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AN ANALYSIS OF REGIONAL COMMUTING FLOWS IN THE EUROPEAN UNION

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An analysis of regional commuting flows in the European Union♦

Jordan Marvakov♠ and Thomas Y. Mathä♣

Abstract: Regional labour mobility is of increasing concern in the context of the Single European Monetary Policy, as EMU implies a reduction of national policy options. Thus, it is important that the remaining adjustment mechanisms function effectively. While most of the empirical literature focuses on labour mobility in terms of migration, this paper provides an empirical assessment of the determinants of aggregate regional commuting flows in the EU, an issue often examined in a local or national context but still un(der)explored on EU level. Using an extended gravity framework, commuting is found to respond to differences in regional wages and unemployment, and to provide an equilibrating mechanism to labour market disequilibria. Higher levels of education and labour force participation of women, as well as a larger services sector are associated with a higher percentage of commuting. Finally, the results reveal interesting geographical differences between internal, border and coastal regions.

Keywords: Labour mobility, regional commuting, EMU, gravity model.
JEL-Codes: J61, R12, R23, C23.

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Nicht-technische Zusammenfassung

Trotz weiterführender ökonomischer und politischer Integration ist die Europäische Union immer noch durch sehr niedrige Personenmobilität gekennzeichnet. Das gilt vor allem im Vergleich zu anderen Staaten, wie den USA, Australien, Canada und Japan. Im Jahr 2000 haben nur 225,000 Menschen oder 0,1 Prozent der EU15 Bevölkerung ihre offizielle Adresse von einem in ein anderes Land gewechselt. Nur 4 Prozent sind jemals in einen anderen EU Mitgliedsstaat und weniger als 3 Prozent sind jemals in ein anderes Land außerhalb der Europäischen Union gezogen. In den USA hingegen leben fast ein Drittel aller US Bürger außerhalb des US Staates, in dem sie geboren wurden. Die geringe grenzüberschreitende Mobilität in der Europäischen Union ist sicherlich zum Teil mit den verschiedenen juristischen, administrativen, kulturellen and sprachlichen Barrieren zu erklären, die dazu führen, dass die Arbeitsmärkte national segmentiert sind.

Jedoch selbst wenn man die Mobilität nur auf nationaler Ebene untersucht stellt man fest, dass die Mobilität sehr gering ist. Nur 18 Prozent der gesamten EU Bevölkerung haben jemals in einer anderen Region innerhalb des gleichen Landes gelebt. Ungefähr ein Drittel der Europäer sind innerhalb ihrer Stadt umgezogen und ungefähr ein Viertel ist in eine andere Stadt gezogen, jedoch innerhalb der gleichen Region. Im Vergleich dazu haben allein im Jahr 1999 5,9 Prozent der US Bevölkerung ihren Wohnort zwischen US „Counties" gewechselt. Die regionale Arbeitsmobilität in der Europäischen Union wird in der Tat zum Teil so niedrig betrachtet, als dass sie nicht als ökonomisch relevanter Anpassungsmechanismus für regionale Arbeitsmarktungleichgewichte angesehen wird – ein Sachverhalt der auch für das Eurosystem von ausgewiesener Bedeutung ist. Dabei ist es gerade dieser regionale Aspekt, der wichtig erscheint, denn die regionalen Arbeitsmärkte in der Europäischen Union zeichnen sich durch starke Nachbarschaftseffekte aus. Das heißt, die regionale Arbeitsmarktsituation ist sehr eng mit der jeweiligen Arbeitsmarktsituation der benachbarten Regionen verknüpft. Regionale Mobilität kann jedoch nicht nur durch regionale Migration erreicht werden, sondern auch durch regionale Pendlertätigkeit. Und es scheint in der Tat so zu sein, dass diese zweite Form der regionalen Mobilität auf dem Vormarsch in der Europäischen Union ist. Laut Europäischer Kommission pendeln jeden Tag im Durchschnitt ungefähr 8 Prozent der Erwerbstätigen zwischen verschiedenen Regionen.

Das Ziel der vorliegenden Studie ist es, neue empirische Erkenntnisse über regionale Pendlerströme und seine Determinanten zu gewinnen. Ein wichtiger Aspekt ist in diesem Zusammenhang, ob regionale Pendlerströme auf regionale Arbeitsmarktungleichgewichte in der zu erwartenden Weise reagieren. Agieren Pendlerströme als ausgleichende Kraft, indem sie den Arbeitskräfteüberschuß in wirtschaftlich schwächelnden Regionen und den Arbeitskräftemangel in wirtschaftlich florierenden Regionen reduzieren? Anders ausgedrückt, können regionale Pendlerströme als potentieller Anpassungsmechanismus für regionale Arbeitsmarktungleichgewichte gesehen werden? Diese Studie versucht anhand eines erweiterten Schwerkraftmodels (gravity model) diesen Fragen nachzugehen. Die Resultate zeigen, dass Pendlerströme mit den Größen der Herkunft– und Zielregionen zunehmen und mit ihrer Entfernung von einander abnimmt. Die empirischen

Schätzergebnisse belegen weiterhin, dass die Pendlerströme in der Tat auf Arbeitsmarktungleichgewichte, wie Unterschiede in regionalen Durchschnittslöhnen und Arbeitslosigkeitsraten, in der zu erwartenden Weise reagieren. Des weiteren weisen die Resultate einen positiven Zusammenhang des durchschnittlichen Ausbildungsniveaus und der regionalen Arbeitsmobilität auf. Geographische Aspekte, die sich jedoch von Land zu Land unterscheiden können, spielen auch eine wichtige Rolle. Ein generell sehr robustes Ergebnis ist, dass Regionen mit einem sehr hohen Urbanisationsgrad Zentren für regionale Einpendler sind und dementsprechend weniger Auspendler als nicht-urbane Regionen haben. Auch erweisen sich Regionen mit einem hohen Spezialisierungsgrad im Dienstleistungsbereich als Regionen mit hohen Auspendlerströmen. Zudem gibt es Unterschiede zwischen landesinneren Regionen, Grenzregionen, Küstenregionen und Regionen, die an eine EU15 Außengrenze stoßen. Diese Ergebnisse sind weniger robust, insgesamt gesehen jedoch pendeln weniger Arbeitnehmer aus Küstenregionen in die Nachbarschaftsregionen als das der Fall ist für landesinnere Regionen. Die EU15 Außenregionen weisen geringere Aus-Pendlerströme auf, was auch durch die sehr viel niedrigeren Einkommen in den neuen EU10 Mitgliedsstaaten bedingt sein dürfte.

I. Introduction

Regional labour mobility is of increasing concern in the context of the single European Monetary Policy. For the participating EU member states, EMU implies a reduction of national policy options. Thus, it is important that the remaining adjustment mechanisms function effectively, in particular since large redistributing fiscal transfers are hitherto relatively uncommon in the EU.[1] Blanchard and Katz (1992) find that, in the U.S., the dominant adjustment mechanism to a region-specific labour demand shock is labour mobility, rather than job creation or job migration. Labour mobility, in turn, appears to be primarily a response to changes in unemployment, rather than consumption wages. According to Decressin and Fatás (1995), in Europe it is the labour force participation rate that absorbs most of the shock. Only from the third year onwards does migration play a substantial role, whereas in the U.S. it does so from the very beginning. Both in the U.S. and Europe, the unemployment rate only moves to a small extent in response to regional labour demand shocks. Puhani (2001) estimates that it takes several years if not a decade for regional unemployment inequalities to be evened out by labour migration, which leads him to conclude that labour mobility in the EU is so low that it cannot be considered an economically significant adjustment mechanism for regional labour market disequilibria.

Regional migration aside, regional labour mobility may also come in form of commuting – and it is this particular form that seems to be on the rise in Europe. The OECD (2005) reports that between 1% and 16% of the employed commute between regions every day. According to the European Commission (2006) the average is 8%. Similarly, while still low in number, cross-border commuting is on the rise, too. According to MKW (2001), the number of cross-border commuters in the European Economic Area (EEA) rose by almost 30% between 1995 and 1999 to 500,000. Mathä and Wintr (2006) analyse the determinants for regional commuting for a comparatively small set of regions surrounding Luxembourg, and find that commuting flows respond to wage and unemployment differences between regions in the expected way.

[1] For a very sceptical view in that the EU may find it hard to resist extending existing EU mechanisms of income redistribution and eventually turn into a transfer union, see Obstfeld and Peri (1998).

Against this background, the present study extends the analysis geographically and provides new empirical evidence of regional commuting behaviour and its determinants within the European Union. One main issue is whether commuting flows in the EU respond to labour market differentials as expected. Does commuting act as an equilibrating force, i.e. help to reduce slack in the depressed regions and shortages in the performing regions? Put differently, can regional commuting be considered a potential adjustment mechanism to regional labour market disequilibria? This issue is of particular interest, as labour markets in Europe are characterised by strong neighbourhood effects. The performance of a region's labour market tends to be closely linked to the performance of adjacent regions, which calls for a regional perspective in labour market analysis. According to Overman and Puga (2002) and the OECD (2005), regions have unemployment outcomes that are closer to neighbouring regions than to other more distant regions in the same country. Surprisingly, this neighbourhood effect does not stop at national borders; the spatial correlation between regions also works across countries. In addition, regional unemployment disparities are not only larger than disparities between countries, but also more persistent.[2]

We estimate an extended gravity model of commuting, and consider the spatial allocation of regions and the population distribution within them. The results indicate that regional commuting flows in the EU15 do respond to both wage and unemployment differentials. The sizes of the origin and the destination regions exert a positive influence, and increased distance between regions reduces commuting flows. Lastly, there is a positive relationship between commuting, the average educational attainment, which suggests higher mobility of skilled labour, and the labour force participation of women.

The present paper is organized as follows. Section II presents a brief discussion of previous empirical findings on commuting behaviour. Section III provides a description of the European geography for some selected labour market outcomes and commuting. Section IV outlines the empirical framework, specifies the model to be estimated, and describes the

[2] For a recent survey on theoretical and empirical explanations of regional unemployment disparities, see Elhorst (2003).

data in more detail. Section V discusses the empirical findings. Section VI concludes with some final remarks.

II. Background

Despite steadily progressing economic and political integration, Europe is still associated with a low degree of mobility, in particular when compared to other OECD countries, such as the United States, Australia, Canada, and Japan. In 2000, only about 225,000 or 0.1% of the total EU15 population changed their official residence from one country to another. Cross-border migration remains almost negligible; 4% have moved to another EU member state and fewer than 3% have ever moved to another country outside the EU, according to a recent Eurobarometer survey on labour mobility. This compares to almost a third (32%) of US citizens living outside the state in which they were born (Vandenbrande et al., 2006).

In part, this low cross-country mobility of labour can be explained by different legal, administrative, cultural and linguistic barriers, which effectively confine labour markets to national boundaries.[3] These arguments aside, mobility remains relatively low even when considering within-country mobility only. Only about 18% of the total EU population has ever lived in another region within the same country, 32% have moved within their own town or city and 24% have moved outside their town or city, but remained within their region of origin (Vandenbrande et al., 2006). In 1999, a modest 1.2% changed official residence to another region - essentially within the same member state. For the labour force the situation is similar; two million workers aged 15-64 have changed residence between regions, representing about 1.4% of the EU employed population. These figures compare to 5.9% of the total US population having changed residence between US counties in 1999 (European Commission, 2002). Mobility in Europe, thus, primarily takes place over relatively short distances.

[3] See European Commission (2001a, 2001b) for details concerning the identified obstacles to increased labour mobility in Europe.

Commuting provides the spatial link between the location of residence and the location of work. A central idea in commuting literature is the compensating principle, that is commuting costs need to be compensated by either cheaper housing or higher wages. Based on this idea, a rich literature has developed examining various issues related to commuting. The specific focus differs depending on whether commuting is analysed in the context of labour, urban, land or housing economics.[4] A relatively new strand of research deals with regional commuting within the framework of New Economic Geography (NEG) models. These emphasise the dependence of agglomeration and dispersion of economic activity on transportation and commuting costs (see Tabuchi, 1998; Murata and Thisse, 2005; Borck et al., 2007).

Aside of the impact of individuals' characteristics on commuting behaviour (e.g. occupation, industry, gender, level of education, marital status, number of children, etc.), empirical studies often confine themselves to metropolitan areas (e.g. Clark et al., 2003), districts or municipalities (e.g. Shields and Swenson, 2000), or groups of regions within a single country. Commuting behaviour has, for example, recently been analysed for the United Kingdom (Cameron and Muellbauer, 1998; Benito and Oswald, 2000), the Netherlands (Vermeulen, 2003; Hensen and Cörvers, 2003), Sweden (Eliasson et al., 2003), Lithuania and Latvia (Hazans, 2004) and Hungary (Kertesi, 2000).

