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A Proposal of a Synthetic Indicator to Measure Poverty Intensity, With an Application to EU-15 Countries*

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Abstract

This paper deals with the proposal of a synthetic indicator to measure intensity of poverty. So, whereas incidence of poverty can be clearly measured using the headcount ratio indicator, according to Sen (1976) dimensions of poverty, the choice of a better intensity poverty measure is still an open question to resolve. Thus, in this paper, a new procedure to obtain a synthetic indicator from a set of well-performed poverty intensity indices as a start is proposed, using an adaptation of Principal Component Analysis (PCA). Conditions needed to make longitudinal comparisons possible are studied and properties of these synthetic indicators will also be analyzed, connected to TIP curves as well. As an illustration, this paper analyzes the evolution of poverty in the 15 countries of E.U., whose household income data are available through the information contained in the European Community Household Panel (ECPH). This analysis allows static and dynamic comparisons, related to the period from 1993 to 2000. Furthermore, the determination of groups of countries according to their characteristics in poverty will be accomplished.

JEL Classification: C43, D31, I32, O52.
Keywords: Economic Poverty, TIP's poverty curves, Poverty in EU countries, PHOGUE.

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"It will be desirable, …, not to rely upon the evidence
of a single measure, but upon the corroboration of several"
(Hugh Dalton, 1920, quoted in B. Zheng, 2000).

1. INTRODUCTION

Social welfare analysis has consistently been considered as one of the main problems in economic science. In this sense, there have been several approaches into this task, but perhaps the most important one is that of social indicators, since the sixties. Through this approach, social welfare may be decomposed in several components, each one defining a social indicator, and all of them together will determine the social welfare status. The choice of these components is also a very interesting issue (Tinbergen, 1991). Furthermore, from an official point of view, this aim has led to a number of National Statistical Services to create their own social indicators systems. In the European Union, EUROSTAT have been the coordinator of this objective, and precedents can be found in OCDE (1982).

Indeed, synthetic-indicator's construction methods have become to be especially interesting in this research field. So, synthetic indicators are designed to merge isolate information provided by each simple social indicator to give a social welfare indicator as a result. Among such methods, factorial ones (INE, 1991, among others) and Ivanovic-Pena's DP2 distance (Pena, 1977) could be remarkable.

Moreover, from this social indicators' perspective, poverty measures must be considered as one of the most relevant ones, because of the great importance of its social, economic and political consequences. Taking the previous argument into account, poverty measurement has generated a great interest among the researchers community, during the last decades. Nevertheless, when poverty is going to be analysed, there are a lot of decisions that have to be made, and all of them produce a direct impact over the obtained results.

To begin with, poverty sometimes has been considered as a multidimensional concept, including monetary and non-monetary elements which could be identified from several social indicators. Indeed, one of the most promising research fields is related to poverty analysis through the capabilities or *functionings* that individuals or households have (Sen, 1983), and how the appropriate indicators may be summarized to obtain a single indicator (Brandolini and D'Alessio, 2000; Martinez and Ruiz-Huerta, 2000, among others). In this multidimensional framework, consideration of the absolute or relative character associated to poverty becomes to be a very interesting matter, depending on the choice of capabilities or resources as source data (Subramanian, 2004). However, this point of view is difficult to manage because of the lack of disposability of adequate data (Laderchi, 1997), and some authors have proposed the use of latent-class models to overcome these difficulties (Ayala and Navarro, 2004; Pérez-Mayo, 2005, for example), although these ideas are perhaps closer to the so-called *economic deprivation analysis* as their nearby research field.

In such circumstances, the most usual option consists of choosing some single variable to approximate the household economic position as a summary of the whole set of potential variables. So does this paper, and thus we refer this framework as *economic poverty* (Sen, 1976).

