MEASUREMENT OF INTRA-DISTRIBUTION DYNAMICS: AN APPLICATION OF DIFFERENT APPROACHES TO THE EUROPEAN REGIONS

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Measurement of intra-distribution dynamics: An application of different approaches to the European regions

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Abstract: This paper examines the intra-distribution dynamics of per capita income between the European regions for the periods 1980-1993 and 1993-2005. To this end, three approaches are applied: the stochastic kernel approach, the highest conditional density approach and the estimation of mobility measures based on the Markov chain approach. One main conclusion and lesson have been obtained. The conclusion is that, although the distribution exhibits a great persistence, the degree of intra-distribution mobility has been much higher in the first period than in the second. The lesson is that, in dealing with intra-distribution dynamics, the use of different but complementary approaches is highly recommended.

Keywords: Intra-distribution dynamics; stochastic kernel; highest conditional density; mobility measures; European regions

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I. Introduction

In the last two or three decades there has been a huge amount of literature devoted to the study of the topic of per capita income (or productivity) convergence between economies; this is especially true for the case of the European regions, where the interest has been encouraged by the ongoing process of economic integration. As a result of this, it is virtually impossible to acknowledge all the researchers that have at some time dealt this issue. Then, just as a short reference to some of the most interesting works, it is worth mentioning the old but excellent survey edited by Armstrong and Vickerman (1995). More recently, the books edited by Cuadrado-Roura and Parellada (2002) and Fingleton (2003), and papers such as those of López-Bazo et al. (1999), Badinger et al. (2004), Magrini (2004), Miller and Genc (2005) or Meliciani (2006) are very good references.

Most of the articles analysing convergence processes between economies have applied the classical σ and β convergence approaches (see the seminal articles of Barro and Sala-i-Martín, 1991 and 1992). However, these approaches present several econometric problems and, in addition, fail to capture some potentially interesting features of the dynamics of the distribution under study. Specifically,

two important drawbacks arise from these approaches: they are informative neither about the shape of the distribution nor about its internal changes (Quah, 1996a and 1996b).

By using the European regions as a sort of laboratory, the aim of this paper is to apply different techniques in order to analyse the second drawback previously mentioned: the lack of knowledge about the intra-distribution dynamics. The so-called stochastic kernel approach is employed as a starting point. However, the main innovation of this paper lies in the application of two other techniques that complete the results obtained by this "traditional" one: the highest conditional density approach and the estimation of mobility measures based on the Markov chain approach.

On one hand, the highest conditional density approach is relatively new in the study of transition dynamics and, among other advantages, offers a much clearer graphical visualization than the stochastic kernel approach. On the other hand, the main advantage of the Markov chain approach is that mobility measures can be estimated, that is to say, we are able to quantify the intra-distribution mobility (Fields and Ok, 1999). With respect to this last approach, in this paper we propose a new mobility index based on the measure developed by Bartholomew (1973, 1996).

Thus, as we have just pointed out, the current paper applies these three alternative techniques for the study of intra-distribution dynamics to the European case. To

be precise, it examines the behaviour of relative per capita income (per capita GAV in PPS) of 196 European regions of the EU-15 for the periods 1980-1993 and 1993-2005[1]. We have chosen these two periods because they are of similar length but with different rates of growth (see Table 1): the first one registered a relatively slow growth (an annual rate of 1.67% in the EU-15), while the second recorded a faster rate (2.21%). This allows us, on the one hand, to compare the results of each approach between periods and, on the other hand, to compare the results of the three different approaches for the same period.

The remainder of the paper is organised as follows. Section II refers to the stochastic kernel approach and its application to the relative per capita income distribution of the European regions. In Section III a modification of the kernel methodology, developed by Hyndman et al. (1996), is applied to the European case; this approach is based on the representation of the so-called highest density regions. Section IV, using the Markov chain approach, proposes an aggregated mobility index that provides a numeric support for the conclusions drawn from the previous approaches. Finally, Section V outlines the main conclusions.

II. Intra-distribution dynamics: the stochastic kernel approach

One of the techniques most commonly used in the analysis of the dynamics of a distribution involves the calculation of stochastic kernels (see Quah, 1997; and

[1] Data are drawn from the Cambridge Econometrics regional database. The entire list of European regions considered in this paper is shown in the Appendix.

