglomeration in Europe. Our work brings two elements of novelty: a) it identifies the determinants of agglomeration from the upcoming transition perspective; b) it is the first attempt to analyse this issue over such a broad geographical terrain.

When defining socio-ecological transformation (SET) we follow the work of Fischer-Kowalsky et al. (2012) prepared within the WP1 of the NEUJOBS project. Their comprehensive definition of SET is not only in line with the majority of scientific research in this area, but also covers the most important future challenges for EU regions and for EU policy effectiveness. The authors characterise the socio-ecological transformation by six plausible mega-trends which are divided into two sub-groups: *mega-trends in national conditions* and *societal mega-trends*. The first group includes energy transition, increasing challenges to resource security and increasing climate change impact. The second group of SET is characterised by demographic transition, shifting economic and political centres of gravity, growing ICT use, and knowledge-spillover. However, the choice of variables that would proxy the existing trends as well as representative territorial coverage is limited by the data availability.

Our main results point towards fairly stable agglomeration over time in Europe for all NUTS2 levels. Its value is even higher in the EU15 than in the EU12 and we have not found any evidence that the difference between them is converging. The size of the index is highest for the smallest regions, mainly capital cities. The factors significantly influencing the agglomeration are mainly related to labour market pooling and demographic change. Other transformations, like energy transition, knowledge diffusion or economic shift of gravity, have an ambiguous effect on agglomeration in Europe and depend on the level of development of a country/region.

The remainder of the paper is organized as follows. Section 2 describes the distribution of agglomeration in Europe, with particular attention paid to the differences between new and old Member States. It also provides a brief overview of the literature on the topic, and the impact of agglomeration on national and regional growth. Section 3 describes the methodological framework: the data set used and the definition of variables. Section 4 presents the results at the aggregate level of the economy, respectively for the two sub-samples of countries (Western European economies and Eastern European transition economies). Section 5 concludes.

2. Literature review

2.1. The impact of socio-ecological transition on regions

The literature on the consequences of economic and ecological changes on agglomeration is rather scarce. Some attempts have been made to analyse the impact of existing trends, like energy transition, climate change or demographic change on regions. However, to our knowledge, until now no study has made an effort to jointly analyse changes in agglomeration economies in the context of socio-ecological transformation for Europe or for a specific European country. In this section, we seek to describe the most prominent literature on the impact of existing demographic and ecological trends on regions and spatial concentration. An extensive literature review of the description of SETs and their changes over time can be found in the paper by Fischer-Kowalsky et al. (2012) prepared within the NEUJOBS project. Our attempt is to extend this literature by presenting the impact of SET at the regional level.

Europe is embarking on a new energy path. Energy prices are rising and dependency on fossil fuels is increasing. Thus, energy supply and demand will have to turn more towards renewable energy sources and focus on more efficient uses of energy in the future. Very little evidence can be found about the impact of the energy transition or resource security on spatial concentration. The ESPON project on the “Regions at Risk of Energy Poverty” (Velte et al., 2010) was aimed at delivering future-oriented territorial evidence on the impact of rising energy prices on the competitiveness of European regions, as well as on cohesion in Europe in the long-term. By analysing the exposure to energy poverty at the regional level, the authors conclude that the poorest regions in Europe have become even poorer due to the lower purchasing power standards. The main challenges from a policy point of view are how to mobilize the considerable potential for renewable energy sources in regions that lack the financial means to do so and how to coordinate a large set of policy instruments to enhance access to energy efficiency measures.

Blair et al. (2011) analyse the opportunities of transitioning towards renewable energy in rural America. The authors conclude that rural areas with high levels of drilling and limited economic diversity may be the most overwhelmed by the buildup phase of an energy boom,

but they are also the places that ultimately may see the greatest long-term fiscal gain from energy development.

Territorial development is generally considered very important for dealing with climate change. The EU White Paper “Adapting to climate change: Towards a European framework for action” (EEC, 2009a, 4) explicitly relates to spatial planning and territorial and regional development. Most of the existing vulnerability studies have a clear sectoral focus, addressing very specific potential impacts of climate change on single elements of a particular sector. Most studies lack a clear regional pan-European focus. Results aiming to fill this gap were produced within the ESPON Climate project, which was applied to selected regions across Europe. The project, entitled “Climate Change and Territorial Effects on Regions and Local Economies in Europe” (ESPON, 2011), was aimed at analysing how and to what degree climate change will impact the competitiveness and cohesion of European regions and Europe as a whole. The main results show that the potential impact of climate change is remarkably high for the population of Southern Europe’s agglomeration areas. A similar impact is projected for large parts of North-West Europe and northern Scandinavia. This pattern results from rising sea levels and a projected increase in river floods. The population of large parts of the core of Europe is potentially not affected or only marginally affected by climate change.

The most recent paper by Desmet et al. (2012) provides a framework for analysing the spatial impact of global warming in a dynamic context. Similarly to a previous study, the results show that one of the main effects of global warming is to shift production and population to the north as it makes some of these regions warmer. Since technology is better in the north, in the absence of migration restrictions, temperature change can lead to small positive welfare effects.

Suocheng et al. (2012) analyse the impact of climate change on urban agglomerations in China’s coastal region. They show that the five big urban agglomerations of China with strong economic power are affected by sea-land compound disasters and are liable to suffer heavy disaster losses with climate change.

In recent decades, most economies have been confronted with tremendous structural changes arising from globalization and demographic developments. Statistics show that fertility rates have decreased in nearly all countries (Eurostat 2010), resulting in lower population growth rates and ageing societies. A major consequence of population ageing is

that the working age population will decline, which may have a downward effect on economic growth and competitiveness in many European regions. These serious economic consequences might be different for different regions. Grafender-Weisstiner et al. (2010) were one of the first authors to attempt to analyse the effect of demography on agglomeration processes. They show that the possibility of agglomeration crucially hinges on the economies' demographic properties, i.e. on birth and mortality rates. While declining birth rates strengthen agglomeration processes, declining mortality rates weaken them. Since population growth weakens wealth and thus expenditure increase due to a higher capital stock, it acts as an important dispersion force.

Tivig et al. (2008) study the demographic location risks that companies encounter in European regions. Demographic change is defined in the report as population ageing with the perspective of shrinking. While ageing is a global phenomenon, shrinking is local. It is therefore necessary to look at the regional aspects of demographic change. The main results show that ageing is expected to continue in all EU regions, but at a varied pace. The working-age population shows much less ageing than the total population, but considerably more shrinking. High demographic location risk is observed in eastern and most southern European countries, while opportunities have been identified in northern and western countries. However, even in high-opportunity countries, fringe regions may bear high demographic risks. Similarly, agglomeration may present considerable opportunities in otherwise risky environments.