In this way of thinking, there are other problems related to economic poverty measurement that must to be faced. The essential one appears in defining what a poor household is, in order to identify the poor subpopulation. This identification step leads us to analyse the extent of poverty and it is regularly named as *poverty incidence.* So, a minimum income level has to be defined, in such a way that if a household falls short of this income, it will be considered as a poor one, and that minimum income will be called *poverty line* or *poverty threshold.* But a unanimous choice is hard to reach because there are many proposals in the related literature and several ways can be used to define a poverty threshold, depending on the assumption of an *absolute, relative* or *subjective* basis[2]. Obviously, results will be conditioned by such a selection and we shall consider relative poverty lines, following well-known recommendations when developed countries are going to be compared (Dagum, 1989). In doing so, we understand poverty as a situation by means of comparison with the life-standard of the society where the household is living in (Townsend, 1985).

[2] Further details on this topic can be found in Hagenaars and van Praag (1985) or Hagenaars (1986).

In such a context, Sen (1976) pointed out incidence, intensity and inequality as the three dimensions of poverty, all of them included into the formulation of the indicator he proposed. These three dimensions of poverty are again present in the construction of TIP curves, proposed in Jenkins and Lambert (1997, 1998a, 1998b) to make global poverty comparisons among income distributions. These curves play a similar role as Lorenz curves in economic inequality analysis do[3] and they have been applied to the Spanish case by Del Río and Ruiz-Castillo (2001) and Casas, Domínguez and Núñez (2003), among others. So, although TIP curves are generally accepted to make poverty comparisons, it is important to remember that they can only generate a quasi-order structure over the income distributions space. Other attempts to compare poverty between income distributions, using global curves, generate quasi-order structures too, like those analysed by Atkinson (1987) or Foster and Shorrocks (1988a, 1988b), as well as those based on dominance criteria (Bishop, Formby and Smith, 1994; Ahamdanech and Garcia, 2007).

Thus, another important decision affects to *intensity* measurement or how many cumulated poverty we can find into the analysed society. The above discussion about global poverty comparisons through curves leads us to the usual decision to quantify intensity of poverty using numerical functions: the so-called *poverty measures* (Sen, 1976). But there are a lot of possible poverty measures up to be used and researcher's agreement can be placed only on imposing a minimal set of adequate properties or *axioms* to be necessarily fulfilled (Foster, 1984; Ruiz-Castillo, 1987). In addition, that minimal set of axioms is not able to characterize a unique indicator which should be considered better than others, and so there exist some alternative indicators in the same way as when a better inequality indicator has to be chosen (Foster and Sen, 1997; Zheng, 1997).

The above discussion leads us to the joint consideration of batteries of poverty indicators, avoiding the difficulty of selection among them. That idea might find a precedent in the *intersection quasi-order* issue, proposed by Sen (1973), in an economic inequality environment. However, the similarity relies only on the consideration of a set of indicators as a starting point, because Sen's approximation generates only a quasi

[3] More details about the role of Lorenz curves in economic inequality analysis can be seen in a number of references. Some of them are Marshall and Olkin (1979), Arnold (1987) or Núñez (2006).

order structure again and, on the other hand, it doesn't provide us with a quantification of the intensity of poverty.

So, instead of looking for global agreement when several indicators are used to compare two income distributions, our proposal consists of using a synthetic indicator built from the whole initial set. This idea is not new, because it has been used to study economic inequality in a similar context. Therefore, we are going to use the guidelines developed in García, Núñez, Rivera and Zamora (2002), which allows only for cross-sectional comparisons, and we shall extend it to make dynamic comparisons, in the same way as Domínguez and Núñez (2007) does. Obviously, both of these approximations will be adapted to measure the cumulated intensity of poverty found in the households of a society, instead of economic inequality. The idea relies on the use of techniques based on the Principal Component Analysis (PCA) applied over the initial set of poverty measures. So, we have no need to choose a better indicator, because the method extracts the common content included in all the selected indicators that will be poverty intensity, of course.