Durlauf and Quah, 1999)[2]. This approach is based on the estimation of the conditional density of a variable *y* (in our case, the relative per capita income in the final year) given a variable *x* (the relative per capita income in the initial year)[3]. Therefore, when, as in this paper, the stochastic kernel approach is applied to examine intra-distribution mobility between European regions in the periods 1980-1993 and 1993-2005, the probability of jumping from a per capita income level in 1980 (or 1993 in the second period) to any other per capita income level in 1993 (2005) is measured.

The results, using the Gaussian kernel with one common (constant) bandwidth calculated following Silverman's rule of thumb, are displayed in Figure[4] 1. The X-axis represents the relative per capita income for the initial year of each period (variable *x*) and the Y-axis the relative per capita income for the final year (variable *y*), while the Z-axis measures the density (or conditioned probability) of each point on the X-Y plane. Thus, the lines parallel to the Y-axis show the probability of moving from a point considered on the X-axis to any other point on the Y-axis. The 2D figure on the right is the contour plot, obtained by taking a cut parallel to the X-Y plane for a particular density value; the lines of this contour plot connect points reflecting the same density on the three-dimensional graph. The interpretation of the kernel is easy, especially if we look at the contour graph.

[2] For more recent papers see, for instance, Maza and Villaverde (2004), Meliciani (2006), Ezcurra et al. (2007) and Villaverde and Maza (2007).

[3] A formal kernel definition is given, for instance, in Laurini et al. (2005).

[4] The kernel density estimator is usually calculated using the same bandwidth in the two directions (of variables) *x* and *y*.

If the lines of this graph are situated along the positive diagonal, the degree of mobility is low, this being lower the tighter the contour lines to the diagonal are: this means persistence in the distribution. If this is not so, there has been mobility, with more mobility the further the lines are from the diagonal.

With this in mind, Figure 1a seems to show that, generally speaking, the distribution of relative per capita income in the European regions has been characterized by persistence during the period 1980-1993. This result persists, and even more clearly[5], in the period 1993-2005 (Figure 1b). However, the aforementioned figures also reveal, especially in the first period of analysis, that some regions have changed their relative positions; in other words, although there seems to be a high degree of persistence, there is also a certain degree of mobility (see the width of the contour lines).

As can be seen, the results obtained by using this technique, although very informative, are not absolutely conclusive. For this reason, the next two sections of this paper will try to clarify them.

III. Intra-distribution dynamics: the highest conditional density approach

In addition to the stochastic kernel approach, another technique to examine intra-distribution dynamics is that developed by Hyndman et al. (1996). These authors propose an alternative conditional density estimator with better statistical

[5] As can be intuited from the different scale of the contour line graphics.

properties than the stochastic kernel estimators. This new approach is based on the estimation of the so-called stacked density plot and highest conditional density plot. The stacked density plot shows a number of densities plotted side by side in a perspective graph. The highest conditional density plot represents, on the other hand, the so-called highest density regions; without entering into details, the highest density region is defined 'as the smallest region of the simple space containing a given probability' (Hyndman et al., 1996, p. 327).

The results, employing optimal bandwidths in the two directions x and y[6], are shown in Figure 2: the stacked density plot on its left side and the highest conditional density plot on its right side. With reference to the stacked density plots, they allow us to see the changes in the shape of the relative per capita income distribution for a given per capita income value in the initial year. Therefore, these plots are more informative than the three-dimensional graph we obtained through the kernel approach, since it highlights the conditioning between relative per capita income levels (Arbia et al., 2006). According to the results, it seems that some European regions have greatly changed their initial per capita income levels, especially in the first period under analysis.

However, a more informative way to represent the changes occurring in a distribution is based on the highest conditional density plot, which, as we have mentioned, displays the highest density regions. Thus, each vertical strip on the

[6] This technique, unlike the kernel approach, applies a different smooth parameter or bandwidth in each direction.

right hand side of Figure 2 represents the conditional density for a relative per capita income level in the initial year. In particular, this figure shows the highest density regions for a probability of 25, 50, 75 and 90% (as it passes from a darker to a less dark area). In addition, it illustrates, as a bullet (•), the mode (value of relative per capita income in the final year where the density function takes on its maximum value) for each value in the initial year. Accordingly, the highest conditional density plot may offer additional insights into the conclusions obtained by means of the stochastic kernel approach.