The goal of the ESPON project on "Demography and Migratory Flows Affecting European Regions and Cities" (2011) was to assess the effects of demographic trends and migration flows on European regions and cities and examine the implications for economic and social cohesion. The project was developed for selected European countries. The analyses of trends between selected regions have revealed significant changes in the regional labour force. If life expectancy continues to grow, the number of persons aged 65+ in those selected regions will increase by 111 per cent. To address these challenges, intra and extra European migration will become increasingly important. Only under favourable economic conditions, i.e. if extra-European migration is high and if the activity rate increases, will the total size of the labour force increase until 2050. Even under these favourable conditions, 35 to 40 per cent of all NUTS2 regions will face a decline in the size of the labour force over this period. If the economic conditions are poor, 55 to 70 per cent of the regions will experience a decline in the labour force by 10 per cent or more. In most regions in the eastern and southern parts

of Europe, the labour force may decrease by even more than 30 per cent. In order to attain the goals of regional competitiveness and territorial cohesion, policy makers have to face these demographic challenges.

The changing global balance of power in international affairs is most often conceived as a result of the emergence of "new powers" such as China, India and Brazil and, with its renewed assertiveness, Russia. However, Zürn et al. (2010) underline an important aspect, namely the growing importance and authority of international institutions and non-state actors. In their main findings, Fisher-Kowalsky et al. (2012) argue that the West's economic and political hegemony is slowly waning. The world is moving towards multipolarity and interdependence. This shift is being triggered by rapid economic growth in emerging economies and slow growth in mature economies. The analysis of the economic centre of gravity dynamics finds that in 1980 the global economy's centre of gravity was in the mid-Atlantic. By 2008, due to the continuing rise of China and the rest of East Asia, that centre of gravity had shifted to the East. It is projected that by 2050, the world's economic centre of gravity will be located between India and China (Quah, 2010). We have found no study that analyses the impact of the dynamics in the centre of gravity on regions or spatial concentration.

The renewed Lisbon strategy emphasises the need to boost growth, competitiveness and cohesion throughout the EU. Information and Communication Technologies (ICT) have been at the core of growth and productivity dynamics over the past decade. There is also a growing perception that ICT strongly determines the way EU regions keep pace with, and possibly benefit from, the globalisation process. However, there is very little evidence of this in the existing literature on the location of ICT industries in EU regions and the impact of ICT investments on regional growth and cohesion.

A study on "The knowledge economy, economic transformations and ICT in the EU25+: Regional dynamics in the deployment phase" (de Panizza et al., 2010) presents a literature review on the impact and determinants of ICT adoption at the regional level. The report explores the influence of the advent of ICT on the spatial pattern of economic activities. The main conclusion is that it is not possible to deduce which prediction prevails, i.e. whether the interaction between knowledge and ICT will stimulate further agglomeration or whether the digital economy will limit distances and make urban regions superfluous. On the one hand, it is argued that ICT is rather likely to increase the efficiency of distribution and transport delivery systems by reducing transport costs and improving use of transport infrastructure.

Moreover, the spread of the use of ICT has the potential to replace face-to-face activities. On the other hand, it has been found that most ICT applications are largely metropolitan phenomena. The development of new technologies and new products seems likely to remain grounded in the large urban regions in the advanced countries, which implies that these regions will maintain their geographic attractiveness.

Barrios et al. (2008) provide empirical evidence of the impact of ICT on regional growth and convergence for Spanish regions over the period 1985-2004. The data used show that ICT has contributed positively to regional convergence in Spanish regions during the studied period. Moreover, ICT appears to be the item that has contributed the most to regional convergence, denoting the widespread positive effect of ICT on convergence, despite large inequalities in ICT investment.

To summarise, we will briefly present the results of the European Commission's reports on future challenges for EU regions (EC, 2008), which assumes that Europe is facing a number of key challenges in the years to come. They include: adapting to globalisation, demographic change, climate change, and energy challenges. We seek to explore the regional effects of these challenges in the medium-term. In an effort to improve our understanding of the potential pattern of regional disparities that these challenges will generate, the following question arises: which regions are the most vulnerable to these challenges?

As stated in the report, a shrinking working age population, an ageing society, and population decline will have a marked effect on many regions. Many factors lie behind this phenomenon. In terms of socio-economic characteristics, regions in demographic decline are often characterised by relatively low income levels, high unemployment, and a large proportion of the workforce employed in declining economic sectors. They tend to have a relatively small proportion of young people, reflecting their migration to other areas, as well as low population density and low growth potential due to the shrinking labour force. Other regions, in particular metropolitan areas and some coastal areas, will experience population growth. Metropolitan regions are projected to face a high inward migration of their working age population, while still remaining primary destinations for international migration. Demographic change is therefore likely to reinforce regional disparities in economic growth, as well as to increase agglomeration in certain areas.

Another significant assumption of this project is that climate change will strain economic, social and environmental systems. Many regions will be increasingly exposed to the

asymmetric impact of climate change. Regions under threat of flooding, coastal erosion, land degradation and desertification, and potential drought hazard are already seeing their economy and their agglomeration affected. These effects will impact the regional growth potential in the affected regions and create disparities with those regions that are less affected by climate change.

Energy prices appear to have become even more volatile, with extreme price peaks reached in recent times. All EU members are facing the challenges of climate change, increasing import dependence and higher energy prices. An Energy Policy for Europe is aimed at delivering sustainable, secure and competitive energy. Regions reliant on energy intensive sectors (such as transport and heavy manufacturing) and regions that depend on distant markets could be more exposed to changing energy conditions. On the other hand, energy efficient regions can benefit from the strong role which innovation, technology and ICT will play in the adaptation and mitigation processes. This can create "win-win" situations, both economically and environmentally, in energy efficient regions. Some regions will potentially benefit from the production of renewable energies, including some rural and remote regions and coastal areas. Substantial disparities among regions are also observed in terms of modal splits in the transport sector and energy intensity, where the highest figures are recorded in countries with low GDP per capita. High energy prices also have significant welfare effects, in particular for lower income households for which energy related expenditure makes up a comparatively high share of their income. High energy prices might therefore reduce the purchasing power of the poorest households and regions with a low average income.

2.2. Stylized facts on agglomeration in Europe

The empirical evidence shows that the degree of concentration (and thus agglomeration) is fairly stable over time in all of Europe for all NUTS spatial levels, although the size of the index usually increases at the smaller geographical scale (Gardiner et al., 2010). This broad stability over time suggests that agglomeration is unlikely to explain cyclical growth patterns particularly well but could be better-suited to explain the long-term effects.

According to the Regional Policy Focus (2009), a higher concentration of economic activity is typical for less developed EU countries. In more developed EU countries, the differences between metropolitan cities and the rest of the country are smaller and growth is far less concentrated. As countries become more developed, the advantages of agglomeration

become more widespread throughout the country due to improvements in business environment, communication and transport infrastructure, and the education level of the labour force outside the main urban regions. At the same time, some of the benefits of agglomeration are offset by congestion costs and high rents. As a result, the economic activity starts to spread over less developed regions, often rural, and the gap between these and urban areas starts to decline, leading to more balanced development (Cohesion Report, 2010). This confirms the hypothesis that agglomeration is more important in less developed countries.