Therefore, the structure of the paper is as follows. Section 2 deals with involved methodology and decisions we have made about poverty measurement, and the construction of cross-sectional and dynamic synthetic indicators, including the study of their outstanding properties. Section 3 describes data used to analyse poverty in the EU-15 countries. In section 4, empirical results are presented and commented, using relative poverty lines, as we mentioned above. Finally, main conclusions are enlightened in last section.

2. METHODOLOGY.

First of all, we need to build the space of incomes as a useful background to develop the subsequent concepts, keeping in mind that the economic position of the households has been selected through its global income[4].

[4] The next construction would be valid if the household economic position variable would have changed, using any other option, like expenditures, earnings or disposable incomes.

Let x be a vector of non-negative incomes, whose dimension should be determined by the population size. Thus, the space of incomes, D, can be defined as:

$$D = \bigcup_{N=2}^{\infty} D_N = \bigcup_{N=2}^{\infty} \left\{ (x_1,\ldots,x_N) : x_i \geq 0, i = 1\ldots N; \sum_{i=1}^{N} x_i > 0 \right\}$$

Clearly, the remainder definitions about poverty measures, which are real-valued functions, must be understood defined over the above set D.

2.1. Poverty lines.

One of the basic problems we found when dealing with economic poverty analysis is the identification of poor elements (individuals or households, as in this case) inside the population, through the poverty threshold or poverty line definition. Dagum (1989) argues that poverty line in a poor and less-developed country should be determined from basic needs on an absolute basis, whereas for developed countries, relative poverty lines must be used.

The relative poverty threshold is related to any indicator of the quality of living of the society, what Thurow (1969) calls the *adequate living standard* as it is perceived by the majority of society. In this paper, we use relative poverty lines, defined by the 60% of the median of equivalent total net household income for each considered country. In doing so, we are following EUROSTAT recommendations. The poverty line is going to be computed each year and for each country. As these are totally relative poverty lines, we have a different poverty line for each country in each wave.

2.2. Selection of an initial set of poverty indicators.

When several poverty intensity indicators are considered, each one may give us a different order among territorial units, depending on each own weighting scheme over the income distribution quantiles. This is the reason because of the choosing of a whole set of them as a starting point in the analysis.

Moreover, as we have discussed in the Introduction, there are a great number of poverty measures proposed in the literature (see for example Foster and Sen, 1997) and there is no agreement about which one could perform the best. However, it is usual to establish a minimal set of properties to limit the scope. In such a case, the selection process could lead to the following simple poverty indicators[5], whose expressions are given in descriptive mode over a general income vector $x \in D$. In all of them, z is the poverty line, n is the number of households in each sample unit (country) and q identifies the number of poor households (those which are under the poverty line):

1. Measure of Sen:

$$\mathrm{SEN}(x,z) = \frac{2}{(q+1)\,nz} \sum_{i=1}^{q} (z - x_i)(q+1-i).$$

2. Measure of Thon:

$$\mathrm{THON}(x,z) = \frac{2}{(n+1)\,nz} \sum_{i=1}^{q} (z - x_i)(n+1-i).$$

3. Measure of Foster, Greer and Thorbecke of order 2:

$$\mathrm{FGT2}(x,z) = \frac{1}{nz^2} \sum_{i=1}^{q} (z - x_i)^2 .$$

4. Measure of Foster, Greer and Thorbecke of order 3:

$$\mathrm{FGT3}(x,z) = \frac{1}{nz^3} \sum_{i=1}^{q} (z - x_i)^3 .$$

5. Exponential Measure[6]:

$$E(x,z) = \frac{1}{n} \sum_{i=1}^{q} \left(1 - \frac{x_i}{z}\right) \exp\left(-\frac{x_i}{z}\right).$$

6. Measure of Chackravarty of order 0.75:

$$\mathrm{CHACK0.75}(x,z) = \frac{1}{n} \sum_{i=1}^{q} \left[1 - \left(\frac{x_i}{z}\right)^{0.75}\right] .$$

The *headcount-ratio* index ($H=q/n$) has been used to analyse the evolution of poverty incidence in the European Countries throughout time. To study poverty intensity, the whole set of previously presented simple indicators has been used.