With respect to the first period (right side of Figure 2a), the position of the modes indicates that, generally speaking, the poorest (richest) regions have improved (worsened) their relative per capita income levels; this is crystal-clear as the modes of the lower (higher) tail of the distribution are above (below) the main diagonal. On the other hand, if we observe the mass of probability (dark areas), we see that in both the lower and higher extremes of the distribution, the area representing a probability of 25 and 50% (and even 75 and 90% in some cases) does not cross the diagonal; this shows again the existence of certain mobility inside the per capita income distribution. Moreover, this approach also shows that mobility, given its direction, has favoured the convergence process between the European regions.

Relative to the second period under study, the right side of Figure 2b clearly shows that the mobility degree was lower (or the persistence higher) than in the first one. The modes are nearer to the diagonal and the dark areas representing a

probability of 25% cross it in most cases. Although it is true that this same circumstance also emerged from the stochastic kernel estimation, there is no doubt this is much more evident with this highest conditional density approach.

IV. Intra-distribution dynamics: the estimation of mobility measures based on a Markov chain approach

From a chronological point of view, the Markov chain approach was the first methodology used in modelling intra-distribution dynamics; although popularized by Quah (1996a) in the analysis of personal income distribution, this approach goes back, at least, to Prais (1955) and Blumen et al. (1955). This is due to the fact that Markov chains provide useful representations of dynamic processes through the estimation of the well-known transition matrices. Recent papers employing this methodology are, for instance, Le Gallo (2004) and Tortosa et al. (2005).

In order to give a simple definition of the concept of transition matrix[7], it is necessary to consider that regions are classified into exhaustive and mutually exclusive states according to their relative per capita income at times t_0 and t_1, $\boldsymbol{p}(t_0)$ and $\boldsymbol{p}(t_1)$ being the initial and final income distribution. The link between these distributions is given by $\boldsymbol{p}(t_1) = \boldsymbol{p}(t_0) \cdot \boldsymbol{P}$, where operator $\boldsymbol{P}$ represents the transition probability matrix, with elements p_{ij}. This expression describes the

[7] For a thorough definition of this concept see, for instance, Parzen (1962).

time evolution of $\boldsymbol{p}(t_0)$, by mapping $\boldsymbol{p}(t_0)$ onto $\boldsymbol{p}(t_1)$, that is, the changes in the income distribution between t_0 and t_1. Thus, the interpretation of a transition matrix is really intuitive: each one of its cells p_{ij} indicates the probability of moving from a per capita income state *i* to a per capita income state *j*.

The main drawback of this approach is the arbitrariness when choosing the number and size of the states. Actually, the results critically depend on this choice and there is no any theoretical method to achieve an appropriate partition of the distribution[8]. However, the main advantage of this technique is that scalar summary indexes of mobility can be derived (Bibby, 1975; Shorrocks, 1978; Sommers and Conlisk, 1978; Bartholomew, 1973, 1996; Parker and Rougier, 2001). The two other approaches employed in this paper are very informative (the second even more than the first), but it is this one that really allows us to quantify the mobility degree.

Among the mobility measures based on a Markov chain, Bartholomew's (1996) measure has been one of the most extensively used in the literature on social mobility because of the introduction of distance into the quantification of mobility (see, for instance, Parker and Rougier, 2001; Ezcurra et al., 2006; Hierro, 2007). Additionally, and unlike other measures, such as that proposed by Shorrocks

[8] When it comes to the choice of the number of states, the researcher should weigh up the clarity of the results and the number of observations in each state.

(1978), Bartholomew's general class of mobility measures is concerned with all transitions between states[9].

In this paper, we propose an extension of Bartholomew's (1996) measure. Our mobility index is given by the expression:

$$d(\boldsymbol{P}) = \sum_i \sum_j \frac{1}{k_i} \cdot p_i \cdot p_{ij} \cdot d_{ij} \qquad [1]$$

where p_i is the initial proportion of regions in *i*'s income state (that is, the size of each income state), p_{ij} denotes, as we have already indicated, the probability of moving from the relative per capita income state *i* to the relative per capita income state *j*, d_{ij} is a distance measure between income states i and j (defined below) and, finally, k_i is an element introduced into the expression in order to normalize the mobility index. Thus, three elements are considered in the quantification of mobility: size (p_i), transitions (p_{ij}) and distance (d_{ij}).