According to Foster et al. (2009), in new Member States, economic activity seems to be more concentrated in the regions bordering Western European countries and to be relatively more concentrated in urban areas, particularly capital cities (when compared to Western European regions). During the period of transition, border regions and capital cities benefited from trade integration and foreign direct investment flows to a larger extent than other regions. Similarly, productivity in these particular regions relative to the overall productivity appears to be relatively high when compared with the same ratio in old Member States. This may be due to the fact that some regions in the new Member States still have large shares of agriculture in economic activity or a less favourable industrial structure. Finally, employment rates in these particular regions are in most cases higher than in agricultural regions for example, again strengthening the effect of employment density.

Arguments in favour of benefits of spatial agglomeration for stimulating growth, innovation and productivity can be found in various disciplines like economic geography, urban economics, or the “new” economic geography (see, for example, Henderson, 2003, 2005; Baldwin et al., 2004; Glaeser, 2008; Florida, 2009). Several studies have tried to find empirical evidence supporting their idea in the case of Europe. Crozet et al. (2007) estimate the effect of agglomeration (measured by the dispersion of economic activity within a region) on economic growth (measured by GDP per capita) for EU regions over the 1980-2000 period. They find a positive effect of agglomeration at the regional European level (NUTS1). In contrast, Sbergami (2002) provides estimates for six European countries over 12 years but finds a negative effect of agglomeration. Also, in his study of 208 regions across the EU over the 1977-2002 period, (Bosker, 2007) finds that agglomerated regions (with a dense concentration of economic activity) grew more slowly than other regions, indicating a negative agglomeration effect. However, growth is stimulated in a region located in the vicinity of growing regions. Brülhatr et al. (2009) find that agglomeration boosts national GDP

growth in a large number of OECD countries, but only up to a certain level of development. Gardiner et al. (2010) examine whether regions with a high density of economic activity have been associated with, other things being equal, higher growth rates of productivity than those with less activity. They concentrate on EU15 countries for the period 1980-2007, but no consistent positive relationship is observed. The estimation results show some slow convergence, which is probably all that can be expected among the more developed Western European Member States.

Other studies question the benefits of agglomeration because of congestion costs, commuting costs, and other negative externalities that may arise (see for example, Glaeser et al., 2004; Accetturo, 2010). This implies that in advanced economies, like most European ones, agglomeration may not boost national growth. The benefits of spatial agglomeration for stimulating growth are valid mainly for new Member States with lower levels of GDP. In advanced Western European economies, the observed agglomeration effect is negative.

Ciccone et al. (1996) and Ciccone (2002) estimate the relationship between economic activity (measured by total factor productivity) and agglomeration (measured by employment density) for the USA at the country level and for five European countries at the regional level. They find a positive effect of agglomeration on economic activity. An extension of Ciccone (2002) was examined within the FP6 MICRO-DYN project (Foster et al., 2009). The analysis at the industry level was done for 255 regions in 26 European countries. For the full sample of countries, the results at the sectoral level indicate significant agglomeration effects, with the exception of agriculture. When considering the differences in the extent of agglomeration effects between new and old EU Member States, the conclusion is that the effects of agglomeration tend to be stronger at both the aggregate and sectoral levels in the case of new Member States. The results suggest that dense regions in new Europe, such as capital cities, may have better prospects for productivity growth when compared with less dense regions. This may reflect uneven levels of transport and business infrastructure in new Europe as compared to old Europe.

The regional analysis provided within the framework of the ESPON 2013 programme (2010) identifies a close correlation between metropolitan areas in Europe and Gross Value Added. The study also finds evidence of a positive relationship between employment density and labour productivity over time, which has strengthened over the last decade.

Relatively little importance is given in the literature to the factors generating agglomeration. The existing studies mainly deal with the theoretical micro-foundations of the phenomenon. A detailed description of this topic can be found in Quigley (1998). The theory demonstrates that the economics of agglomeration can originate from labour market pooling (Helsley et al., 1990), input sharing (Goldstein et al., 1984) and knowledge spill-overs (Glaeser, 1999). Rosenthal et al. (2001) empirically confirm that all three sources of agglomeration are significant for the U.S manufacturing industries. The strongest evidence appears for labour market pooling at all geographical levels. The proxy variables for knowledge spill-overs show an impact on agglomeration only at the zip-code level. Shipping-oriented attributes (like manufactured inputs, resources and perishability) influence agglomeration only at the state level. Martin et al. (2010) analyse the impact of a country's institutional environment on agglomeration for 266 firms across 29 countries from 1975 to 2004. Their results show that the decision to agglomerate is strongly dependent on a country's institutional context. Specifically, firms prefer to agglomerate when investing within countries with collectivist cultures, especially those characterized by political and economic uncertainty.

3. Methodological framework

3.1. Data

The statistical data used for analysis comes from the Eurostat REGIO database, which is the only source that provides comparable EU-wide regional information according to the standardised classification of regions (NUTS). Following the work of other Tasks in WP8, we cover all European NUTS2 regions (210 in total) for the period 2001-2010.

There are some important limitations to this study that mainly arise from the availability and quality of available information. Population and employment data has relatively better coverage, while the data necessary to picture the SET is extremely uneven and generally quite poor. The complete country information needed for estimation analysis is available for only one country - Hungary. In the case of some smaller member states, data collection is less problematic because the country corresponds administratively to a NUTS region. A large share of regional data is missing in the cases of Germany, Greece and Portugal. Following the work of Combers et al. (2004), we assume that if more than 20% of the data is missing, this is not acceptable for the purpose of estimation analysis. Thus, the descriptive part of

agglomeration distribution and dynamics is provided for all of Europe, while estimation analysis is provided for selected countries, in which at least 80% of information is available.

Another important limitation is that in some cases, EU-wide data is available only at the aggregate level of classification. In this situation, the missing information at the regional level is approximated by data at the national level or originating from national accounts (where possible). Consequently, we were able to cover 75 European regions in 11 selected countries (Austria, Belgium, Czech Republic, Finland, France, Hungary, Italy, Latvia, Netherlands, Slovakia and Slovenia) over the 2001-2009 period.

Apart from data limitations, we also face a problem related to the effectiveness of territorial coverage forced by data availability. There is a clear trade-off between the territorial coverage of an investigation and the accurateness of analysis that is obtained. It is well known that the spatial units for which economic data is collected in most countries are often more a reflection of administrative convenience rather than any judgement on the economic boundaries that are relevant to the operation of localization effects. Spatial units of observations are rather heterogeneous, with variations in collection policies, access and pricing conditions, confidentiality requirements or legal frameworks. The extensive description of the limitations of REGIO dataset presented in Combes et al. (2004) and Cullmann et al. (2012) confirms that the pan-European data situation is very problematic. Consequently, the identification of characteristics as well as the results of the estimates can only be considered very crude proxies of what is actually taking place in the sample. However, the countries under scrutiny constitute an interesting sample in Europe: we have peripheral countries, like Spain and Sweden; we equally included countries from the core of EU, like Belgium, Netherlands, or Austria; we also studied countries that have relatively miscellaneous territorial and/or population size. At the same time, we selected a sample with a comparable number of Old and New Member States.