These studies usually focus on the driving forces behind commuting flows and the reasons why certain locations generate higher commuting numbers than others. By and large, they confirm that commuting is positively related to the labour force in the origination region and the employment in the destination region, and negatively to the travel costs or distance between them. Other factors frequently considered are wages, housing prices and unemployment levels, as well as the differences therein. Cameron and Muellbauer (1998) conclude that commuting and migration respond to the same labour market factors, i.e. relative earnings and relative employment opportunities. Eliasson et al. (2003) suggest the existence of a trade-off between commuting and migration in the sense that migration can be

[4] For more detailed surveys see Crampton (1999), Van Ommeren (2000) and Clark et al. (2003).

construed as an alternative to commuting. Hazans (2004) reports that commuting reduces urban-rural wage and employment disparities, and increases national output. In a similar vein, Kertesi (2000) finds that high commuting costs result in the segregation of the local labour market, high local unemployment rates and limited equalisation of regional unemployment rate differentials. However, while these studies can explain local and national commuting developments, they offer little insight about the systematic determinants of regional or cross-border commuting patterns within the European Union. Whereas the latter has for example been analysed by Mathä and Wintr (2006) for a comparatively small set of border regions surrounding Luxembourg, the issue of regional commuting flows in the EU15 remains largely unexplored.

A rather robust result is the positive effect of education and schooling on commuting. Benito and Oswald (2000) report commuting time or distance increases together with the level of educational attainment and Hazans (2004) reports that the probability of commuting increases with the level of education. To give a more specific example, according to special Eurobarometer survey in September 2005 dedicated to geographical and labour market mobility, 70% of those who completed their full-time education at the age of 15 commute for less than 30 minutes day. The corresponding figure for those who finished at the age of 20 is 54%; the respective figures for 60 minutes are 11% and 18%. For Vandenbrande et al. (2006) this indicates that commuting tends to take the form of a functional equivalent of geographical mobility, in particular for better educated people. They argue firstly that if geographic mobility is of greater importance in highly skilled jobs, the better educated may opt for longer commuting instead more frequent residential moves, and secondly that the suburbanisation process may a contributing factor with the better educated preferring to live in suburban residential areas and working in the city. Similarly, the OECD (2005) argues that, as households' income rises and commuting costs decline, households tend to demand larger dwellings and plot sizes that cannot be accommodated (or alternatively afforded within) cities, and that part of the recent increases in commuting rates and distances are also related to developments in public infrastructure facilitating urban sprawl. However, whereas labour mobility in terms of migration is generally associated with higher educational attainment, commuting seems more important among the highly skilled in the UK and in Germany, but more important among the low and medium skilled in Austria, France and Italy.

III. European Geography

Are commuting flows are driven by labour market imbalances between closely located EU regions? Before we proceed with a formal econometric analysis we need to establish what spatial differences among NUTS2 regions are visible in the data that might potentially affect the mobility of workers between EU regions. Do certain locations exhibit consistently worse labour market conditions, and are such locations dispersed or clustered in space? How do differences within countries relate to differences between countries? Does disaggregating data to the regional level provide any insights that might have been lost when examining national data?

In the EU, regional statistical units mainly refer to regions according to the "Nomenclature of Territorial Units for Statistics" (French abbreviation NUTS), which present a reasonable sub-national disaggregation of national economies. These regional units are, however, generally based on administrative rather than functional considerations, an important issue that needs to be kept in mind when interpreting the results.[5] The main regional data used in the paper refer to the second least level of disaggregation known as NUTS2 and are drawn from Eurostat's REGIO database. The final data set used in this paper discards Greece due to its spatial detachment from the rest of the sample (as well as data availability and reliability issues) and remote islands (such as *Madeira*, *Corse* or *Sardegna*) with the exception of Sicily. This reflects the paper's main focus on regional commuting and thus neighbouring effects across regions. Furthermore, new member states were excluded due to data availability and reliability issues. The final dataset comprises 187 NUTS2 EU15 regions and covers the period 1999-2004.

[5] On the specific issue of the data problems with regional EU data see also Coombes and Overman (2004).

Table 1: Geography of regions included in the analysis.

Country	*No. of regions*	*Internal regions*	*Border regions*	*Coastal regions*	*EU15 ext. land border regions*	*Avg. no. of adjacent regions*	*Avg. region area (sq.km)*
AT	9	1	8	—	5	5.2	9319
BE	11	3	8	1	—	5.3	2775
DE	41	19	21	4	8	5.6	8708
DK	1	—	1	1	—	1.0	43098
ES	15	3	9	8	—	4.7	32902
FI	4	—	3	3	2	2.8	84148
FR	21	5	11	10	—	5.2	25618
IE	2	—	1	2	—	1.5	34899
IT	20	1	7	15	1	4.0	13862
LU	1	—	1	—	—	5.0	2586
NL	12	1	4	6	—	5.1	3461
PT	5	—	5	5	—	3.4	17803
SE	8	—	4	8	—	2.6	55125
UK	37	13	1	24	—	4.0	6590
EU15	187	46	84	88	16	4.6	16297

Notes: Greece is excluded due to the spatial detachment to the rest of the sample (as well data availability and reliability issues). Border regions are regions that share a land border with a different country. EU15 external border regions are regions that share a land border with a non EU15 country. Sweden is not considered to have a EU15 external land border with Norway due to the highly integrated Nordic labour markets.

To what extent are regions similar or different to their neighbouring regions in terms of labour market outcomes? As Overman and Puga (2002) and Niebuhr (2003) report, regions are characterised by strong neighbourhood effects. To analyse this issue, as well as due to the unavailability of region specific in-commuting data, we construct *synthetic destinations*. A synthetic destination is a construct comprising all adjacent regions with whom region i shares a land border, where the respective size (in terms of employment) E_j) is used as a weight. Doing so we obtain a surrounding neighbouring area, which is specific to each region i. Unlike simple averages, these measures take into account the differences in size of individual NUTS2 regions. Thus, these synthetic groupings are overlapping and not mutually exclusive. Note that this approach also includes foreign neighbours, but excludes the origination region i itself.[6] (Labour market) indicators relating to the synthetic

[6] To give a specific example, the NUTS2 level neighbours of the region (and country) *Luxembourg* are in the French region *Lorraine*, the Belgian provinces *Luxembourg* and *Liège* and the German Bundesland *Saarland* and Regierungsbezirk *Trier*. *Lorraine* and *Luxembourg* are neighbours, and they share some neighbours (i.e. *Saarland*), but not all of them (*Alsace* is a neighbour of *Lorraine* but not of *Trier*).

destination, denoted with a tilde (~) sign, are calculated as $\tilde{\Lambda}_i = \sum_j w_{ij} \Lambda_{ij}$, with $\Lambda \in \{W, U, U^{lt}, Y\}$, where, W, U, U^{lt} and Y refer to (wage) compensation per employee, unemployment rate, long-term unemployment rate and gross value added per employee, respectively. The share of the adjacent region j is given by $\omega_{ij} = E_{ij} / \tilde{E}_i$, where $\tilde{E}_i = \sum_j E_{ij}$ and $\sum_j \omega_{ij} = 1$. A similar concept is used by Eliasson et al. (2003) in their analysis of geographical labour mobility in the form of migration and commuting. This weighting will be followed when calculating other synthetic destination measures.

Table 2: Descriptive Statistics

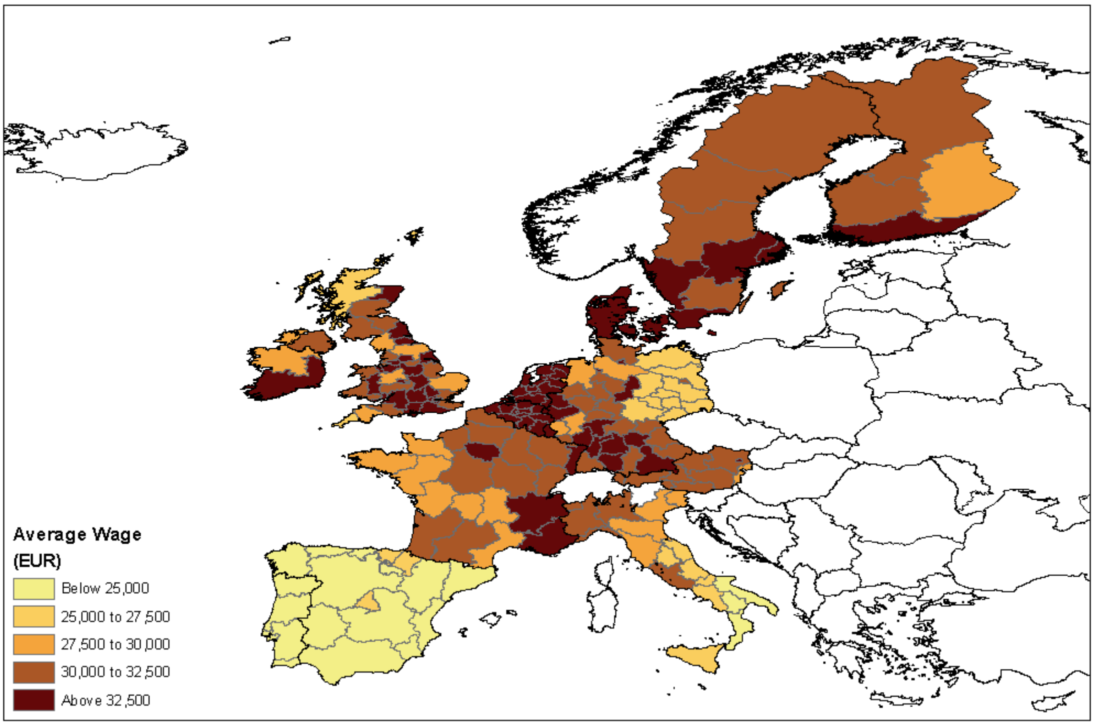
Variable	*Obs.*	*Mean*	*Std.*	*Min.*	*P25*	*P50*	*P75*	*Max.*
Origination Regions								
Out-commuters (thousands)	157	67	84	2	26	47	91	924
Labour force (thousands)	182	904	742	57	409	701	1157	5511
Gross value added per employee (EUR)	187	54460	10054	23408	48514	54016	59389	87939
Compensation per employee (EUR)	185	31007	5636	12845	29043	31192	33671	51525
Long-term unemployment rate	170	0.030	0.030	0.002	0.011	0.021	0.033	0.173
Total unemployment rate	187	0.070	0.046	0.015	0.038	0.057	0.082	0.257
Urbanization rate	162	0.461	0.237	0.053	0.267	0.428	0.596	1.000
Distance in km	187	131	64	30	86	117	168	417
Education level	182	0.54	0.14	0.15	0.47	0.55	0.64	0.82
Participation rate of women	182	0.49	0.08	0.27	0.44	0.49	0.54	0.74
Service sector share	187	0.69	0.07	0.52	0.64	0.68	0.73	0.91
Synthetic Destinations								
Employment (thousands)	187	3497	2050	332	1926	3298	4733	9538
Gross value added per employee (EUR)	187	54102	8838	26789	48824	54678	59232	72052
Compensation per employee (EUR)	187	30921	5193	13638	29247	31774	33419	43146
Long-term unemployment rate	187	0.030	0.027	0.004	0.014	0.024	0.034	0.170
Total unemployment rate	187	0.071	0.040	0.019	0.045	0.059	0.087	0.257
Origin-to-destination Ratios								
Gross value added ratio	187	1.012	0.14	0.641	0.939	0.991	1.058	1.617
Compensation per employee ratio	185	1.009	0.141	0.657	0.934	0.993	1.065	1.637
Long-term unemployment ratio	170	1.016	0.638	0.152	0.593	0.93	1.232	5.748
Total unemployment ratio	187	0.994	0.378	0.218	0.755	0.938	1.178	3.486

Note: All data refer to 2001.