This index differs from the traditional Bartholomew (1996) measure in three important aspects. First, it considers an alternative definition of distance for situations of state-hierarchy[10]. In our opinion, the distance measure proposed in this paper is especially suitable for income contexts. This distance is defined as

[9] Shorrocks's (1978) mobility measure considers exclusively the elements on the main diagonal of the transition matrix.

[10] When there is a natural ordering of the states, Bartholomew proposes $d_{ij} = |i - j|$ as the distance measure.

the absolute difference between the average per capita income ($\bar{y}$) of the states under consideration, that is, $d_{ij} = \left| \bar{y}_j - \bar{y}_i \right|$. Therefore, according to this definition, when dealing with transitions within each income state, the distance moved, d_{ii}, is 0. On the other hand, transitions between income states will give positive values of d_{ij}; as is evident, the distance is higher when the differences in the average income of the states considered are larger.

Second, another difference with the original Bartholomew mobility measure is that, instead of the ergodic distribution, our index includes, as a weighting factor, the initial income distribution, given by the elements p_i. This decision responds to the fact that, with non-stationary processes (as is usual in income contexts), the ergodic distribution does not provide a faithful picture of the ultimate consequences of the current income distribution because intra-distribution patterns do not remain unchanged. On the contrary, the initial income distribution allows us to capture the relative size of each income state at the time the mobility degree is being analysed.

Finally, the last difference consists of the introduction of the element k_i, defined as the largest value in the i's row of $\boldsymbol{D}$ (matrix of distance with generic elements d_{ij}), in order to obtain a normalized measure in the interval $[0,1]$. As should be obvious, the definition of distance conditions the meaning of maximum mobility. In our particular case, a situation of maximum mobility, given by $d(\boldsymbol{P}) = 1$, arises

when, from each income state, all transitions occur towards the more distanced income state, regardless of being an upward or a downward transition.

In addition, mobility indexes for each state can be obtained. This is because the preceding aggregate measure can be inferred by the corresponding state-by-state mobility measures, $d(\boldsymbol{P}_i)$,

$$d(\boldsymbol{P}) = \sum_i p_i \cdot d(\boldsymbol{P}_i) \qquad [2]$$

where

$$d(\boldsymbol{P}_i) = \sum_j \frac{1}{k_i} \cdot p_{ij} \cdot d_{ij} \qquad [3]$$

This allows immobile and mobile states to be identified and, accordingly, a separate analysis of the performance of each income state to be carried out.

In order to apply the aforementioned indexes to the European regions, we have considered the following five exhaustive and mutually exclusive income states according to their per capita income relative to the European average: [0, 75), [75, 90), [90, 110), [110, 125), [125, $+\infty$)[11]. Results reported in Table 2 are enlightening, since they provide a numeric support to the conclusions drawn from the highest conditional density and the stochastic kernel approaches. In particular, it is shown that the aggregate mobility measure $d(\boldsymbol{P})$ reaches a much higher

[11] These are the income states usually employed in the literature (see, for instance, Cuadrado et al., 2002; Ezcurra et al., 2006). In addition, this classification is normally used for the European Union in its publications on regional issues.

value for the first period (0.23) than for the second (0.11). This means that mobility in the European income distribution over 1980-1993 has been twice as high as over the 1993-2005 period. Notwithstanding this, the relatively low level of intra-distribution mobility given by this aggregate index for both periods indicates the existence of a strong persistence in the regional per capita income distribution in Europe.

A first look into the transition matrices and the state-by-state indexes allows us to look more deeply into this result. With reference to the period 1980-1993, a feature of note is that the mobility degree is considerably higher in this period than over 1993-2005 not only for the whole distribution but also for all of the income states. This finding comes from the existence of higher transition probabilities to contiguous and non-contiguous states, along with the fact that relative distances between them are greater over this period (see Table 3). Besides, it is worth highlighting the performance of the upper income state of the distribution, $[125, +\infty)$, which reaches the highest mobility (0.36); this, together with its relatively large size in the distribution (0.28), contributes to its effect on the aggregate mobility being eventually noteworthy.