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[5] The selected indicators verify the axioms usually imposed in the literature. See Domínguez (2003), for further details.

[6] Further details on this measure can be found in Domínguez (2003).

2.3. Construction of the cross-section synthetic poverty indicators.

Let us present the data structure where this methodology works. Consider a set of p simple poverty indicators $\{I_1, I_2, \ldots, I_p\}$, which can be seen as a p-dimensional variable defined over the income space generated by each situation we need to study (European countries in this case), along different points in time. So, we have one data matrix in each period of time we have considered. Let **I(t)** be such a function of $(n(t)xp)$ data matrices, with t varying in the actual time interval $T=[t_0 , t_1]$ and $n(t)$ as the number of cases at this period of time. Nevertheless, income data are characterized by its discrete time character and so we have a temporary set $T = \{t_0, t_1, \ldots, t_k\}$.

Thus, we can consider a data matrices classification, where groups are defined by the elements of the set T. So, we can perform multivariate dimension-reduction methods on the data matrix defined over each period of time, generating a cross-section result. As all indicators in the initial set are measuring poverty intensity, their content should be determined using such a fact. This argument leads us to think of Principal Components Analysis as a useful technique to extract the common information the battery of indicators offers. Particularly useful must be the First Principal Component if the explained variance is large enough, as we can expect.

The formal construction of such a cross-section indicator follows the guidelines developed in García, Núñez, Rivera and Zamora (2002), when time is not taken into account. Let $(Y_1(t), Y_2(t),..., Y_p(t))$ be the p-dimensional variable defined using the former variables under standardization along the corresponding cases in $t \in T$. Thus, data matrix in $t \in T$ will be $\boldsymbol{Y(t)}$, whose elements are defined by:

$$Y_{ij}(t) = Y_j(x_i(t)) = \frac{I_j(x_i(t)) - \mu_j(t)}{s_j(t)}, \quad i = 1,2,\ldots,n(t); \quad j = 1,2,\ldots, p; \quad t \in T \qquad (1)$$

where $x_i(t) \in D$ stands for the ith territorial unit vector of incomes, measured at moment t, $\mu_j(t)$ is the mean of the indicator I_j calculated over all cases in t and $s_j(t)$ is the corresponding standard deviation. In such circumstances, let $\boldsymbol{R(t)}$ be the associated variance-covariance matrix from **Y(t)**[7] and let $u_1(t), u_2(t), ..., u_p(t)$ be the eigenvectors extracted from **R(t)**, associated to its eigenvalues decreasingly ordered.

The first principal component can be now expressed as follows:

$$Z_1(t) = Z_1(x(t)) = u_1(t) \cdot (Y_1(x(t)), ..., Y_p(x(t)))' = \sum_{j=1}^{p} u_{1j}(t).Y_j(x(t)) \qquad (2)$$

with $x(t) \in D, \quad t \in T$. This becomes to be the optimal linear predictor when minimum squared error is used (Peña, 2002, 168-170). Furthermore, if the explained variability by the first principal component becomes bigger, the obtained error will be smaller.

After elementary algebraic manipulations, we have:

$$Z_1(x(t)) + K(t) = \sum_{j=1}^{p} \frac{u_{1j}(t)}{s_j(t)} \cdot I_j(x(t)),$$

where $K(t)$ is a value depending on $u_1(t)$, $\mu(t)$ and $s(t)$, but not on $x(t)$, except through the vectors expressed. Obviously, $\mu(t)$ and $s(t)$ are vectors compounded by the indicators means and standard deviations, respectively.