For our data sample, the average region has a labour force of 904,000, about 65,000 regional commuters and shares a land border with an average of 4.6 adjacent regions (see Table 1 and 2). The average size of the synthetic destination in terms of employment is almost 3.5 million and the average distance to reach an adjacent region about 62 kilometres.[7] The number of NUTS2 regions varies widely across EU15 member states; Germany is comprised of 41 NUTS regions, whereas Denmark and Luxembourg are comprised of a single NUTS2 region; Ireland is comprised of two NUTS2 regions. The average is slightly over 13 regions per country. The five countries that exceed this average make up over 70 percent of all regions. The regions' sizes in square kilometres differ rather substantially from country to country. Whereas the average region's size is about 2,800 square kilometres in Belgium, it is about 30 times as much in Finland. Furthermore, only a quarter of NUTS2 regions are internal, i.e. regions with neither a coastline nor a national border. In contrast, almost twice as many regions are considered border regions and coastal regions. Thus, from a geographical point of view more, regions are located in the (national) periphery than in the core. Only in Germany, are internal regions (19) almost as numerous as peripheral regions (22).

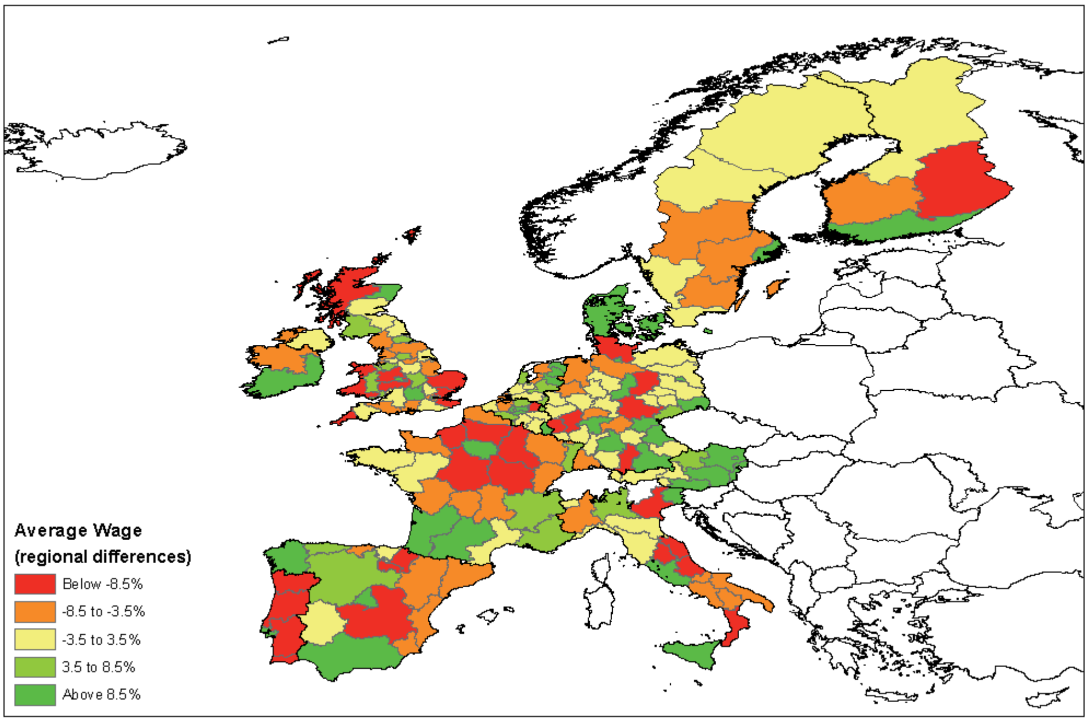
[7] This is derived by assuming a circular regional shape with size equal to the observed area, and applying the formula $r = (A/\pi)^{1/2}$.

Figure 1: Regional average wages in EU15 regions



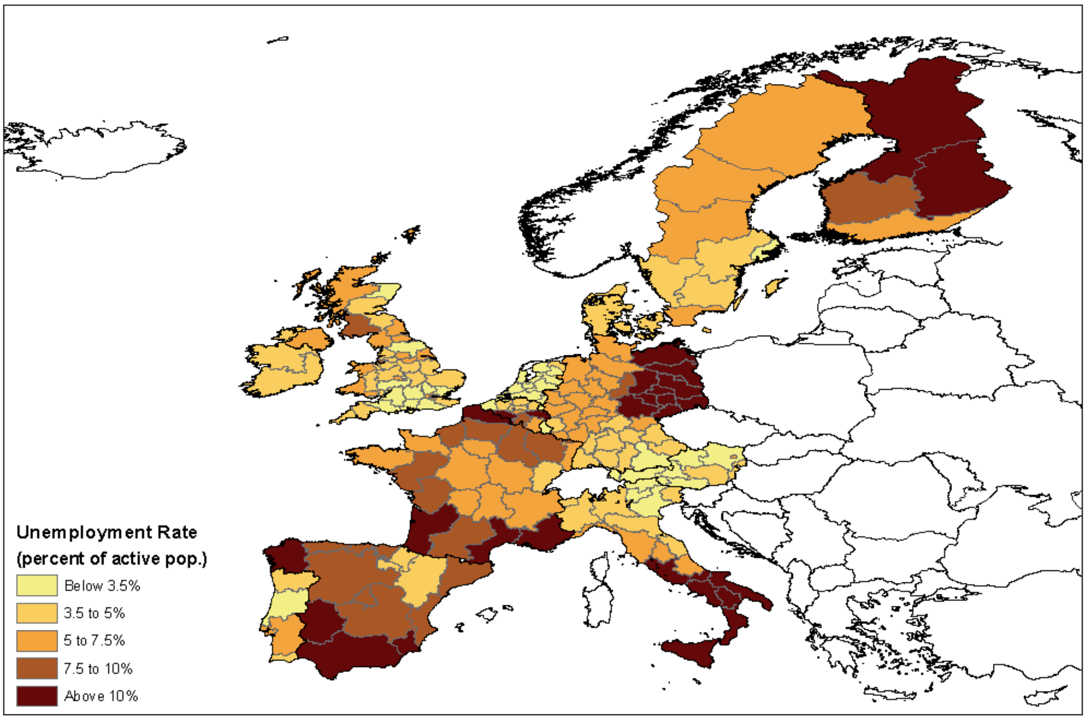
Source: Eurostat data for 2001.

Figure 2: Wage differences between EU15 regions and their adjacent regions



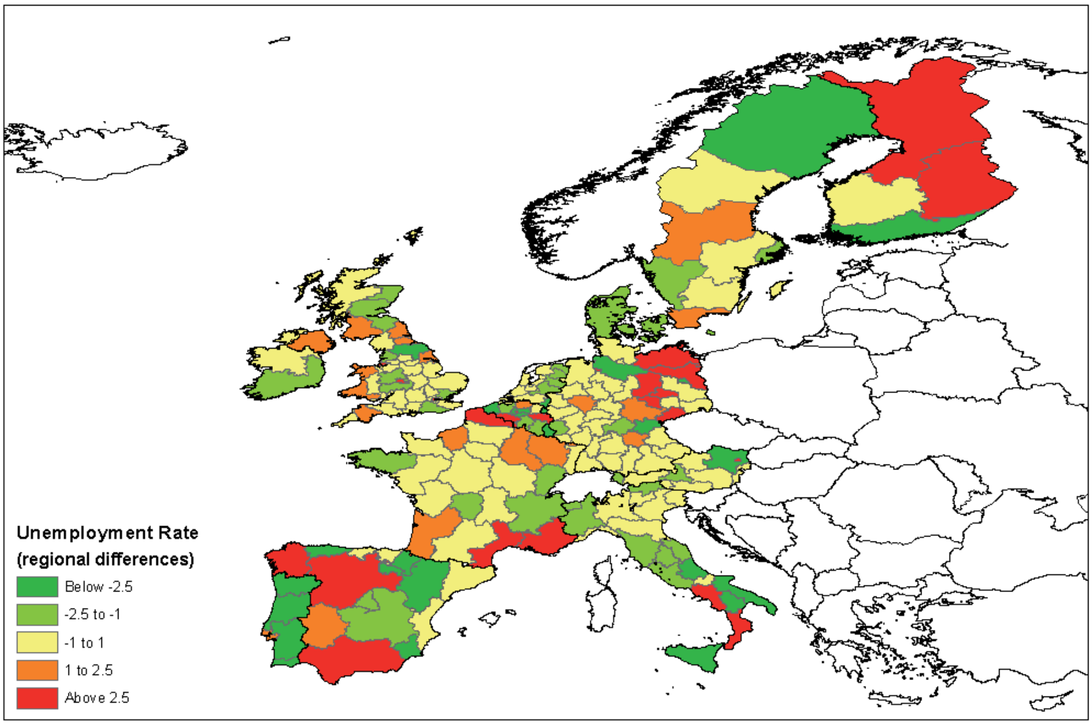
Note: Log difference of region i to the weighted average of its adjacent regions.
Source: Own calculations based on Eurostat data for 2001.

Figure 3: Regional unemployment rates in the EU15



Source: Eurostat data for 2001.

Figure 4: Unemployment differences between EU15 regions and their adjacent regions



Note: Log difference of region i to the weighted average of its adjacent regions.
Source: Own calculations based on Eurostat data for 2001.

Figures 1-4 provides a cartographic overview of the of EU15 regions' performance with regard to various labour market indicators and their distribution across space. The figures illustrate very well that labour market outcomes reflect both national and regional characteristics. The unemployment rates in 2004 are relatively low in the UK, the Netherlands and Austria. Other well-known stylised facts are the high unemployment rate in regions of the former German Democratic Republic, in the Italian Mezzogiorno and in the Belgian Wallonie. The highest unemployment rates are found for regions at the external border of the EU15.

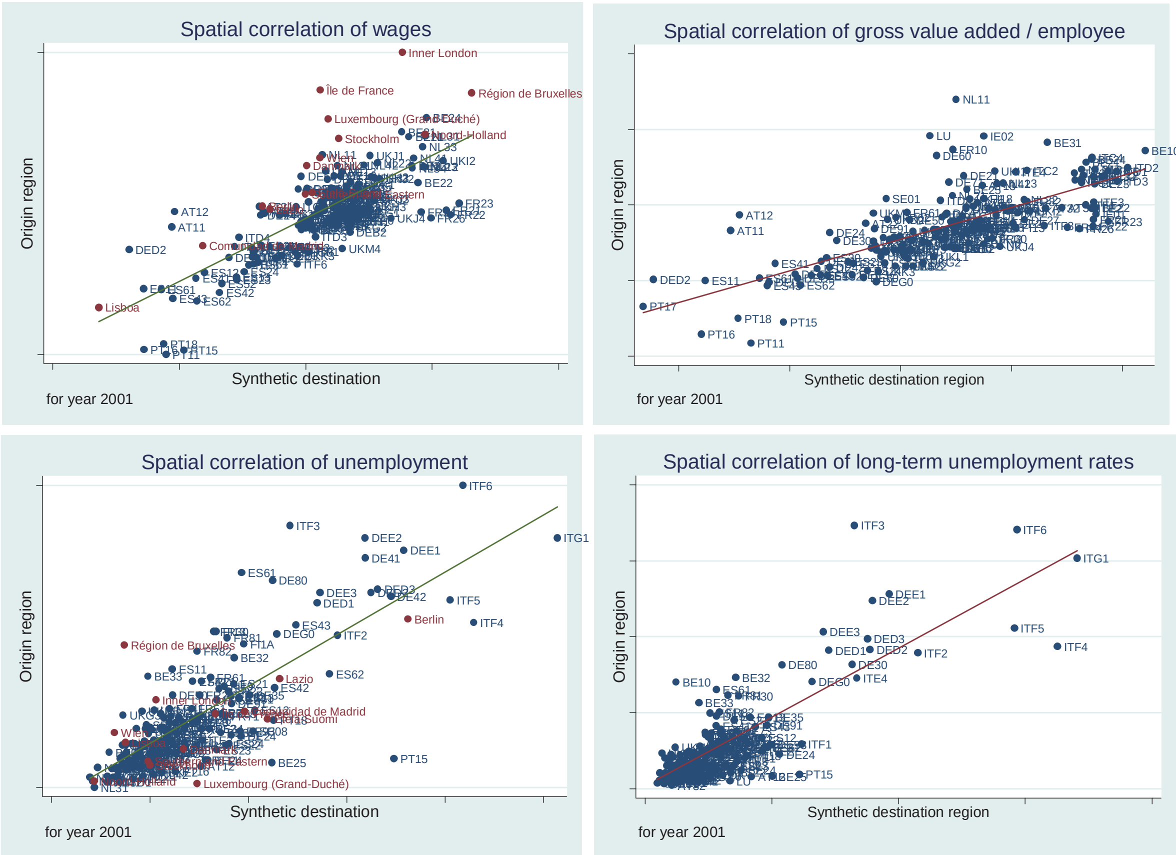
Table 3: Wage differences across regional categories

Regions	Nobs	Mean	Std.error	T-test on means equality	Wilcoxon rank sum test
Non-*Cap*ital vs.	171	30504.9	384.7	Pr(T>t)=0.007	Prob>|z|=0.001
*Cap*ital	14	37138.9	2312.4	t = -2.830	z = -3.369
non-*Core* vs.	140	30316.2	446.2	Pr(T<t)=0.004	Prob>|z|=0.012
Core	45	33155.8	925.5	t = -2.764	z = -2.525
non-*Coast* vs.	98	32446.1	532.1	Pr(T>t)=0.000	Prob>|z|=0.000
Coast	87	29385.7	603.1	t = 3.805	z = 3.714
non-*Border* vs.	99	31670.7	547.8	Pr(T>t)=0.044	Prob>|z|=0.481
Border	86	30242.8	623.1	t = 1.721	z =0.705
non-*Ext*ernal vs.	169	31172.5	447.5	Pr(T>t)=0.011	Prob>|z|=0.042
*Ext*ernal	16	29258.0	658.3	t = 2.405	z = 2.032

Note: Data for 2001, t-statistic allows for unequal variances.