As regards the second period, the higher probabilities on the main diagonal point to a higher persistence; this is especially remarkable in the tails of the distribution. Actually, most income states register an index very close to 0. The only exception refers to the state [110, 125), for which the state-state mobility index is 0.31;

however, its small size (0.14) makes its contribution to the aggregate mobility index quite small.

V. Conclusions

In this paper we have analysed the intra-distribution dynamics of the relative per capita income between the European regions in two periods: 1980-1993 and 1993-2005. To achieve this objective three different approaches have been applied: the stochastic kernel approach, the highest conditional density approach and the estimation of mobility measures based on a Markov chain approach.

The estimation of stochastic kernels, the most generally method used to handle this topic, allows the main changes having occurred in the regional per capita income distribution in Europe to be seen. According to this approach, persistence is the predominant note, although there are also some signs of mobility. More generally, the comparison of the two periods shows that mobility seems to be higher in the first (1980-1993) than in the second period (1993-2005). Nevertheless, the stochastic kernel estimation results cast some doubts.

In order to solve these doubts, the highest conditional density approach is used. This methodology is clearer from a graphical point of view and, furthermore, has better statistical properties than the stochastic kernel approach. Two features of this technique are worth mentioning: first, it highlights the conditioning between variables (while the kernel method displays the joint distribution) and, second, it

employs two bandwidth parameters, controlling the smoothness between conditional densities in the two directions *x* and *y*. In this case, the results undoubtedly reveal that, especially in the first period under analysis, some European regions have changed their relative per capita income in a very significant way. Besides this, the results indicate that mobility (both in the first and in the second period) has favoured the convergence process between the European regions, because the poorest (richest) regions have improved (worsened) their relative positions.

Subsequently and, among other reasons, in order to test the robustness of the previous results, the estimation of mobility measures based on a Markov chain approach is carried out. This allows us to obtain an exact measure of intra-distribution mobility. More precisely, this paper has proposed an adaptation of the mobility measure proposed by Bartholomew (1973, 1996) for income contexts. When it is applied to the European regions, this technique not only confirms that the intra-distributional mobility has been higher in the first than in the second period, but it also quantifies this difference; the intra-distribution mobility has been, according to our index, twice as high between 1980 and 1993 as between 1993 and 2005. All the same, the low value of both mobility indexes also corroborates that, in general terms, the regional per capita income distribution in Europe has been characterised by persistence in the last few decades.

To conclude, this paper underlines, and perhaps this is its main lesson, that the application of different approaches is advisable to gain more insight into the

internal mobility of a given distribution. In fact, what we have shown is that the three different approaches employed to deal with the topic of intra-distribution dynamics seem to be complementary, as each one offers a specific, precise view of the issue at stake.