Finally, the proposed cross-sectional synthetic indicator can be expressed in the following way:

$$Z(x(t)) = \frac{Z_1(x(t)) + K(t)}{\sum_{h=1}^{p} (u_{1h}(t)/s_h(t))} = \sum_{j=1}^{p} a_j^*(t) \cdot I_j(x(t)), \quad x(t) \in D, \quad t \in T, \qquad (3)$$

with:

$$a_j^*(t) = \frac{u_{1j}(t)/s_j(t)}{\sum_{h=1}^{p} (u_{1h}(t)/s_h(t))}, \quad j = 1,2,...,p,$$

[7] As the variables have been standardized, this variance-covariance matrix is equivalent to the correlation matrix of the original variables.

and we have the synthetic longitudinal indicator as a convex linear combination of the initial simple indicators in the selected initial battery[8].

So, Z(t) must be a poverty intensity indicator because it has been built using a initial set of poverty measures, and this should be the primary content of the first principal component.

2.4. A synthetic poverty indicator which allows dynamic comparisons.

Unfortunately, as when economic inequality is studied (Domínguez and Núñez, 2007), the synthetic indicator proposed in (3) will give us different functions on each instant, because the first eigenvector of **R(t)** changes depending on *t*. To avoid this drawback, we must remember that data come from samples of households and, thus, correlation matrices are only estimations of the population ones. If we could admit that all these matrices were the same, then equality among first eigenvectors involved would be assumed. In such a case, we might use a pooled estimate of the common variance-covariance matrix in order to obtain a unique eigenvector, which will be time-independent, providing a valid indicator for all periods in *T*.

So, as a first option, we propose the use of a test to check the hypothesis of a stable variance-covariance structure (correlation in our case). The selected test will be an adaptation of Box M, whose basic details can be found in Rencher (1995), for example.

If the same variance-covariance structure is accepted, then joint consideration of simple indicators is proposed, independently of their temporary period of reference, obtaining the pooled correlation matrix, $\boldsymbol{R}$. So, we might use only the first eigenvector, u_1, over the whole time period, and the proposed *global first principal component synthetic indicator* can be written as:

[8] By construction, the elements of the eigenvector $u_1(t)$ must be non-negative because it was derived from the matrix $R(t)$.

$$Z_{GPC}(x(t)) = \sum_{j=1}^{p} a_j^* . I_j(x(t)) = \sum_{j=1}^{p} \left(\frac{u_{ij}/S_j}{\sum_{i=1}^{p} u_{ij}/S_j} \right) I_j(x(t)), \quad t \in T \tag{4}$$

Now, we can observe how the convex linear combination coefficients are constant across time. So, the impact of each country income vector depends only on its values, which are measured through the simple poverty intensity indicators. Thus, dynamic analysis of cases is allowed, because the basic framework is the same, providing a stable weighting scheme over the initial set of indicators along the whole considered period of time. Also, an analysis of the differential facts involved in the individual measuring characteristics could be possible, taking into account the second principal component.

On the other hand, let us suppose now that null hypothesis of stable correlation structure has been rejected and, therefore, at least one variance-covariance matrix is different. In such a case, it may still be possible to find out another way of solving the problem of dynamic comparisons, using an adaptation of an algebraic method to locate the closest vector to the common space generated by principal components, proposed in Krzanowski (1979, 1982), named the *Common Space Analysis* procedure.