At the regional level, capital regions (*Cap*) not only show higher average wages than their adjacent regions, but also significantly higher wages than other regions (Figure 1 and Table 3). There are also some significant differences for other geographical groupings. The average wage is higher in internal regions (*Core*), lower in coastal regions (*Coast*) and in regions located at the EU15 external border (*Ext*), whereas the evidence for lower average wage in border regions (*Border*) is mixed. This is confirmed both by formal t-tests and Wilcoxon rank sum tests, where the differences in the means are statistically significant as can be seen in Table 3. In contrast, a similar exercise for unemployment, be it long-term or not, does not reveal any systematic differences, at least not along the regional categories above.

Figure 5: Spatial neighbourhood effects



Source: Own calculations based on Eurostat data

Turning more specifically to neighbourhood effects, the regions' labour market outcomes are highly correlated with the outcomes of adjacent regions. In terms of average wages per employee, the correlation coefficient is 0.75 in 2001. For the unemployment and the long-term unemployment rates, the correlation coefficients are even higher at 0.80 and 0.83 respectively. This regional interdependency extends beyond the pure labour market outcomes to regional output. With a coefficient of 0.74, even regions' gross value added per employee is strongly correlated across space. Further, the origin-to-destination ratios for the various labour market indicators have a mean value close to unity. It is 1.009 for the origin to destination wage ratio ($W_i / \widetilde{W}_i$), 1.012 for gross value added ratio ($Y_i / \widetilde{Y}_i$), 0.994 for the unemployment rate ratio ($U_i / \widetilde{U}_i$), and 1.016 for the long-term unemployment rate ratio ($U_i^{lt} / \widetilde{U}_i^{lt}$). The standard deviations of these measures are around 0.14 for both the wage ratio ($W_i / \widetilde{W}_i$) and GVA ratio ($Y_i / \widetilde{Y}_i$), whereas they are substantially higher for the unemployment measures (0.367 for $U_i/\widetilde{U}_i$ and 0.638 for $U_i^{lt}/\widetilde{U}_i^{lt}$). A t-test does not reject the equality of means of wages and gross value added in the origin and synthetic destination region.

Table 4: T-test of equality of variable means

$H_0: \Lambda_i - \widetilde{\Lambda}_i = 0$	No. obs	Mean diff.	Std. error	T-stat	$Pr(\|T\|>\|t\|)$
$w - \widetilde{w}_i$	185	10.323	0.015	0.035	0.972
$y_i - \widetilde{y}_i$	187	10.887	0.142	0.338	0.736
$u_i - \widetilde{u}_i$	187	-2.843	0.043	-2.626	0.009
$u_i^{lt} - \widetilde{u}_i^{lt}$	170	-3.894	0.017	-3.229	0.002

Note: Data for 2001. w = log of compensation per employee, u = log of unemployment rate, u^{lt} = log of long-term unemployment rate, y = log of gross value added per employee. i = region i and ~ = synthetic destinations to region i.

Last, we present kernel density plots of a region's labour market outcomes relative to its adjacent regions' outcomes (in log differences) (Figure 6). The neighbourhood effect is revealed by accumulation of observations around zero and missing mass at the tails compared to the normal distribution. This is particularly well-depicted in the graphs showing logarithmic wage and gross value added differences. In case of the unemployment and long-term unemployment rates, these characteristics are also present, albeit to a lesser extent. A skewness/kurtosis test (see Table 5) formally rejects normality for all four distributions at a 10% or better significance level.

Figure 6: Kernel density plots

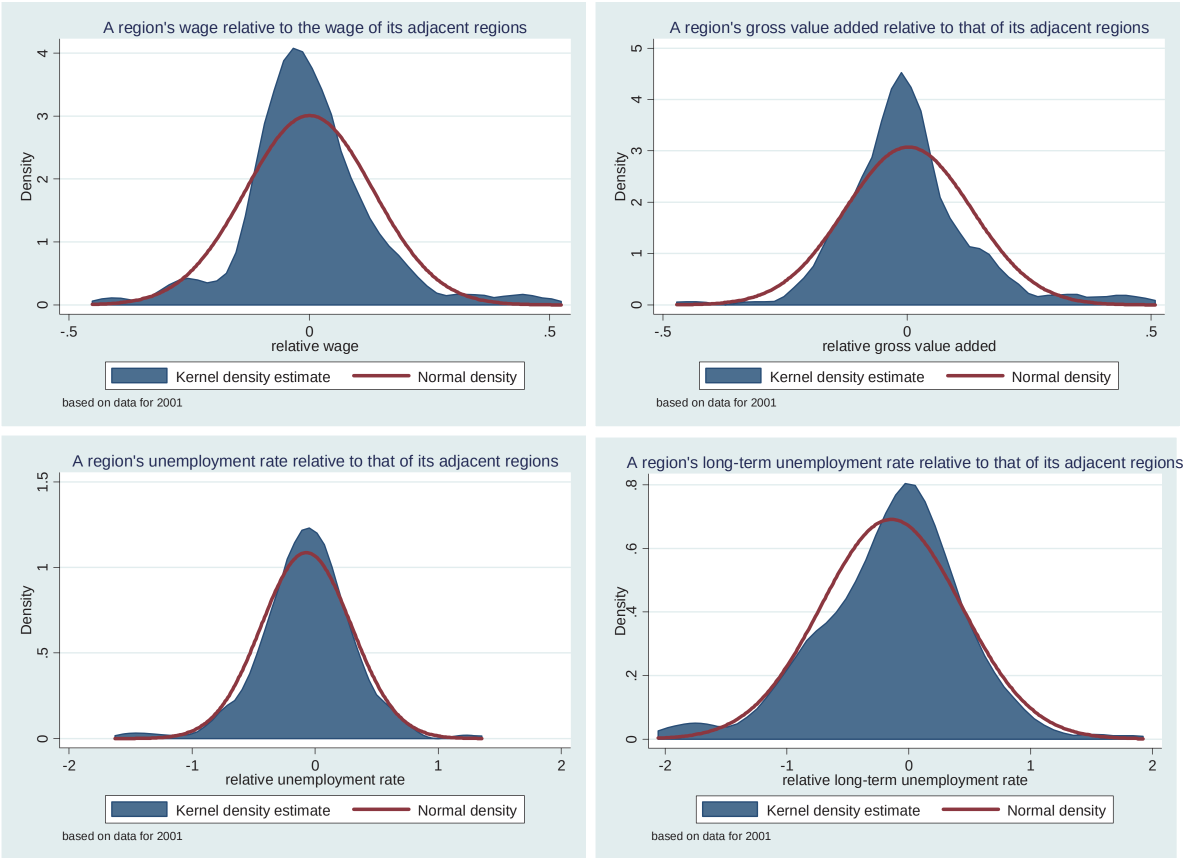


Table 5: Skewness/kurtosis test

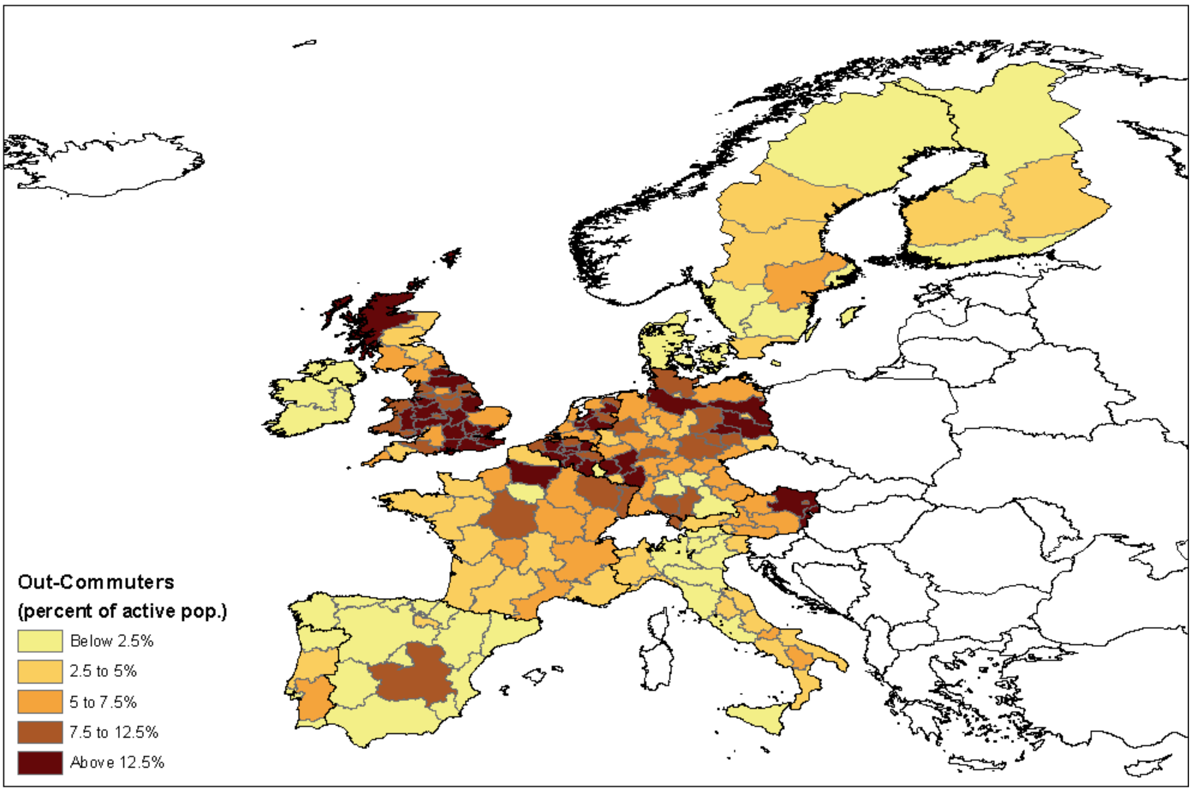
			joint – test	
Variable	Prob(Skewness)	Prob(Kurtosis)	Adj. $\chi^2(2)$	Prob> χ^2
$w - \tilde{w}_i$	0.005	0.000	18.35	0.0001
$y_i - \tilde{y}_i$	0.000	0.000	26.91	0.0000
$u_i - \tilde{u}_i$	0.022	0.000	15.55	0.0004
$u_i^{lt} - \tilde{u}_i^{lt}$	0.050	0.027	7.97	0.0186

Note: Variables in small letters denote variables in natural logs. Data for 2001.

Turning to the commuting patterns in the EU15, Figure 7 reveals the existence of substantial regional differences, but some country-specific patterns are also observable. Regional out-commuting flows are generally small in Spain, Portugal, Italy, Ireland, Denmark and Luxembourg, whereas they seem to be substantially larger in Belgium, the Netherlands, the United Kingdom, Germany and Austria, and thus, generally larger in Middle and Northern Europe. For some countries, low figures are mainly explained by the fact that the country in its entirety is represented by a single NUTS2 region, such as Denmark and Luxembourg.