3.2. Variables

There are several possibilities to characterize the degree of agglomeration (see for example Krugman, 1991 or Audretsch et al., 1996). In order to get a theoretically meaningful measure of the density of economic activity, we constructed a density index based on Ciccone (2002) and Ciccone et. al (1996). The agglomeration in region *j* at time *t* is measured through the ratio of employment density between regional and national levels. The agglomeration index, which represents the dependent variable in the regression, is therefore calculated as follows:

$$\gamma_{jt} = \frac{E_{jt}L_t}{E_tL_{jt}} \quad (1)$$

Where:

E_{jt} - total employment in region j at time t

E_t - total national employment at time t

L_{jt} - Physical size of region j at time t

L_t - Physical size of country at time t

γ_{jt} - proxy for agglomeration in region j at time t.

In order to create a consistent set of independent variables we followed the work of the most prominent papers in the fields of agglomeration and socio-ecological transformation, while taking into account the data availability.

First, specialised literature on agglomeration distinguishes traditional congesting forces that are assumed to have a significant impact on spatial concentration. They can be roughly classified as labour market pooling (Helsley et al., 1990), input sharing and local competition (Goldstein et al., 1984; Glaeser et al., 1992) and knowledge spill-overs (Glaeser, 1999). Moreover, several costs of agglomeration are identified in the literature (for example Glaeser, 1998). They include pollution, crime and social problems. Our choice of explanatory variables capturing congesting forces described above is mainly based on the work of Koo (2005), but is limited by data availability. Consequently, relative average regional expenditure on R&D is a variable used to capture knowledge spillover. It is expected to have positive effect on agglomeration. The second indicator used is the number of business entities, treated as a proxy of local competition; following the work of Glaeser et al. (1992), it is expected to have a negative effect on agglomeration. Regional population is the last variable that captures congesting forces. It can be viewed as the labour pooling source as well as the pool of consumers who consume the produced goods and services (Mishra, 2010). It is expected to have a positive effect on agglomeration. One of the agglomeration costs, namely, pollution, is approximated by regional generation and treatment of municipal waste (Glaeser, 1998).

When creating the set of variables that cover SET, we based our choice on the work of Fischer-Kowalsky et al. (2012) – a report prepared within the WP1 of NEUJOBS project – and respectively Cullmann et al. (2012) – the working paper presented within the WP8 of the same project. Fischer-Kowalsky et al. (2012) distinguish and describe six mega-trends taking place in Europe, which represent the SET. The first group, defined as *mega-trends in natural conditions*, includes energy transition, increasing challenges to resource security and increasing climate change impact. The second group, presented as *societal mega-trends,* includes demographic transitions, shifting economic and political centres of gravity, growing ICT use, and knowledge spillover. Each trend is characterised by key sources, which are summarized in the Table below.

Table 1. Characteristics of SET

Group	Characteristic	Key sources
Mega-trends in natural conditions	Energy transition	- Energy demand development - Share of renewable energy sources in the energy mix - Fossil fuel (or oil) price developments - Energy Return on Investment
	Increasing challenges to resource security	- Demand for critical raw materials
	Increasing climate change impact	- Greenhouse gas emissions - Changes in water resources
Societal mega-trends	Demographic transition	- Mortality - Fertility - Migration
	Shifting economic and political centres of gravity	- Global distribution in military expenditures - GDP growth
	Growing ICT use and knowledge spill-over	-ICT use - On-going digital accumulation of knowledge and information - Right to internet - Ambient intelligence: support daily living

Source: Own compilation based on Fisher-Kowalsky et al. (2012)

As stated in Cullmann et al. (2012), the shift towards knowledge-intensive activities can be based on various sources of information and a number of statistical indicators related to technology, knowledge intensity, human capital and innovation. When selecting their variables, the authors adopt a sectoral perspective as well as individual activity perspective. We follow their assumptions and consequently we chose analogous indicators of growing ICT use and knowledge spill-over available from Eurostat.

Cullmann et al. (2012) also state that two overlapping and opposing trends have been determining the regional pattern of the EU: overall convergence, on the one hand, and spatial concentration on the other. When the distinction between New and Old Member States is taken into account, the convergence of per-capita income and productivity turns out to be very slow or even non-existent. Consequently, we included a dummy variable that takes into account the fact of being New or Old Member State. The crisis period is equally taken into consideration.

Based on the issues described above and due to data limitations, we use the following explanatory variables of agglomeration changes:

Table 2. List of explanatory variables

Group	Characteristic	Proxy variable used	Variable #
I. Congesting forces	***Knowledge spill-over***	R&D expenditures	1
	Labour market pooling	Regional population	2
	local competition	Number of business entities	3
	Pollution	Regional generation and treatment of municipal waste	4
II. Regional SET characteristics	***Energy transition***	i) Primary production/final consumption energy ii) % of renewable energy in final energy consumption	5 6 7
	Demographic transition	i) Life expectancy ii) Fertility rate iii) Internal regional migration	8 9 9
	Shift of political and economic gravity	Regional GDP	10
	Growing ICT use	i) ICT patent application ii) Employment in technology and knowledge intensive sectors iii) R&D expenditures	11 12 1
	Knowledge diffusion and human capital accumulation	i) Number of students ii) Participation of adults in education iii) Use of internet	13 14 15
III. Time & country characteristics	***Dummy variables***	i) Crisis impact ii) Old versus New Member States	16 17

Source: Own compilation

We anticipate that life expectancy and internal regional migration (used as proxies for demographic transition) will have a positive effect on our spatial concentration measure. The same positive impact is expected from human capital accumulation, which is very closely related to labour market pooling and the competitiveness of the labour force.

However, since the fertility rate negatively affects the labour force and employment, we expect a negative impact on agglomeration.

Regional GDP, which is the measure of regional economic well-being, is assumed to be positively correlated with agglomeration, but only up to a limit. The empirical evidence shows that when individuals reach a certain level of welfare, they start to move to less dense (residential) regions in search of a better quality of life. Consequently, we expect GDP to have a positive impact in less developed countries (new EU members), but a negative one in the developed economies of Europe (old members). It is difficult to anticipate the impact on spatial concentration of energy transition, the shift of political and economic gravity. The first variable has an ambiguous effect and its impact may be therefore either positive or negative. As a general rule, an increase in energy consumption means more pollution, which in turn discourages agglomeration. It follows that the transition to green energy should have a positive impact on agglomeration. However, when the use of renewable energies increases, agglomeration could be negatively affected because companies may decide to relocate to traditionally clean (and relatively low populated) areas to reduce their operating costs. Local authorities are more likely to accept economic activities that preserve the environment than those using fossil energies. On the other hand, some forms of renewable energies (in particular wind power and solar) can be (self-) produced on a small scale, which offers energy independence to both producers and individuals; they are therefore more willing to move far from traditional agglomerations. Other forms of energy (biogas, for example) are less expensive than fossil ones and consequently, the transportation cost diminishes; people are therefore more willing to move outside agglomerations and make longer trips to and from their jobs.