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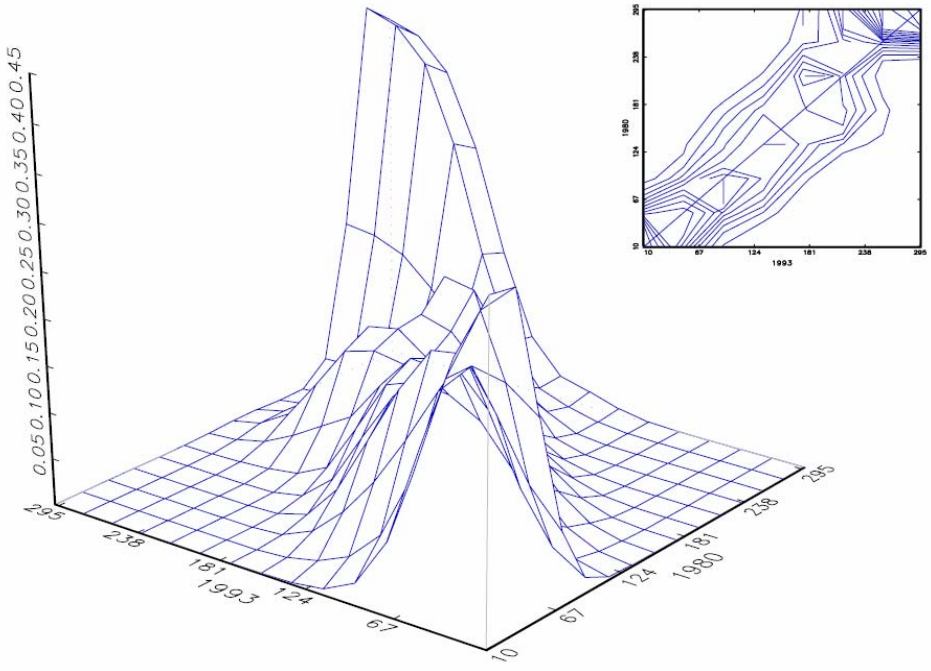
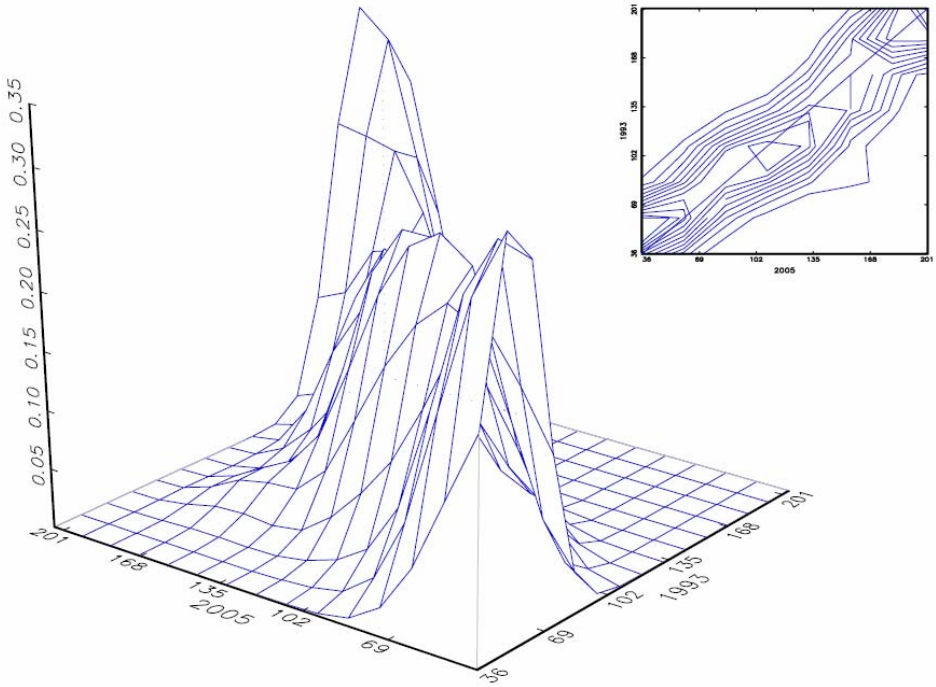
Table 1. EU per capita income: regional growth rates

Annual average rates of growth	1980-1993	1993-2005
EU-15	1.67	2.21
Ten highest regions	4.06	4.25
Ten lowest regions	-0.99	0.54
Standard deviation	1.00	0.86