Similarly, Ireland is an island comprised of merely two regions, which makes spatial interaction difficult. In the case of Luxembourg, the figures are misleading considering that Luxembourg is one of the most popular commuting destinations in Europe due to its high wages and low unemployment rate compared to its neighbouring regions (Mathä and Wintr, 2006). This is also visible in Figure 2 and 4. Figure 7 cannot directly reveal this, as data constraints limit the analysis to out-commuting and not in-commuting flows. However, it is clear that the surrounding regions of Luxembourg have much higher out-commuting figures than Luxembourg itself, a fact which may partly reflect to the large commuting flows to Luxembourg.

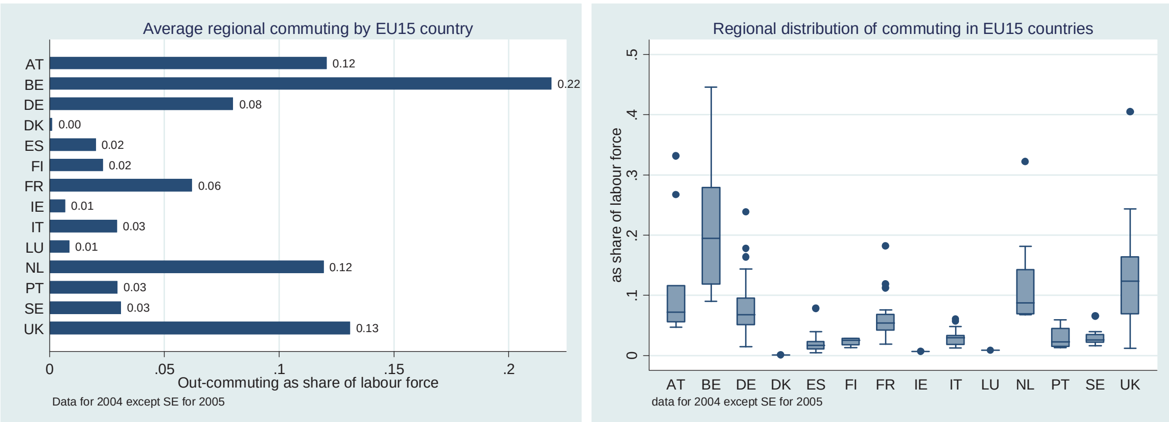
Figure 7: Regional out-commuting in the European Union 15



Source: Own calculations based on Eurostat data for 2004, Sweden for 2005.

Neighbouring regions of capital cities seem to have larger out-commuting rates, whereas the region hosting the capital city has lower out-commuting rates. Examples are *DE30 Berlin* and its surrounding regions *D41 Brandenburg–Nordost* and *D42 Brandenburg–Südwest*, *AT13 Wien* and its surrounding region *AT12 Niederösterreich* or the region *FR10 Île de France*, which includes Paris, and its five surrounding regions *FR21 Champagne-Ardenne*, *FR22 Picardie*, *FR23 Haute-Normandie*, *FR24 Centre* and *FR26 Bourgogne*. Another discernible regularity in Figure 7 is that the area size and thus the internal distance of a region matters. Countries with the smallest NUTS2 regions, such as Belgium, the Netherlands, the UK, and Germany seem to have larger commuting rates than countries, such as Sweden, Finland or Spain. This underlines the importance of appropriately capturing those differences in the empirical estimations. Finally, Figure 8 also corroborates the distinct national differences in terms of out-commuters discussed above. While it is likely that some of the differences in commuting can be attributed to the heterogeneity in region sizes across countries, we expect that regional economic factors also have a pronounced effect on the propensity to commute.

Figure 8: Regional out-commuting figures per country



Source: Own calculations based on Eurostat data.

IV. Empirical implementation

We use the gravity model for our empirical analysis. It is a straightforward yet informative tool for modelling flows across space.

(1) $$T_{ij} = k \cdot L_i \cdot E_j \cdot d_{ij}^{-1}$$

In equation (1), the interaction level T between the spatial classes i and j is directly proportional to their respective sizes L_i and E_j, and inversely related to the distance d_{ij} between them, with a proportionality constant k. This simple form is appealing; it allows an easy implementation of different definitions of size and distance and has a remarkably high explanatory power. Transformations of the basic gravity model have found applications in numerous fields in social sciences, including studies on migration, trade, shopping behaviour, etc.[8]

Our analysis uses as a starting point the unconstrained gravity model (see Alonso, 1978; Fotheringham and O'Kelly, 1989, and de Vries et al., 2001). Since official data is unavailable for region-to-region commuting flows in the EU, we estimate the total originating flows to synthetic destinations.

$$O_i = k \cdot L_i^{\gamma_1} \cdot \tilde{E}_i^{\gamma_2} \cdot \tilde{\delta}_i^{\gamma_3} \cdot \left(\Lambda_i / \tilde{\Lambda}_i\right)^{\chi} \cdot \sum_{m=1}^{M} H_{m,i}^{\varphi_m} \qquad (2)$$

Equation (2) explains out-commuting flows O_i using the sizes L of the origin region i and $\tilde{E}$ of the synthetic destination surrounding region i. Again, the tilde sign (~) denotes the synthetic destination surrounding region i. The distance $\tilde{\delta}_i$ is similarly calculated by combining the internal distance of region i and the interregional distance between region i and its surrounding regions. As in Lowry (1966), Vermeulen (2003) and others, we expand the basic gravity equation to allow differential effects $\Lambda_i / \tilde{\Lambda}_i$, where $\Lambda = \{W, U, U^{lt}, Y\}$. These differential effects are included to analyse the pull and push forces of regional commuting, such as differentials in wages $(W_i / \tilde{W}_i)$, gross valued added $(Y_i / \tilde{Y}_i)$ or unemployment rates $(U_i / \tilde{U}_i)$. Finally, we introduce a set of characteristics that control for structural factors specific to the origin region H_i.

As in section 2, the data are drawn from Eurostat's REGIO database and refer to the NUTS2 level for the EU15 countries and the period 1999-2004. However, two countries were dropped; Sweden was omitted as no commuting data was available for the above time period; Greece was omitted due to data unavailability and the spatial detachment from the rest of the EU15 sample. Furthermore, some implausible data points were removed after cross-checking and consultation with a Eurostat expert.[9] Finally, we dropped all observations where the commuting flow changed by more than 50% from one year to another. The

[8] See Batten and Boyce (1986) for a survey and Sen and Smith (1995) for a detailed treatment of the family of spatial interaction models to which the gravity model belongs.

[9] For example, significant changes occurred in the Austrian labour force survey in 2004, leading us to drop all preceding observations.

principal variable of interest, out-commuting flows, is defined as the number of people that were employed outside of their region of residence during a certain year.

As is standard practice in the labour mobility literature, the mass at the origin and destination region are taken to be the size of the labour force (*L)* and the employment level (*E*) reflecting potential mobility and employment opportunities (e.g. Vermeulen, 2003). They are defined respectively as the total economically active population by place of residence (from the Labour Force Survey) and the total number of employees by place of work (from ESA95). Two different measures are used for the average wage: compensation per employee (*W*) and gross value added per employee (Y). While the former is to be preferred, the use of gross value added provides one extra year of observations. The two variables perform similarly in the estimations. Unemployment either refers to total unemployment rate (*U*) or the long-term unemployment rate (U^{lt}). The latter measure is less sensitive to short-run transitory shocks, but comes at the expense of less variability than the normal unemployment rate. It is defined as the number of unemployed for 12 or more months as a percentage of the labour force.

A further word concerning the construction of the synthetic destination is in order. We assume that all out-commuting from region *i* is directed to its adjacent NUTS2 regions. This is a crucial assumption, but we are confident that it is consistent with most of the relevant out-commuting flows. The region sizes at the NUTS2 level are fairly small, but not too small. For example, the average size A of a region in the data set is about 16,300 square kilometres. Based on the formula $r = (A/\pi)^{1/2}$, the average distance r from a region's centre to its borders would be about 62 kilometres. Commuting distances are typically much smaller than this. In the Netherlands, only 10% of employees commuted more than 32 kilometres in 1992 (Van Ommeren, 2000), and in Germany, only 5% of commuters travel more than 50 kilometres (Statistisches Bundesamt, 2005). According to a recent ad hoc labour market survey in 2004, 38% of employees in the EU15 cross a local boundary when travelling to work, 70% of these travel less than 30 kilometres (European Commission, 2006; Buscher et al., 2005).

Some further data imputation was necessary to limit the number of missing observations. In particular, occasional missing values for gross value added, compensation, unemployment and employment were approximated by an ordinary least squares prediction using NUTS1 data and the available NUTS2 data. These approximations were used solely for the calculation of synthetic destination.[10] Also, for regions with an external EU15 border with new member states, regional data from outside the EU15 were included in the construction of the synthetic destination indicator data on the adjacent regions in new EU member states were included.[11]

Spatial deterrence of economic activity is commonly modelled as a function of geographical distance. We follow this approach and implement the distance effect δ as a function of the average distance to the regions in the synthetic destinations. To calculate this distance measure, we assume that each region can be approximated as a disc with size equal to its observed area. By assumption, all economic activity (and by extension, all employment opportunities) occur in the centre. The distance between two regions is approximated by the distance between the centres of the discs, which is equal to the sum of the radii.[12] The individual region-to-region distances are then averaged by weighting them with their respective region's employment. This approach is similar to the spatial separation index constructed by Midelfart-Knarvik et al. (2000) for their analysis of trade patterns in the EU. The resulting measure is interpreted as the *average distance to surrounding employment opportunities*. Mathematically, it can be represented by $\tilde{\delta}_{it} = \sum_j \mathrm{E}_{ijt}(r_i + r_j) / \sum_j \mathrm{E}_{ijt}$, where r are the disc radii, E is employment, and the summations are made over all adjacent regions j.

---

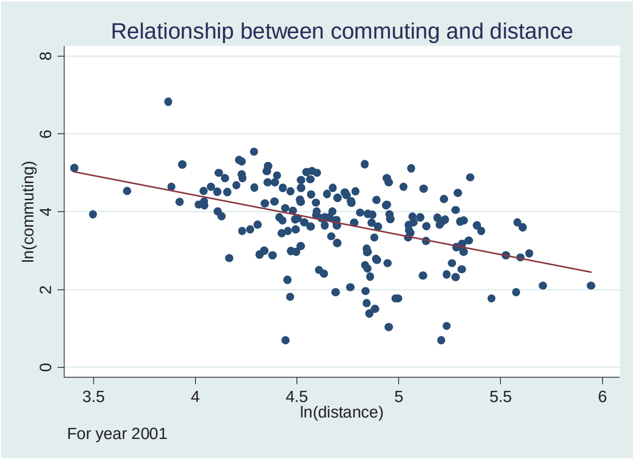
[10] In the Netherlands, the complete absence of data for long-term unemployment for 1999 on any level required the use of the total unemployment rate to predict values for long-term unemployment.

[11] With the exception of *Sicilia* remote islands forming separate NUTS2 regions, such as *Açores*, *Madeira*, *Canarias*, *Corse*, *Sardegna* and *Åland*, as well as French DOMs, were generally excluded from the subsequent analysis due to the difficulty to construct synthetic destination regions.

[12] More on the appropriate calculation of internal and interregional distances can be found in Wei (1996), Head and Mayer (2000), Helliwell and Verdier (2001), Nitsch (2001, 2002), and Niebuhr (2004).

Generally, distance deterrence in gravity models can be included either as a power, or as an exponential function. Fotheringham and O'Kelly (1989) recommend using an exponential function for shorter distances, and a power function for longer ones. A closer look at our data presented in Figure 9 reveals that the power representation seems to be a valid choice. We therefore incorporate the spatial deterrence function as $\tilde{\delta}_i(\cdot)$.[13]

Figure 9:



Spatial deterrence, however, not only depends on geographical distance but also on the spatial distribution of population. To account for this we include a measure of urbanisation (*Urb*), defined as the average share of households living in areas with a population density in excess of 500 per square kilometres during 1999-2004. This variable helps control for regions that contain at least one very substantial urban agglomeration. There is good reason to believe that commuting patterns out of highly agglomerated regions will be different. Urban economic theory suggests that cities provide significant positive externalities to their residents (e.g. Abdel-Rahman and Anas, 2004). Unemployed workers in cities, therefore, might prefer to endure longer unemployment spells to continue enjoying these externalities rather than commute. The implications of this argument for a commuting model that *does not* account for urban agglomeration patterns are twofold. First, it is likely to over-predict the number of out-commuters from agglomerated areas. Second, the unemployment differential of cities might provide misleading information, since it might be positive for urban areas. A

[13] For further discussions on the form of the distance deterrence term, see de Vries et al. (2004).

quick look at Figure 4 shows that several regions with major cities (e.g. Birmingham, Wien, Bremen, Lisboa, and Brussels) display an unemployment rate more than 1 percentage point above that of their surrounding regions.