Growing ICT use and knowledge diffusion are assumed to increase the competitiveness of a region and should therefore have a positive impact on agglomeration. However, this is not always the case because knowledge diffusion is also assumed to spread easily from more dense to less populated regions, increasing their competitiveness and attractiveness. Consequently, the anticipated impact of these variables is equally ambiguous.

A detailed description of these variables is provided in Table A.1 in the Appendix[1].

3.3. Methodology

The methodology adopted in this paper is in line with the overall methodology used for the analysis of agglomeration in Europe (see for example Ciccone, 2002; Rosenthal et. all, 2001). The effect of SETs on the spatial concentration index is measured by estimating

$$\gamma_{j,t} = \beta X_t + \varepsilon_{j,t} \quad (2)$$

Where γ_{jt} is the agglomeration index from Equation (1) in region j at time t, Xt is the vector of determinants of agglomeration described in the previous part, with the associated vector of coefficients β. ε is assumed to be an independent and identically distributed error term. We estimate Equation (2) by using the ordinary least-square method[2]. The estimations are provided for the overall sample, as well as separately for new and old member states.

4. Results

In this section we consider the distribution of agglomeration economies during the 2001-2010 period for all of Europe and separately for new and old member states. Based on this, we then seek to explain the spatial concentration in Europe by analysing its determinants, with special attention given to the socio-ecological transformation that takes place on the continent. The analysis is also carried out separately for new and old Member states.

4.1. Agglomeration economies in Europe

The distribution of agglomeration across all European regions in 2010 is shown in Figure 1. The map clearly demonstrates the existing core-periphery pattern, with denser regions

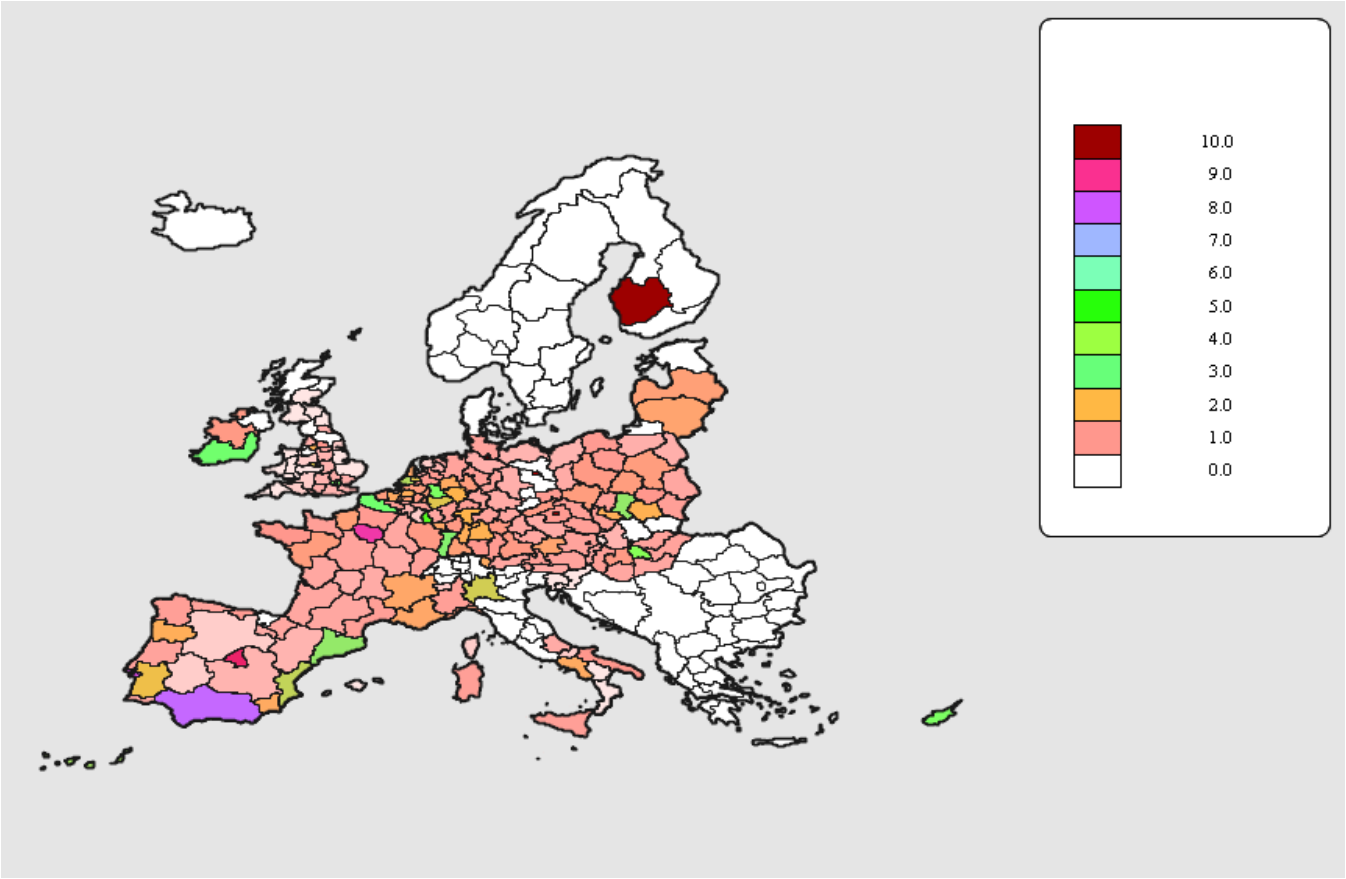
[1] An attempt was made to include additional information of oil prices and demand/use of raw materials. However, such information is available only for western European countries and only at the national level. In the present situation we decided to exclude this information at the cost of higher territorial coverage.

(Source: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=5&aid=2, http://www.livecharts.co.uk/economiccalendar.php).

[2] The fixed effect model was also incorporated. However, due to the ejection of time-invariant variables, that were significant for the scope of our analysis, we decided to follow the methodology adopted in several studies of determinants of agglomeration.

located in the central parts of Western Europe. It runs through the Netherlands, Belgium, Western Germany and into the Northern parts of Italy. Additionally, the majority of capital city regions show up as the densest regions. Vienna, Prague, Lansi-Suomi, Berlin and the Brussels region were found to be the most agglomerated regions, ranking in first to fifth positions, respectively. The highest agglomeration index is in the smallest NUTS2 regions, artificially separated from their economic hinterland. Similarly, Swedish regions (Ovre Norrland, Mellersta Norrland, Sydsverige, Norra Mellansverige) and the UK's Highlands and Islands were found to be last out of all NUTS2 regions (Table 3).

Figure 1. Distribution of agglomeration in Europe at NUTS2 level



Source: Own compilation based on REGIO-database

A comparison of regional differences within countries demonstrates a relatively stronger core-periphery pattern in Eastern European countries than in the Western parts of Europe. Small single regions with very high values on the agglomeration index are surrounded by less dense regions. Agglomeration in Western European countries is distributed relatively

more evenly. However, it is difficult to generalise, as mixed patterns can be observed in each country.