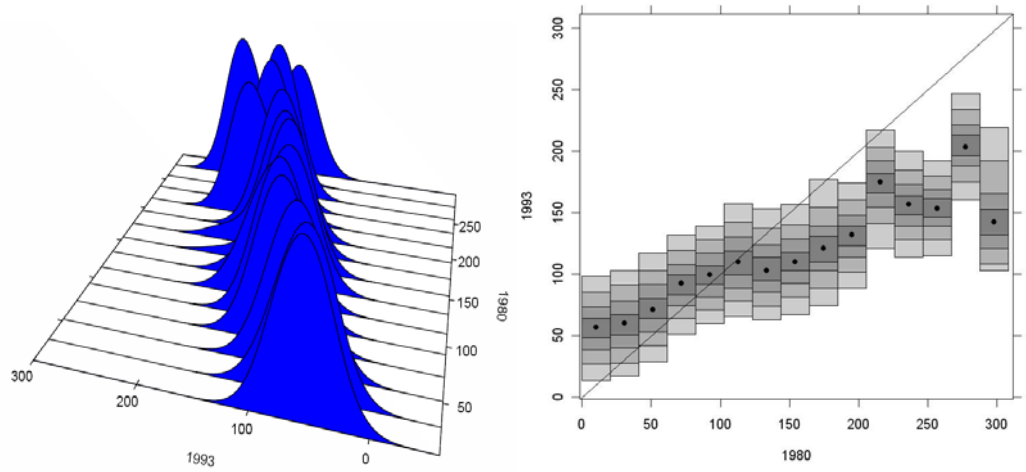


(a) 1980-1993

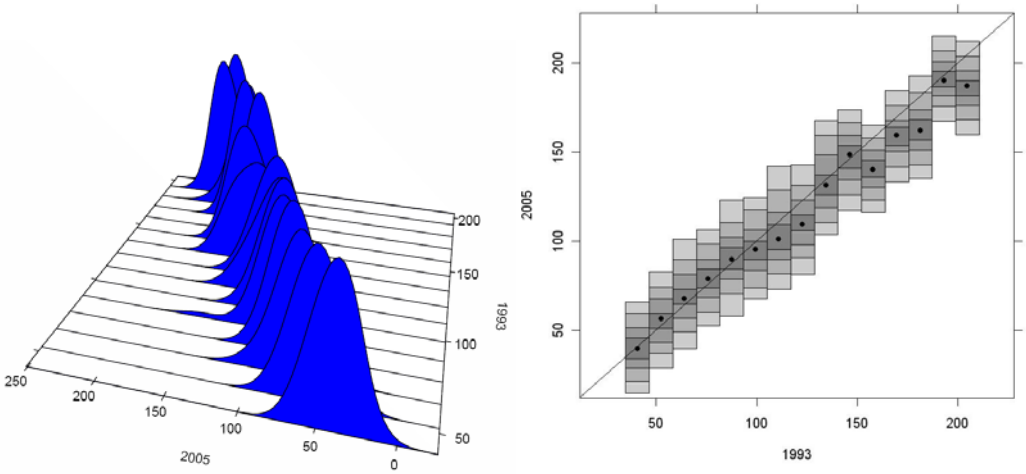


(b) 1993-2005

Fig. 1. Stochastic kernels



(a) 1980-1993



(b) 1993-2005

Fig. 2. Stacked density and highest conditional density plots

Table 2. Aggregated and state-by-state mobility indexes

(a) 1980-1993

States	[0, 75)	[75, 90)	[90, 110)	[110, 125)	[125, $+\infty$)
[0, 75)	0.51	0.29	0.18	0.00	0.00
[75, 90)	0.00	0.11	0.68	0.21	0.00
[90, 110)	0.00	0.05	0.81	0.05	0.00
[110, 125)	0.00	0.00	0.27	0.36	0.36
[125, $+\infty$)	0.00	0.00	0.41	0.30	0.28
p_i	0.42	0.14	0.11	0.06	0.28
$d(\mathbf{P}_i)$	0.17	0.24	0.11	0.32	0.36
$d(\mathbf{P})$			0.23		

(b) 1993-2005

States	[0, 75)	[75, 90)	[90, 110)	[110, 125)	[125, $+\infty$)
[0, 75)	0.84	0.14	0.02	0.00	0.00
[75, 90)	0.00	0.55	0.42	0.03	0.00
[90, 110)	0.00	0.24	0.68	0.08	0.00
[110, 125)	0.00	0.00	0.61	0.21	0.18
[125, $+\infty$)	0.00	0.00	0.00	0.15	0.85
p_i	0.22	0.16	0.38	0.14	0.10
$d(\mathbf{P}_i)$	0.05	0.10	0.09	0.31	0.06
$d(\mathbf{P})$			0.11		

Table 3. Absolute distances between states

(a) 1980-1993

States	[0, 75)	[75, 90)	[90, 110)	[110, 125)	[125, $+\infty$)
[0, 75)	0.00	31.67	49.48	68.47	114.02
[75, 90)	31.67	0.00	17.80	36.80	82.35
[90, 110)	49.48	17.80	0.00	19.00	64.54
[110, 125)	68.47	36.80	19.00	0.00	45.55
[125, $+\infty$)	114.02	82.35	64.54	45.55	0.00