Additionally, we include the structural condition H_i, which identifies several factors at the origin region that influence regional commuting. Regions differ in their sector structure, and thus in their potential mobility, which we control for by including as an additional regressor the share of services (*Ser*) the region's gross value added. We expect regions with a relative specialisation in services to exhibit more mobility than regions with a relative specialisation in industry or agriculture, as employees in the services sector seem to be more mobile than employees in other sectors (European Commission, 2006). We also conjecture that commuting varies with educational attainment and include a measure of educational attainment (see the discussion in section 2). The education variable (*Edu*) represents the share of the economically active population that have pursued schooling beyond the full-time compulsory education (ISCED codes 3-6). This is broadly equivalent to an upper secondary or higher level of education.[14] We additionally include the participation rate of women (*Wom*) defined as the percentage of the female population that is either employed or actively looking for a job. This is motivated by reported gender differences in labour mobility. Ederveen et al. (2006) find that the female activity rate negatively affects migration whereas the male activity does not, which they argue is consistent with the idea that male labour supply is almost inelastic, whereas female labour supply is not. They conjecture that the female labour market participation may act as an alternative labour market adjustment mechanism. With regard to commuting it is generally reported that commuting distance are lower women than for men (OECD, 2005; European Commission, 2006; Buscher et al., 2005). It is not clear a priori whether female labour force participation is negatively or positively correlated with commuting, as female participation rates tend to be higher in the more mobile Northern and Middle European countries, and as they are also positively correlated with educational attainment.

[14] The International Standard Classification of Education (ISCED) was designed by UNESCO to provide a universal instrument for assessing education levels. For details, see http://www.uis.unesco.org.

Finally, we include a set of controls. We include various geographical dummy variables. These dummy variables take respectively the value of 1 if the origin region is on a coastline (*Coast*) (e.g. *NL34 Zeeland*), on a border with another country (*Border*) – be it EU15 member state or not (e.g. *FR42 Alsace*), and on the eastern external border of the EU15 (*Ext*) (e.g. *DE41 Brandenburg–Nordost*).[15] Since national capitals usually display a disproportionate amount of economic activity, and often constitute an administrative region by themselves (e.g. *Berlin*, *Wien*), a capital city dummy (*Cap*) controls for potential distortions. A further variable distinguishes Eastern and Western German regions (*East*g); the regions in the former GDR are the only regions belonging to a former communist country in the data set. Three dummy variables capture proximity to three popular commuting destinations in non-EU15 countries not covered in our dataset, namely Switzerland, Monaco and Gibraltar. Separate year effects are also added, and in some specifications the overall constant *k* is replaced by national fixed effects.

V. Results and Discussion

Turning to the econometric analysis, we add a multiplicative error term and take the natural logarithm of both sides of the previous equation to obtain the following regression equation:

$$
\begin{aligned}
\ln O_{it} &= \gamma_1 \ln(L_{it}) + \gamma_2 \ln(\tilde{E}_{it}) + \gamma_3 \tilde{\delta}_{it} \\
&+ \chi_1 \ln(W_{it} / \tilde{W}_{it}) + \chi_2 \ln(U_{it} / \tilde{U}_{it}) + \chi_3 \ln(U_{it}^{lt} / \tilde{U}_{it}^{lt}) + \chi_4 \ln(Y_{it} / \tilde{Y}_{it}) \\
&+ \varphi_1 Edu_{it} + \varphi_2 Wom_{it} + \varphi_3 Ser_{it} \\
&+ \varphi_4 Urb_i + \varphi_5 Cap_i + \varphi_6 Border_i + \varphi_7 Coast_i + \varphi_8 Ext_i + \varphi_9 Eastg_i \\
&+ \sum_{t=1999}^{2004} \kappa_t Year_t + \psi_1 Corr\_MC + \psi_2 Corr\_CH + \psi_3 Corr\_GI + \varepsilon_{i,t}
\end{aligned}
\tag{3}
$$

Equation (4) can be evaluated by ordinary least squares under the assumption that O is a continuous, normally distributed variable. The number of commuters, however, is a count variable which cannot take negative values, and its distribution is skewed towards zero. The number of commuters, however, is a count variable which cannot take negative values, and its distribution is skewed towards zero. Such models are usually estimated using a Poisson

[15] DE80 Mecklenburg - Vorpommern is an example of a region that combines all three of those characteristics.

regression, which assumes that the probability of O_{it} people commuting from region i is drawn from a Poisson distribution with parameter λ_{it} (the mean), where the distribution mean is equal to the variance of O_{it}; this is clearly not the case for our data sample, where in 2001 the average and the variance are about 67 000 and $84\,000^2$ (Table 2). The negative binomial regression model provides a solution to this problem by allowing for overdispersion of the mean through an extra variation parameter (u_{it} term below) in the Poisson model. The negative binomial regression model assumes that the count data of commuters are generated by a Poisson process with parameter λ_{it}, i.e. $O_{it} \sim Poisson\ (\lambda_{it})$, where $\lambda_{it} = \exp(x_{it}\beta + u_{it})$ and u_{it} is an error term following the gamma distribution: $\exp(u_{it}) \sim gamma(1/\alpha, \alpha)$. α is the overdispersion parameter, β is the vector of parameters, and x_{it} is the matrix of explanatory variables. The larger α, the greater the overdispersion; if α is zero then the negative binomial model reduces to the Poisson model. Alternatively, the model can be further generalised by allowing the overdispersion parameter α to vary across observations as a linear combination of a set of covariates z_{it}, i.e. $\ln \alpha = \mu z_{it}$. Since the data in our sample is drawn from regions that come from different countries and have different settlement, we also apply the second approach and run a generalised negative binomial regression, where the over-dispersion parameter is modelled as a function of a set of country dummies. We will, however, start the discussion of the results with the negative binomial estimations, where the significance of the α coefficient reveals the presence of overdispersion in the data and the rejection of the simple Poisson distribution. The results are presented in Table 6.

Table 6: Negative binomial estimation results

	(1) b/se	(2) b/se	(3) b/se	(4) b/se	(5) b/se	(6) b/se
Labour force (origin)	0.902 ***	0.959 ***	0.903 ***	0.903 ***	0.957 ***	0.941 ***
	(0.035)	(0.035)	(0.034)	(0.034)	(0.034)	(0.035)
Employment (destination)	0.077 *	0.099 ***	0.086 **	0.092 **	0.098 ***	0.065 *
	(0.040)	(0.037)	(0.039)	(0.040)	(0.037)	(0.036)
Distance	-1.517 ***	-1.600 ***	-1.536 ***	-1.564 ***	-1.622 ***	-1.550 ***
	(0.066)	(0.066)	(0.068)	(0.069)	(0.067)	(0.064)
Wage differences	-0.999 ***		-0.945 ***	-0.903 ***		
	(0.164)		(0.162)	(0.166)		
Unemployment differences		0.160 ***	0.104 *			
		(0.058)	(0.057)			
LT unempl. differences				0.088 **	0.146 ***	
				(0.044)	(0.044)	
GVA differences						-0.634 ***
						(0.186)
Education	1.030 ***	0.887 ***	0.964 ***	0.902 ***	0.863 ***	1.125 ***
	(0.185)	(0.191)	(0.193)	(0.194)	(0.189)	(0.184)
Female participation	0.650 **	0.963 ***	0.769 ***	0.891 ***	1.074 ***	0.698 ***
	(0.285)	(0.270)	(0.293)	(0.299)	(0.270)	(0.264)
Services	3.441 ***	3.145 ***	3.409 ***	3.430 ***	3.059 ***	3.265 ***
	(0.315)	(0.316)	(0.318)	(0.322)	(0.318)	(0.318)
Urbanisation rate	-1.309 ***	-1.639 ***	-1.371 ***	-1.421 ***	-1.695 ***	-1.473 ***
	(0.123)	(0.110)	(0.123)	(0.125)	(0.111)	(0.120)
Capital city	-0.650 ***	-0.738 ***	-0.649 ***	-0.662 ***	-0.731 ***	-0.688 ***
	(0.099)	(0.099)	(0.099)	(0.103)	(0.102)	(0.094)
Border	0.068	0.067	0.065	0.069	0.066	0.083 *
	(0.044)	(0.044)	(0.044)	(0.045)	(0.044)	(0.043)
Coast	-0.104 **	-0.078 *	-0.105 **	-0.102 **	-0.077 *	-0.082 **
	(0.044)	(0.043)	(0.044)	(0.045)	(0.044)	(0.042)
External border	-0.110 **	-0.163 *	-0.123 **	-0.135 **	-0.197 **	-0.084
	(0.053)	(0.088)	(0.052)	(0.053)	(0.090)	(0.086)
East Germany	-0.349 ***	-0.290 ***	-0.360 ***	-0.357 ***	-0.338 ***	-0.328 ***
	(0.057)	(0.070)	(0.059)	(0.060)	(0.068)	(0.066)
Year effects	YES	YES	YES	YES	YES	YES
Correction dummies	YES	YES	YES	YES	YES	YES
Nobs	634	766	634	622	752	766
LogL	-2798.2 ***	-3397.3 ***	-2796.4 ***	-2740.7 ***	-3325.2 ***	-3392.6 ***
P-value	0.000	0.000	0.000	0.000	0.000	0.000
alpha	0.150 ***	0.173 ***	0.150 ***	0.149 ***	0.170 ***	0.170 ***

Note: Robust standard errors in ()
* p<0.1, ** p<0.05, *** p<0.01

The basic gravity components remain very stable across specifications, and coefficient estimates conform to prior expectations. Commuting flows increase with the labour force in the origin region and the synthetic destination. The coefficient estimates suggest that the main driving force of out-commuting is, however, the labour force of the origin region. The effect is about ten times stronger then the effect of the employment in the surrounding regions. The restriction that both coefficients sum to 1 cannot be rejected by conventional confidence bands. As in other studies, distance has a profound negative effect on commuting. Coefficient estimates indicate that a 1% increase in distance decreases commuting flows by 1.5%-1.6%. Wages, unemployment (including long-term unemployment) or gross value added differences between the origin region and destination regions exhibit the desired equilibrating pull and push forces. The estimates suggest that a 1% increase in the relative wage in the origin region reduces commuting by about 0.9%-1.0%, whereas a 1% increase in the relative unemployment rate increases commuting by 1.0%-1.6%. The results for the long-term unemployment rate are similar but slightly weaker in size.

Differences in gross value added also affect; a 1% increase in relative gross value added decreases out-commuting by 0.6%.

Structural factors pertaining to the origin regions are also of relevance. The share of secondary education increases commuting. Coefficient estimates indicate that a 1 percentage point increase in the share of secondary education increases commuting flows by 0.9%-1.1%. Similarly, higher female participation rates encourage commuting, although coefficient estimates vary somewhat more, lying in the range 0.65-1.07. The share of services in a region's output exerts a very strong effect on the commuting. A 1 percentage point increase in the services share increases commuting by 3.1%-3.4%.

Concerning the geographical factors, the coefficient of the urbanization rate is negative and highly significant, indicating that urbanized areas provide strong disincentives for its residents to seek employment in adjacent locations. As expected, regions hosting a nation's capital city have much lower out-commuting flows than other regions. Capital cities often either make up a region by themselves (*DE30 Berlin*) or they are so large that they dominate the region they are located in (i.e. *FR10 Paris* and *Île de France*). The dummy variable for East German regions is negatively significant, indicating that fewer numbers of out-commuters than otherwise expected. Being located at the coastline decreases commuting by 0.8%–1.0%. This negative effect may reflect obstacles to regional mobility, simply as fewer commuting destinations are available. Coastal regions have on average 3.7 adjacent regions compared to 5.4 for non-coastal regions. In addition, coastal regions also exhibit significantly lower wages on average than non-coastal regions (see Table 3), and for this reason should be expected to have more out-commuting. However in 2001, the average share of commuters was 7.1% in coastal regions compared to 10.1% in non-coastal regions.

We now consider the generalised negative binomial results, where we allow the overdispersion parameter α to vary across a set of country dummies.[16] The results very much

[16] All country overdispersion parameters are highly significant suggesting the presence of substantial cross country heterogeneity.

mirror those in Table 6. The log likelihood is somewhat less negative, suggesting a somewhat improved fit. One noticeable difference is the lower coefficient estimates for the relative labour market indicators and the positive significant *Border* coefficient suggesting increased out-commuting flows by 1.0%–1.4%. Except for specification (6) in Table 7, the latter fell just short of being significant at the conventional confidence interval. Otherwise, the coefficients remain remarkably similar to those presented in Table 6.