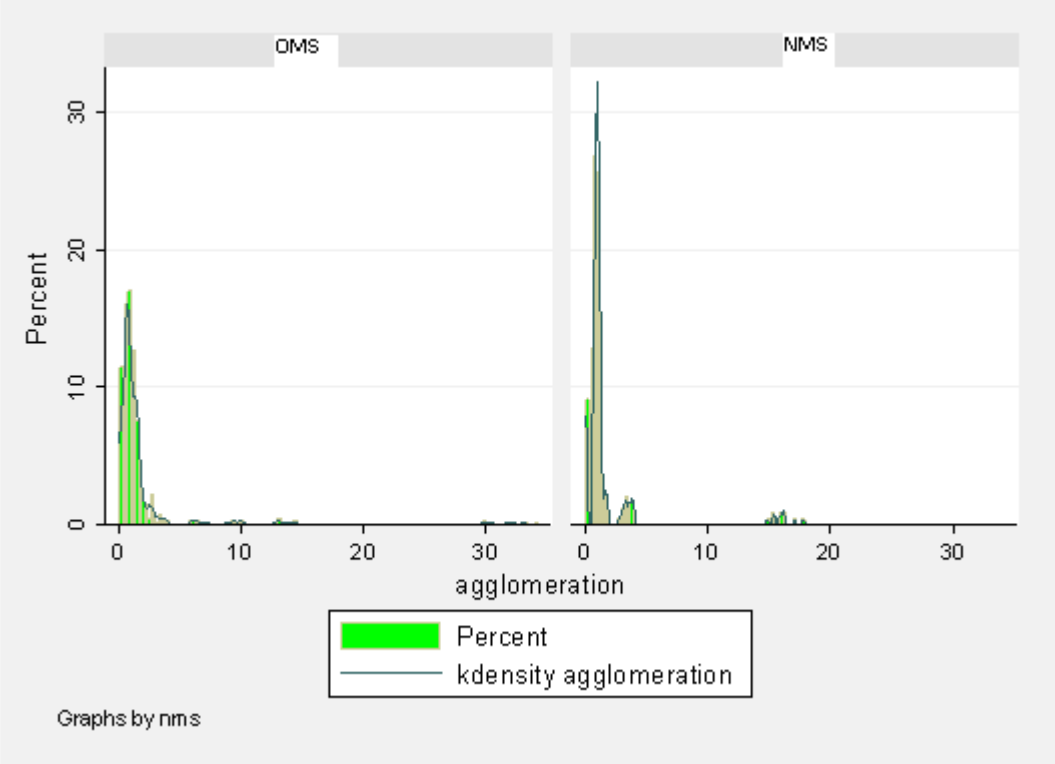
Table 3. Agglomeration index of top five and least five NUS2 regions

Region	Agglomeration Index for the top five NUTS2
Vienna	31,67
Prague	17,79
Lansi-Suomi	13,56
Berlin	13,55
Greater Brussels region	12,63
	Agglomeration Index for the least five NUTS2
Ovre Norrland	0,0023
Mellersta Norrland	0,0030
Sydsverige	0,0031
Norra Mellansverige	0,0037
Highlands and Islands	0,0039

Source: Own compilation based on REGIO-database

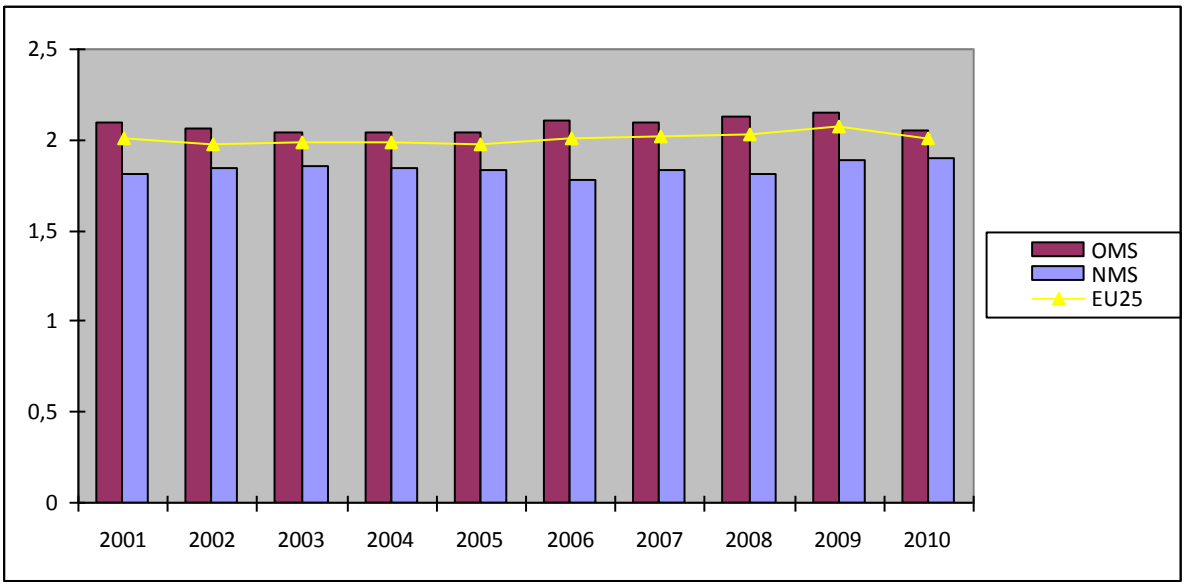
With respect to the differences in agglomeration distribution between new and old member states, a higher concentration exists in Eastern European countries. Figure 2 shows the share of regions (percentage-wise) that have relatively high levels of agglomeration. A flatter graph indicates a high concentration of agglomeration in few regions, while a steeper one means that the level of agglomeration is comparable across regions. Therefore, from Figure 2 we can see that a high proportion of regions in the NMS have a comparable and relatively low level of spatial concentration of economic activity, while the highest level of agglomeration is recorded in very few regions. A higher spatial location of economic activity in few regions confirms the core-periphery model in the NMS. On the other hand, the spatial location of economic activity in old member states is more diversified. These results suggest a different pattern of agglomeration among European countries, which imposes the need for providing separate estimation analyses of the two sub-samples, as the results might be different.

Figure 2. Distribution if agglomeration in OMS and NMS



Source: Own compilation based on REGIO-database

Figure 3. Average agglomeration by year and country



Source: Own compilation based on REGIO-database

In a dynamic perspective, agglomeration economies have not revealed any notable changes during the 2001-2010 period (Figure 3), which confirms the findings of the specialised literature. As expected, the observed average agglomeration in the NMS is slightly lower that in Western European countries.