(b) 1993-2005

States	[0, 75)	[75, 90)	[90, 110)	[110, 125)	[125, $+\infty$)
[0, 75)	0.00	23.90	37.73	55.18	90.95
[75, 90)	23.90	0.00	13.83	31.28	67.05
[90, 110)	37.73	13.83	0.00	17.45	53.22
[110, 125)	55.18	31.28	17.45	0.00	35.77
[125, $+\infty$)	90.95	67.05	53.22	35.77	0.00

Appendix: List of European regions

The complete list of regions employed in this paper is the following: BELGIUM (10 regions): Antwerpen, Limburg, Oost-Vlaanderen, Vlaams Brabant, West-Vlaanderen, Brabant Wallon, Hainaut, Liege, Luxembourg, Namur. DENMARK (1): Denmark. GERMANY (31): Stuttgart, Karlsruhe, Freiburg, Tubingen, Oberbayern, Niederbayern, Oberpfalz, Oberfranken, Mittelfranken, Unterfranken, Schwaben, Berlin, Bremen, Hamburg, Darmstadt, Giessen, Kassel, Braunschweig, Hannover, Luneburg, Weser-Ems, Dusseldorf, Koln, Munster, Detmold, Arnsberg, Koblenz, Trier, Rheinhessen-Pfalz, Saarland, Schleswig-Holstein. GREECE (13): Anat. Mak., Kent. Makedonia., Dytiki Makedonia, Tesalia, Ipeiros, Ionia Nisia, Dytiki Ellada, Sterea Ellada, Peloponnisos, Attiki, Voreio Aigaio, Notio Aigaio, Kriti. SPAIN (17): Galicia, Asturias, Cantabria, Pais Vasco, Navarra, Rioja, Aragon, Madrid, Castilla-Leon, Castilla-la Mancha, Extremadura, Cataluña, Com. Valenciana, Baleares, Andalucia, Murcia, Canarias. FRANCE (22): Ile de France, Champagne-Ard., Picardie, Haute-Normandie, Centre, Basse-Normandie, Bourgogne, Nord-Pas de Calais, Lorraine, Alsace, Franche-Comte, Pays de la Loire, Bretagne, Poitou-Charentes, Aquitaine, Midi-Pyrenees, Limousin, Rhone-Alpes, Auvergne, Languedoc-Rouss., Prov-Alpes-Cote d'Azur, Corse. IRELAND (2): Border, Southern and Eastern. ITALY (20): Piemonte, Valle d'Aosta, Liguria, Lombardia, Trentino-Alto Adige, Veneto, Fr.-Venezia Giulia, Emilia-Romagna, Toscaza, Umbria, Marche, Lazio, Abruzzi, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia, Sardegna. LUXEMBOURG (1): Luxembourg. NETHERLANDS (12): Groningen, Friesland, Drenthe, Overijssel, Gelderland, Flevoland, Utrecht, Noord-Holland, Zuid-Holland, Zeeland, Noord-Brabant, Limburg. AUSTRIA (9): Burgenland, Niederosterreich, Wien, Karnten, Steiermark, Oberosterreich, Salzburg, Tirol, Vorarlberg. PORTUGAL (7): Norte, Centro, Lisboa e V.do Tejo, Alentejo, Algarbe, Acores, Madeira. FINLAND (6): Ita-Suomi, Vali-Suomi, Pohjois-Suomi, Uusimaa, Etela-Suomi, Aland. SWEDEN (8): Stockholm, Ostra Mellansverige, Sydsverige, Norra Mellansverige, Mellersta Norrland, Ovre Norrland, Smaland med oarna, Vastsverige. UK (37): Tees Valley and Durham, Northumb. et al., Cumbria, Cheshire, Greater Manchester,

Lancashire, Merseyside, East Riding, North Yorkshire, South Yorkshire, West Yorkshire, Derbyshire, Leics., Lincolnshire, Hereford et al., Shrops., West Midlands (county), East Anglia, Bedfordshire, Essex, Inner London, Outer London, Berkshire et al., Surrey, Hants., Kent, Avon et al., Dorset, Cornwall, Devon, West Wales, East Wales, North East Scot., Eastern Scotland, South West Scot., Highlands and Islands, Northern Ireland.

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