Table 7: Generalised Negative Binomial Regression Results

	(1) b/se	(2) b/se	(3) b/se	(4) b/se	(5) b/se	(6) b/se
Labour force (origin)	0.915 ***	0.980 ***	0.930 ***	0.933 ***	0.992 ***	0.932 ***
	(0.028)	(0.036)	(0.028)	(0.029)	(0.035)	(0.039)
Employment (destination)	0.100 ***	0.118 ***	0.101 ***	0.107 ***	0.114 ***	0.111 ***
	(0.026)	(0.033)	(0.026)	(0.025)	(0.028)	(0.035)
Distance	-1.539 ***	-1.581 ***	-1.560 ***	-1.601 ***	-1.624 ***	-1.555 ***
	(0.067)	(0.068)	(0.068)	(0.066)	(0.067)	(0.064)
Wage differences	-0.791 ***		-0.820 ***	-0.767 ***		
	(0.158)		(0.154)	(0.153)		
Unemployment differences		0.187 ***	0.156 ***			
		(0.063)	(0.054)			
LT unempl. differences				0.113 ***	0.196 ***	
				(0.042)	(0.049)	
GVA differences						-0.627 ***
						(0.140)
Education	1.174 ***	1.002 ***	1.038 ***	1.031 ***	0.972 ***	1.391 ***
	(0.149)	(0.146)	(0.148)	(0.151)	(0.140)	(0.148)
Female participation	0.428 **	0.876 ***	0.670 ***	0.671 ***	0.939 ***	0.282
	(0.195)	(0.206)	(0.204)	(0.210)	(0.198)	(0.208)
Services	3.727 ***	3.111 ***	3.577 ***	3.597 ***	3.023 ***	3.444 ***
	(0.286)	(0.336)	(0.296)	(0.296)	(0.324)	(0.313)
Urbanisation rate	-1.409 ***	-1.725 ***	-1.524 ***	-1.570 ***	-1.794 ***	-1.590 ***
	(0.105)	(0.104)	(0.109)	(0.112)	(0.104)	(0.101)
Capital city	-0.451 ***	-0.586 ***	-0.425 ***	-0.441 ***	-0.588 ***	-0.452 ***
	(0.076)	(0.072)	(0.072)	(0.075)	(0.071)	(0.087)
Border	0.119 ***	0.107 **	0.101 **	0.101 **	0.102 **	0.138 ***
	(0.039)	(0.047)	(0.040)	(0.040)	(0.043)	(0.042)
Coast	-0.145 ***	-0.093 *	-0.149 ***	-0.145 ***	-0.098 **	-0.080
	(0.047)	(0.049)	(0.045)	(0.046)	(0.048)	(0.050)
External border	-0.193 ***	-0.270 ***	-0.183 ***	-0.188 ***	-0.302 ***	-0.209 ***
	(0.053)	(0.059)	(0.052)	(0.053)	(0.050)	(0.059)
East Germany	-0.357 ***	-0.255 ***	-0.369 ***	-0.375 ***	-0.310 ***	-0.312 ***
	(0.053)	(0.058)	(0.052)	(0.054)	(0.055)	(0.056)
Year effects	YES	YES	YES	YES	YES	YES
Correction dummies	YES	YES	YES	YES	YES	YES
Nobs	634	766	634	622	752	766
LogL	-2736.1 ***	-3340.6 ***	-2731.6 ***	-2677.6 ***	-3265.6 ***	-3335.3 ***
P-value	0.000	0.000	0.000	0.000	0.000	0.000

Note: Robust standard errors in ()
* p<0.1, ** p<0.05, *** p<0.01

Next, we report some country-specific results for the five largest EU15 countries (Table 8). The gist of those results is as discussed above. The labour force in the origin region is significantly positive and employment in the synthetic destination is most often significantly positive. Distance remains significantly negative with the exception of the UK and Spain, where it is negative and positive, but not significant. The wage differential for Spain has the wrong sign and is significant. In the UK, the unemployment differential features a significant and wrongly signed coefficient. Except for France, where the unemployment differential is positive and highly significant, for the remaining countries (Germany, Spain and Italy), the coefficient of the unemployment differential is insignificant.

The results with regard to urbanisation and services are generally robust. The capital city dummy is significantly negative for Spain and Italy, significantly positive for Germany. Education has a significantly positive effect in Spain and Italy, the two large low-mobility countries, but no significant effect in Germany, France and the UK. Similarly, the border and the coastal effects seem to be country-specific. Thus, in general, gravity variables work and the differential effects exert some equilibrating forces. The country specific regression in Table 8 also suggest that much of the overall results in Table 6 and 7 emanate from small countries for which no individual estimations could be undertaken.

Table 8: Country specific results

	(DE) b/se	(ES) b/se	(FR) b/se	(IT) b/se	(UK) b/se
Labour force (origin)	0.692 ***	0.974 ***	1.333 ***	1.163 ***	0.860 ***
	(0.107)	(0.089)	(0.112)	(0.070)	(0.136)
Employment (destination)	0.421 ***	-0.558	0.168 *	0.244 ***	0.336 ***
	(0.122)	(0.442)	(0.088)	(0.040)	(0.126)
Distance	-1.156 ***	0.739	-2.059 ***	-2.307 ***	-0.272
	(0.434)	(1.725)	(0.256)	(0.484)	(0.270)
Wage differences	-0.961 **	4.332 ***	-0.663	0.336	-2.339 ***
	(0.384)	(1.303)	(0.616)	(0.315)	(0.607)
Unemployment differenes	-0.137	-0.153	0.316 **	0.101	-0.339 **
	(0.244)	(0.175)	(0.158)	(0.111)	(0.170)
Education	1.926	6.952 ***	-0.917	3.767 ***	-0.602
	(1.465)	(2.550)	(1.487)	(1.306)	(2.496)
Female participation	-1.438	-0.576	1.119	-2.050 **	-1.487
	(1.542)	(1.583)	(2.087)	(0.955)	(2.654)
Services	1.796 **	-2.742	1.531	4.104 ***	1.229
	(0.756)	(2.972)	(1.550)	(0.747)	(0.923)
Urbanisation rate	-0.902 ***	-1.437 **	-4.089 ***	-1.834 ***	0.413
	(0.340)	(0.655)	(0.711)	(0.337)	(0.471)
Capital city	0.413 *	-2.952 **	0.135	-0.865 ***	0.337
	(0.227)	(1.451)	(0.299)	(0.144)	(0.354)
Border	0.049	-1.021 ***	0.088	0.110 **	
	(0.093)	(0.236)	(0.077)	(0.049)	
Coast	0.462 **	-0.888 ***	-0.242 ***		-0.176
	(0.184)	(0.313)	(0.087)		(0.122)
External border	0.047			-0.301 ***	
	(0.145)			(0.101)	
East Germany	-0.100				
	(0.219)				
Year effects	Yes	Yes	Yes	Yes	Yes
Correction dummies	Yes	Yes	Yes	Yes	No
Nobs	170	58	105	82	101
LogL	-759.7 ***	-125.8 ***	-395.0 ***	-229.0 ***	-494.3 ***
P-value	0.000	0.000	0.000	0.000	0.000
alpha	0.105 ***	0.000 ***	0.019 ***	0.000 ***	0.133 ***

Note: Robust standard errors in ()
* p<0.1, ** p<0.05, *** p<0.01

As a final exercise we undertake a robustness checks by including either country fixed effects into the non-negative binomial and generalised non-negative binomial model of Tables 6 and 7, and additionally by using panel estimation methods. For the latter, we show both the results for the random and the conditional fixed effects negative binomial estimation. The model assumes that $O_{it} \mid \gamma_{it} \sim Poisson(\gamma_{it})$, where $\gamma_{it} \mid \delta_i \sim gamma(\lambda_{it}, \delta_i)$ with $\lambda_{it} = \exp(x_{it}\beta + u_{it})$. δ_i is the dispersion, which is assumed to be the same for all elements in the same panel identifier group, i.e. a country or a region in our case. In the random effects model, the dispersion varies randomly from panel identifier to panel identifier, such that $1/(1+\delta_i) \sim beta(r,s)$. In the conditional fixed effects model, the dispersion parameter is allowed to take on any value for a specific panel identifier group.

Table 9: Robustness checks

	NBREG b/se	GNBREG b/se	RE NBREG b/se	CFE NBREG b/se	RE NBREG b/se
Labour force (origin)	0.869 ***	0.920 ***	0.853 ***	0.848 ***	0.967 ***
	(0.032)	(0.027)	(0.036)	(0.036)	(0.071)
Employment (destination)	0.213 ***	0.194 ***	0.276 ***	0.276 ***	0.106
	(0.038)	(0.029)	(0.034)	(0.034)	(0.070)
Distance	-1.127 ***	-1.289 ***	-0.981 ***	-0.970 ***	-1.699 ***
	(0.106)	(0.103)	(0.085)	(0.085)	(0.136)
Wage differences	-0.772 ***	-0.474 ***	-0.941 ***	-0.926 ***	-0.409
	(0.156)	(0.153)	(0.189)	(0.189)	(0.251)
Unemployment differences	-0.104 **	-0.046	-0.197 ***	-0.209 ***	-0.056
	(0.053)	(0.050)	(0.057)	(0.056)	(0.057)
Education	0.358	0.083	-0.494 *	-0.511 *	-0.038
	(0.254)	(0.203)	(0.275)	(0.275)	(0.163)
Female participation	-1.390 **	-1.539 ***	-2.583 ***	-2.679 ***	0.644
	(0.558)	(0.435)	(0.490)	(0.489)	(0.472)
Services	2.940 ***	2.883 ***	3.175 ***	3.163 ***	2.488 ***
	(0.333)	(0.305)	(0.336)	(0.337)	(0.502)
Urbanisation rate	-1.152 ***	-1.193 ***	-1.056 ***	-1.054 ***	-1.389 ***
	(0.124)	(0.104)	(0.122)	(0.122)	(0.243)
Capital city	-0.234 ***	-0.304 ***	-0.164 *	-0.143 *	-0.743 ***
	(0.076)	(0.064)	(0.087)	(0.086)	(0.190)
Border	0.042	0.051	-0.041	-0.036	-0.025
	(0.049)	(0.040)	(0.041)	(0.041)	(0.086)
Coast	-0.043	-0.043	-0.027	-0.028	-0.134
	(0.044)	(0.046)	(0.043)	(0.043)	(0.087)
External border	0.003	-0.038	0.189 **	0.185 *	-0.124
	(0.062)	(0.052)	(0.094)	(0.094)	(0.199)
East Germany	-0.043	-0.008	0.161 *	0.168 *	-0.091
	(0.065)	(0.064)	(0.086)	(0.086)	(0.173)
Country effects	Yes	Yes	No	No	No
Year effects	Yes	Yes	Yes	Yes	Yes
Correction dummies	Yes	Yes	Yes	Yes	Yes
No. of obs.	634	634	634	634	634
Panel identifier			country	country	region
No. of groups			9	9	149
Group Max.			170.0	170.0	5.0
Group Avg.			70.4	70.4	4.3
Group Min.			5.0	5.0	2.0
LogL	-2696.4 ***	-2649.1 ***	-2772.6 ***	-2692.2 ***	-2299.2 ***
LR-test (Pooled vs. Panel)			203.6 ***		1150.3 ***

Note: (Robust) standard errors in ()
* p<0.1, ** p<0.05, *** p<0.01

The results are presented in Table 9. The coefficients of the gravity variables remain almost unchanged and significant regardless of the model estimated. The wage differential coefficient retains its significance except in the estimation where the panel identifier is the NUTS2 region. The (long-term) unemployment differential has become insignificant or wrongly significant. Concerning the other parameters, only the urbanisation rate, the capital city dummy and the services share remain significant. All other geographical dummy variables are insignificant. As not otherwise expected, allowing for country fixed effects in the parameters or random or fixed effects in the dispersion parameter, much of the cross-section variability of the structural factors of origin regions is absorbed. However, χ^2 tests indicate that those model specifications are to be preferred over the pooled estimates of corresponding specifications in tables 6 and 7.