4.2. Impact of SET on agglomeration

Table 4 provides the estimated determinants of agglomeration for all of Europe. The factors that significantly affect agglomeration are related mainly to the situation on the labour market. *Regional population density*, which is a proxy for labour market pooling, increases the agglomeration in the region. The same positive effect is observed in the case of demographic transition, approximated by *ageing of the population*, *fertility rate* and *regional migration*. As people are living longer, they remain on the labour market for longer periods and therefore contribute to an increase in the labour force. A higher *fertility rate* has a negative impact on spatial concentration, as it is related to exiting the labour force, and thus a lower participation rate. Human capital accumulation, approximated by the *number of students,* increases the agglomeration index. Specific characteristics of the labour force represent a natural advantage that affects the location decision of firms.

Another factor significantly influencing agglomeration is local competition, approximated by the number of *business establishments*. Although positive, its impact is relatively small because the share of micro- and small enterprises in total number of firms is high. The rate of growth of employment is therefore inferior to the growth rate of the number of business establishments; since agglomeration is calculated on an employment basis, the contribution of this factor appears to be relatively low.

Conversely, *R&D expenditure* coefficients are insignificant. A possible explanation for this result might be that the geographical unit used is far too large and too variable to capture local knowledge spillovers.

Three variables are used as proxies for energy transition. All of them are statistically insignificant, suggesting that the forthcoming energy transformation does not seem to noticeably affect the pattern of economic activity in Europe.

The shift of the political and economic centre of gravity in Europe is statistically insignificant in the process of agglomeration. The same insignificant effect is observed for the transformation in ICT use and knowledge diffusion. However, when the analysis is done

separately for old and new member states, significant changes appear, as described in the next section.

It follows that countries and regions are relatively diverse and it is therefore difficult to provide comprehensive results. The variable that differentiates between new and old member states shows that regions in Eastern European countries record a lower agglomeration index than their Western counterparts. Concluding, very little can be said based on the results of the overall analysis of the whole sample, as most of the explanatory variables turn out to be insignificant.

Table 4. Determinants of agglomeration in Europe - estimation results

Independent variables	Coefficient
Knowledge spillover	
R&D expenditures	-0,345
Labour market pooling	
Population density	3,753***
Local competition	
Business establishment number	0,001***
Pollution	
Treatment of municipial waste	0,523
Energy transition	
Primary production and final consumption of energy per inhabitant	0,098
Share of renewable energy in final energy consumption	-0,003
Demographic transition	
Life expectancy	0,017*
Fertility rate	-4,708***
Internal regional migration	0,011*
Political and economic centre of gravity	
Regional GDP per capita	-0,002
Growing ICT use and knowledge diffusion	
ICT patents application	0,004
Employment in technology and knowledge intensive sectors	-0,063
Human capital accumulation	
Number of students	0,003*
Adult participation in education	-0,003
Use of internet	0,002
New Member State	-1,745***
Crisis period	0,304
Adjusted R^2	0,69
Sample size	888

Source: Own compilation based on REGIO-database.

Note: Level of significance: *** - at 1% level, **- at 5% level, *- at 10% level, blank – statistically not significant

Regression results in countries' sub-samples

Given the above results, question arises of whether the impact of SET on spatial concentration is similar across all countries or only within groups of countries, and in particular whether there are differences between new and old member states. In order to test for the existence of such differences, we estimate the model described above on two sub-samples: representative countries of "old Europe" (EU15) and "new Europe" (EU12)[3]. We carry out this separate estimation because we believe that socio-ecological transformation has different paths in the two groups of countries, which implies that SET's impact on agglomeration is varied.

The estimation results from Table 5 prove the existence of such differences. The variable *R&D expenditures* has a positive impact on agglomeration only in Western European countries, where local knowledge spillover therefore has a non-negligible contribution to agglomeration. However, the same variable has a negative impact on economic activity in the NMS. Several elements may explain this difference. Firstly, the R&D expenditures only partially approximate the knowledge spill-overs. Other variables, such as speed of internet diffusion for example, may represent a better proxy for this characteristic. Secondly, the R&D expenditures have a slightly different meaning in Western Europe as compared to the Eastern part: a significant share of R&D in the OMS is carried out by large (private) companies, which explains the positive impact on agglomeration of this variable. Nevertheless, in Eastern Europe, the R&D is essentially carried out by the government in areas that do not necessarily influence employment, and therefore the agglomeration. Even if large enterprises operate in the NMS, they are usually branches of Western firms and their R&D is almost exclusively done in the mother company.

Not surprisingly, the number of *business establishments* has a positive influence on the region's economic activity in both sub-samples. The same positive impact, but much more significant, is observed in the case of labour market pooling – approximated by population density.

The separate estimates for old versus new member states reveal that all three micro-foundations of agglomeration, namely knowledge spillover, labour market pooling, and local competition, have a significant impact on spatial concentration in the regions.

[3] The group of new member states included in estimations includes: Czech Republic, Hungary, Latvia, Slovak Republic and Slovenia.

Table 5. Determinant of agglomeration in NMS and OMS – estimation results

Independent variables	New Member States	Old Member States
Knowledge spillover		
R&D expenditures	-1,642**	1,272**
Labour market pooling		
Population density	6,057***	5,091***
Local competition		
Business establishment number	0,001***	0,001***
Pollution		
Treatment of municipial waste	-0,131*	7,354***
Energy transition		
Primary production and final consumption of energy per inhabitant	-0,088***	0,105
Share of renewable energy in final energy consumption	0,008***	-20,022***
Demographic transition		
Life expectancy	0,003	-0,267*
Fertility rate	-0,650**	-7,102***
Internal regional migration	-0,007	-0,079***
Political and economic gravity		
Regional GDP per capita	0,029***	-0,009
Growing ICT use and knowledge diffusion		
ICT patents application	0,122**	-0,004
Employment in technology and knowledge intensive sectors	0,023	2,594
Human capital accumulation		
Number of students	0,001	-0,005
Participation of adults in education	-0,021	-0,133*
Use of internet	-0,003	0,002
Crisis period	0,133	1,308*
Adjusted R^2	0,89	0,79
Sample size	242	646

Source: Own compilation based on REGIO-database

Note: Level of significance: *** - at 1% level, **- at 5% level, *- at 10% level, blank – statistically not significant

After considering the theoretical determinants of agglomeration, we search for differences in the impact of SETs on economic activity patterns between new and old member states. The proxy variables for energy transition have opposite signs when comparing the two sub-samples: the *primary production and final consumption of energy per inhabitant* have a negative effect on agglomeration in the new member states, whereas it is positive but statistically insignificant in old member states. Although the shift from carbon to "green" energy should have a positive impact on agglomeration because it decreases pollution (Glaeser, 1998), this is only true in Western European countries. Its impact on agglomeration depends very much on the type of energy used. In general, less polluting energy sources (wind power, solar, nuclear) are more frequently used in the OMS as compared to the NMS, where fossil sources of energy are still dominant. Consequently, the most polluted capital cities in Europe are Bucharest and Budapest[4], while the most polluted town in the whole European Union is Pernik (near Sofia) in Bulgaria.[5] As a result, the coefficient of this variable is negative (and statistically significant) in the NMS.

This particularity is confirmed by the second variable expressing the energy transition – the share of renewable energy in final consumption. Its coefficient is positive in Eastern European countries (indicating the fact that people agglomerate if pollution declines), but negative in the OMS. In this second situation, the negative impact could be explained by the fact that the increasing use of renewable energies allows companies to relocate to traditionally clean areas, where the local authorities are usually ready to accept economic activities that preserve the environment. At the same time, certain renewable energies can be self-produced, offering energetic independence to both producers and individuals; they are therefore more willing to move far from traditional agglomerations. Other forms (biogas, for example) are less expensive than fossil fuels and consequently reduce transportation costs; people are therefore more willing to move outside agglomerations and make longer trips to and from their jobs.

It follows that our estimates relating to energy transition are consistent with the theory only in the case of NMS.

As expected, the demographic transition has had a negative effect on the pattern of economic activity in both sub-samples, though not all variables are statistically significant in

[4] http://www.linternaute.com/actualite/monde/pollution-air-ville/pollution-budapest.shtml
[5] http://opentravel.com/blogs/worlds-most-polluted-cities/

the NMS. Higher *life expectancy* negatively influences agglomeration in Western Europe, whereas it is statistically insignificant in NMS. This is due to shorter life expectancy in Eastern European countries, where the average life expectancy is 72.5, as compared to 79 in Western Europe (Schoenmaeckers et al., 2009). Older people leave the labour market, significantly affecting the economic activity in Western Europe, which is not yet the case in the NMS. The *fertility rate* has a negative impact on economic activity in both sub-samples: it is evident that the change in traditional female roles and women's decisions to postpone maternity increases their activity rate. Migration intensity is believed to increase agglomeration (according to the results of Task 1 in this WP). In our case the *internal regional migration* decreases agglomeration in Western Europe, whereas it is statistically insignificant in the NMS. This is because higher internal migration is equivalent to increased mobility of labour. However, a negative impact on agglomeration in the OMS may be linked to the energy transition: the increasing use of renewable energies (with a very high coefficient) favours the move from agglomerated areas to less populated regions.

Overall, the results provide strong evidence that labour market pooling and demographic transformation, which influence the labour force, are generally associated with agglomeration.

The transition in the political and economic centre of gravity, approximated by *regional GDP per capita,* is statistically insignificant in Western Europe and has a positive impact on agglomeration in the NMS. Higher regional GDP in a particular region encourages people to move and work there. This result supports the thesis that regional GDP boosts agglomeration only to a point and after obtaining a certain level of welfare, people start to move to less dense regions. The differences between old and new member states in this respect are also due to the fact that regional development is much more balanced in Western countries than in Eastern ones; in the latter, economic activity is generally concentrated in large cities, which offer more employment opportunities.

Growing ICT use and knowledge diffusion is statistically insignificant in both sub-samples. Only in the NMS did ICT patent application have a positive and significant impact on economic activity. These results however have to be taken with caution as the quality of this data is very poor and mainly approximated from other sources (see Appendix). The human capital accumulation also has an irrelevant significance in both sub-samples.

In order to see if the 2008 crisis had any significant impact on the pattern of economic activity, we constructed a dummy variable that separates the period into two sub-periods: the pre-crisis one (until 2008), respectively the post-crisis period (after 2008). The variable is not significant in the NMS, but has a positive and strong impact on agglomeration in Western Europe. This effect is due to the fact that the crisis affected employment levels in relatively small regions more than in large agglomerations.

As expected, the regression coefficients from Table 5 confirm that in many socio-ecological respects, the Western and Eastern European member states are still significantly different. Averaging across all regions hides important disparities in the level of regional development and in the change over time.

5. Concluding Remarks

The aim of this paper is to consider the spatial distribution of economic activity in the European Union at the NUTS2 level for the 2001-2010 period. In particular, we seek to present descriptive evidence on agglomeration in Europe and to consider the changes over time among new and old member states. Moreover, we investigate the impact of possible socio-ecological transformation on agglomeration in Europe.

The main results reveal that the agglomeration index has been fairly stable over the last decade in Europe and in both new and old Member States at all NUTS2 levels. Its value is still higher in EU15 than in the EU12, and we did not find any evidence that the difference between them converges. The size of the index is highest for the smallest regions, mainly capital cities. The analysis of the agglomeration distribution suggests significant differences between old and new member states.

The factors significantly influencing agglomeration are mainly related to labour market pooling and demographic change. Other transformations, such as energy transition, knowledge diffusion, or economic shift of gravity have an ambiguous effect on agglomeration in Europe and depend on the level of development of a country/region and the advancement of such a transition.

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Annex

Table A.1. Definition and availability of variables

Variable	Definition
Agglomeration	Number of people employed in a region divided by regional area
Knowledge spillover	
R&D expenditures	Regional R&D expenditures per inhabitant
Labour market pooling	
Population density	Regional population by land area
Local competition	
Business establishment number	Yearly business establishment number in all sectors available
Pollution	
Treatment of municipial waste	Regional generation and treatment of municipal waste (in thousands of tons) per inhabitant
Energy transition	
Primary production and final consumption of energy per inhabitant	Primary production and final consumption of energy (in thousands of tons) per inhabitant
Share of renewable energy in final energy consumption	Share of renewable energy in final energy consumption
Demographic transition	
life expectancy	Life expectancy at given exact age
fertility rate	Fertility rate
Internal regional migration	Internal regional migration related to regional population
Political and economic gravity	
regional GDP per capita	Gross domestic product (GDP) at current market prices in EUR per inhabitant

Variable	Definition
Growing ICT use and knowledge diffusion	
ICT patents application	ICT patent applications to the EPO by priority year at the regional level per million inhabitants
Employment in technology and knowledge intensive sectors	Employment in technology and knowledge-intensive sectors per land area
Human capital accumulation	
Number of students	Number of students per inhabitant
Participation of adults in education	Participation of adults aged 25-64 in education and training (in %)
Use of internet	Percentage of individuals regularly using the Internet

Table A.2 Descriptive statistics

Variable	Europe	EU15	EU12
Agglomeration	1,779	1,819	1,672
Knowledge spillover			
R&D expenditures	0,489	0,643	0,093
Labour market pooling			
Population density	0,309	0,346	0,210
Local competition			
Business establishment number	74 162	77 220	65 931
Pollution			
Treatment of municipial waste	0,708	0,623	0,886
Energy transition			
Primary production and final consumption of energy per inhabitant	0,639	0,737	0,406
Share of renewable energy in final energy consumption	0,749	0,024	2,565
Demographic transition			
Life expectancy	70	72	64
Fertility rate	1,356	1,429	1,16
Internal regional migration	6,233	6,494	5,571
Political and economic centre of gravity			
Regional GDP per capita	23,373	30,091	6,302
Growing ICT use and knowledge diffusion			
ICT patent application	6,044	7,539	0,498

Variable	Europe	EU15	EU12
Employment in technology and knowledge intensive sectors	0,438	0,431	0,455
Human capital accumulation			
Number of students	208,79	217,37	186,98
Adult participation in education	2,711	3,133	1,584
Use of internet	18,372	19,51	15,35