VI. Conclusion

Our analysis of regional commuting flows in the European Union found that the number of commuters is explained well by standard gravity factors based on the size of the labour force in the origin and the employment in the destination region, as well as distance. In addition, structural economic characteristics, such as differences in wages and unemployment exert the desired pull and push forces for regional commuting to act as an equilibrating mechanism. There is some evidence that commuting is higher in regions with a higher average level of education, with a higher female participation rate and higher share of services. Geographical factors are also of importance for commuting. Differences between internal, bordering, coastal and external regions exist, which are to some extent country-specific.

In summary, we believe there is persuasive evidence that some of the factors that explain commuting on a small-scale regional level are also valid across the EU. While certainly not exhaustive in scope, we believe this paper provides a good first step in the analysis of regional commuting within the larger EU picture. Several avenues for future research are possible: (1) using region-to-region commuting flows, which would allow richer analysis and discrimination between intra- and international commuting flows; it would also make it possible to control for other important factors, such as differences in languages; (2) an extension to an EU27 framework to investigate the differences in labour mobility between old and new member states and the effects of the labour mobility restrictions that are still imposed on new member states.

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Appendix: Table A1: Variable definitions

Dependent variables	
O_{it}	Count of regional out-commuters in thousands from region i
Determinants	
$\ln(L_{it})$	Log of labour force in thousands in region i
$\ln(\tilde{E}_{it})$	Log of employment in thousands in the synthetic destination (specific to region i)
$\ln(\tilde{\delta}_{it})$	Log of distance; See text for exact derivation.
$\ln(U_{it}/\tilde{U}_{it})$	Log difference of the total unemployment rate or long-term unemployment rate between origination region i and the synthetic destination
$\ln(W_{it}/\tilde{W}_{it})$	Log difference of the compensation per employee between origination region i and the synthetic destination
$\ln(Y_{it}/\tilde{Y}_{it})$	Log difference of the gross value added between origination region i and the synthetic destination
Edu_{it}	Education; the share of the economically active population that have pursued schooling beyond the full-time compulsory education (ISCED codes 3-6)
Wom_{it}	The participation rate of women in the labour force
Ser_{it}	Share of services in regional gross value added
Urb_i	Urbanisation level; the percentage of households that reside in areas with a population density exceeding 500 people per sq. km
Cap_i	Dummy variable; 1 for region hosting nation's capital, 0 otherwise
$Coast_i$	Dummy variable; 1 for the region having coastline, 0 otherwise
$Border_i$	Dummy variable; 1 for region sharing a land border with another country, 0 otherwise
Ext_i	Dummy variable; 1 for region sharing a land border with a non EU-15 country, 0 otherwise
$Eastg_i$	Dummy variable; 1 for region being located in the former GDR, 0 otherwise
_MC, _GI, _CH	Correction dummies for Switzerland, Monaco, Gibraltar, which are popular commuting destinations from some regions
Year	Year dummies

Table A2: Map of NUTS2 Regions Included in the Dataset

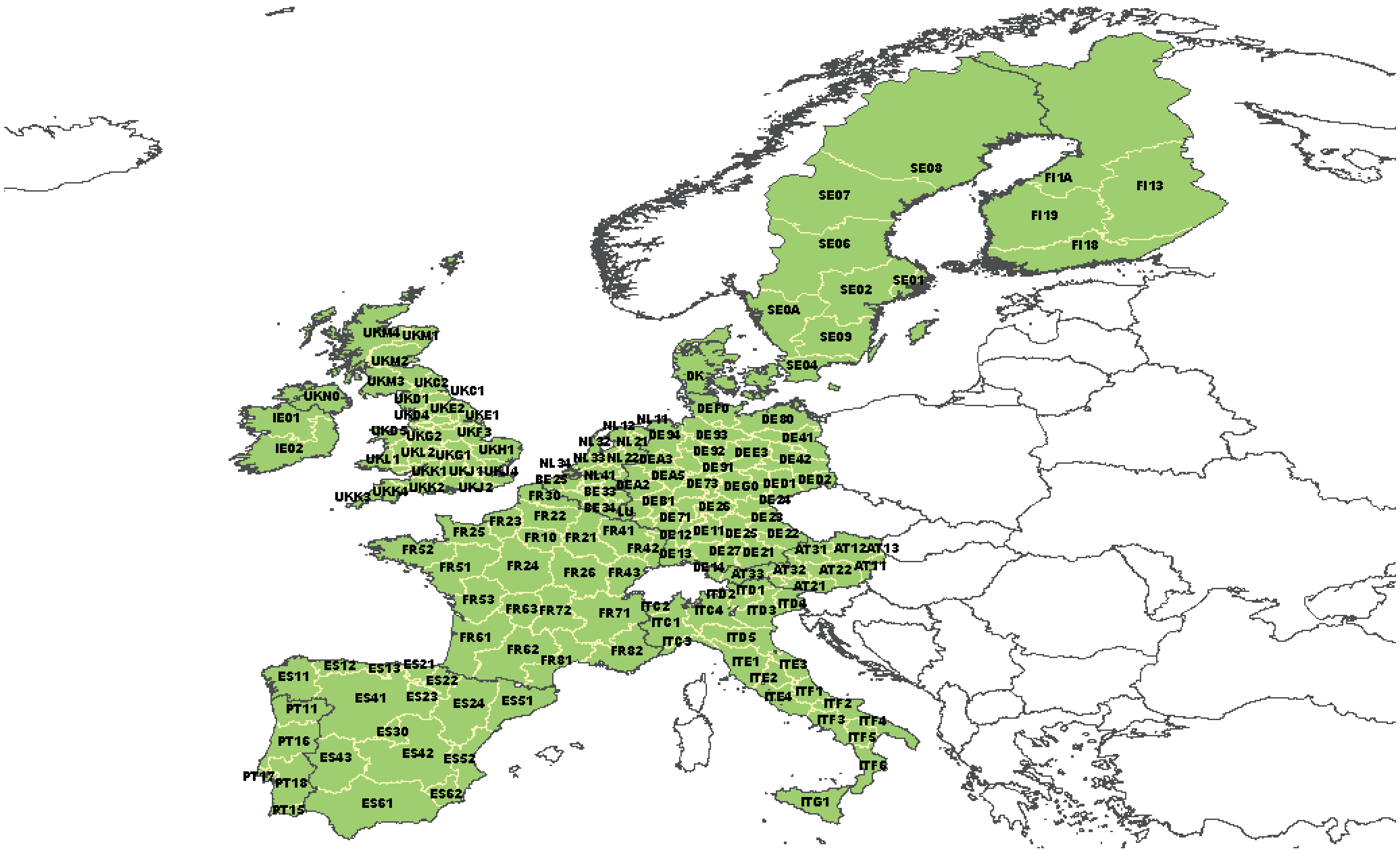

Table A3: List of NUTS2 Regions Included in the Dataset

AT11	Burgenland
AT12	Niederösterreich
AT13	Wien
AT21	Kärnten
AT22	Steiermark
AT31	Oberösterreich
AT32	Salzburg
AT33	Tirol
AT34	Vorarlberg
BE10	Région de Bruxelles-Capitale / Brussels Hoofdstedelijk Gewest
BE21	Prov. Antwerpen
BE22	Prov. Limburg (B)
BE23	Prov. Oost-Vlaanderen
BE24	Prov. Vlaams-Brabant
BE25	Prov. West-Vlaanderen
BE31	Prov. Brabant Wallon
BE32	Prov. Hainaut
BE33	Prov. Liège
BE34	Prov. Luxembourg (B)
BE35	Prov. Namur
DE11	Stuttgart
DE12	Karlsruhe
DE13	Freiburg
DE14	Tübingen
DE21	Oberbayern
DE22	Niederbayern
DE23	Oberpfalz
DE24	Oberfranken
DE25	Mittelfranken
DE26	Unterfranken
DE27	Schwaben
DE30	Berlin
DE41	Brandenburg - Nordost
DE42	Brandenburg - Südwest
DE50	Bremen
DE60	Hamburg
DE71	Darmstadt
DE72	Gießen
DE73	Kassel
DE80	Mecklenburg-Vorpommern
DE91	Braunschweig
DE92	Hannover
DE93	Lüneburg
DE94	Weser-Ems
DEA1	Düsseldorf
DEA2	Köln
DEA3	Münster
DEA4	Detmold
DEA5	Arnsberg
DEB1	Koblenz
DEB2	Trier
DEB3	Rheinhessen-Pfalz
DEC0	Saarland
DED1	Chemnitz
DED2	Dresden
DED3	Leipzig
DEE1	Dessau
DEE2	Halle
DEE3	Magdeburg
DEF0	Schleswig-Holstein
DEG0	Thüringen
DK	Danmark
ES11	Galicia
ES12	Principado de Asturias
ES13	Cantabria
ES21	País Vasco
ES22	Comunidad Foral de Navarra
ES23	La Rioja
ES24	Aragón
ES30	Comunidad de Madrid
ES41	Castilla y León
ES42	Castilla-La Mancha
ES43	Extremadura
ES51	Cataluña
ES52	Comunidad Valenciana
ES61	Andalucía
ES62	Región de Murcia
FI13	Itä-Suomi
FI18	Etelä-Suomi
FI19	Länsi-Suomi
FI1A	Pohjois-Suomi
FR10	Île de France
FR21	Champagne-Ardenne
FR22	Picardie
FR23	Haute-Normandie
FR24	Centre
FR25	Basse-Normandie
FR26	Bourgogne
FR30	Nord - Pas-de-Calais
FR41	Lorraine
FR42	Alsace
FR43	Franche-Comté
FR51	Pays de la Loire
FR52	Bretagne
FR53	Poitou-Charentes
FR61	Aquitaine
FR62	Midi-Pyrénées
FR63	Limousin
FR71	Rhône-Alpes
FR72	Auvergne
FR81	Languedoc-Roussillon

FR82	Provence-Alpes-Côte d'Azur
IE01	Border, Midland and Western
IE02	Southern and Eastern
ITC1	Piemonte
ITC2	Valle d'Aosta/Vallée d'Aoste
ITC3	Liguria
ITC4	Lombardia
ITD1	Provincia Autonoma Bolzano/Bozen
ITD2	Provincia Autonoma Trento
ITD3	Veneto
ITD4	Friuli-Venezia Giulia
ITD5	Emilia-Romagna
ITE1	Toscana
ITE2	Umbria
ITE3	Marche
ITE4	Lazio
ITF1	Abruzzo
ITF2	Molise
ITF3	Campania
ITF4	Puglia
ITF5	Basilicata
ITF6	Calabria
ITG1	Sicilia
LU	Luxembourg (Grand-Duché)
NL11	Groningen
NL12	Friesland
NL13	Drenthe
NL21	Overijssel
NL22	Gelderland
NL23	Flevoland
NL31	Utrecht
NL32	Noord-Holland
NL33	Zuid-Holland
NL34	Zeeland
NL41	Noord-Brabant
NL42	Limburg (NL)
PT11	Norte
PT15	Algarve
PT16	Centro (P)
PT17	Lisboa
PT18	Alentejo
SE01	Stockholm
SE02	Östra Mellansverige
SE04	Sydsverige
SE06	Norra Mellansverige
SE07	Mellersta Norrland
SE08	Övre Norrland
SE09	Småland med öarna
SE0A	Västsverige
UKC1	Tees Valley and Durham
UKC2	Northumberland and Tyne and Wear
UKD1	Cumbria
UKD2	Cheshire
UKD3	Greater Manchester
UKD4	Lancashire
UKD5	Merseyside
UKE1	East Riding and North Lincolnshire
UKE2	North Yorkshire
UKE3	South Yorkshire
UKE4	West Yorkshire
UKF1	Derbyshire and Nottinghamshire
UKF2	Leicestershire, Rutland and Northamptonshire
UKF3	Lincolnshire
UKG1	Herefordshire, Worcestershire and Warwickshire
UKG2	Shropshire and Staffordshire
UKG3	West Midlands
UKH1	East Anglia
UKH2	Bedfordshire and Hertfordshire
UKH3	Essex
UKI1	Inner London
UKI2	Outer London
UKJ1	Berkshire, Buckinghamshire and Oxfordshire
UKJ2	Surrey, East and West Sussex
UKJ3	Hampshire and Isle of Wight
UKJ4	Kent
UKK1	Gloucestershire, Wiltshire and North Somerset
UKK2	Dorset and Somerset
UKK3	Cornwall and Isles of Scilly
UKK4	Devon
UKL1	West Wales and The Valleys
UKL2	East Wales
UKM1	North Eastern Scotland
UKM2	Eastern Scotland
UKM3	South Western Scotland
UKM4	Highlands and Islands
UKN0	Northern Ireland