The aforementioned adaptation of Krzanowski's method can be described as follows. If all the first eigenvectors associated to $\{\mathbf{R(t)},\ t \in T\}$ were close to each other, it would be possible to find out a vector located very near to all of them. Using only the first principal components, Theorem 3 included in Krzanowski (1979, pg. 705) allows us to assure that the vector we are looking for is the first eigenvector (v) of the matrix:

$$H = \sum_{t \in T} u_1'(t) \cdot u_1(t),$$

which maximizes

$$B = \sum_{t \in T} \cos^2 \delta_t ,$$

where δ_t is the angle between $u_1(t)$ and v. This solution is valid only if the first eigenvectors associated to $\{\mathbf{R(t)},\ t \in T\}$ are very close, in such a way that all the angles between v and each of them are small enough. But it seems reasonable to expect such behavior when we are dealing with indicators trying to measure the same concept (poverty intensity in our case). Finally, the alternative synthetic inequality indicator would be named the *common space-based synthetic indicator*, defined as:

$$Z_{CS}(x(t)) = \sum_{j=1}^{p} b_j^* \cdot I_j(x(t)) = \sum_{j=1}^{p} \left(\frac{v_j / s_j}{\sum_{h=1}^{p} (v_h / s_h)} \right) \cdot I_j(x(t)), t \in T \ . \qquad (5)$$

Now, it comes evident how if the first proposed synthetic indicator (equation 4) is adequate, the second (equation 5) must be very close to it. Nevertheless, in contexts where high correlations among the indicators should be expected, the second approximation provides an interesting alternative when the first one fails (in cases where sample oscillations may be important).

2.5. Some properties of the proposed synthetic poverty indicators

Both the Global First Principal Component and the Common Space based indicators are convex linear combinations of the initial simple poverty indicators. This is a very remarkable property, because allows us to extend a good number of properties from the initial indexes to the synthetic ones.

So, related to TIP curves analysis, Zheng (2000) proves that only invariant measures against equal income and poverty line increments (absolute measures) are TIP-compatible, when poverty lines differ in the compared income distributions, in the sense that these measures preserve TIP curves order. So, it is trivial the proof of the following statement.

Proposition 1.

a) If all the poverty intensity measures compounding the initial set are absolute measures, then both the Global First Principal Component and the Common space synthetic indicators are absolute ones.

b) Moreover, if all the initial poverty intensity measures are TIP-compatible, then both the Global First Principal Component and the Common space synthetic indicators are TIP-compatible ones.

Note that the second part in Proposition 1 includes the set of measures TIP-compatible, when the poverty lines of compared income distribution are the same or not, whose properties are described in Jenkins and Lambert (1997, 1998a, 1998b).

On the other hand, it is interesting to see the proposed synthetic indicators as linear projections of the p-dimensional poverty indicator, defined by means of the initial set of indicators. So both proposals are optimal projections, because each one is the solution to an optimization problem (Maximum explained variance for the First Principal Component and Minimum distance to all the first eigenvectors, when Common space analysis is to be applied). The only restriction in both cases is related to the normalization of the vector which brings the coefficients of the linear combination, transforming it in a convex one.

Above discussion allows us to express both proposals as optimal projections and so included in the general framework of *Projection Pursuit* (Huber, 1985; Friedman, 1987). In this way of thinking, it would be possible to obtain new synthetic indicators if we choose different projection functions to be optimized. For instance, mean of initial indicators is again an optimal projection. Nevertheless, this is probably a worth research field to be explored.

3. DATA DESCRIPTION

The computation of poverty indexes will be accomplished using data from the European Community Household Panel (ECHP). ECHP is a longitudinal survey of households and individuals, centrally designed and coordinated by the Statistical Office of the European Communities (EUROSTAT) and covering all countries of the European Union. An attractive feature of ECHP is its comparability across countries and over time, as the questionnaire is similar and the elaboration process of the survey is carried out by EUROSTAT (Álvarez-García, Prieto-Rodríguez and Salas, 2002).

As household economic position we have chosen, as a shake of convenience, is the total net household income, which is one of the variables included in ECHP. In order to include household inner scale economies in the analysis through the *number of equivalent adults* concept (Duclos and Mercader-Prats, 1999), we use the potential equivalence scale proposed in Buhmann *et al.* (1988), using s=0.5 as its elasticity value. It is well known that levels in measured income poverty can vary depending on the choice of equivalence scale, although none of them has been proved to be superior. It is not the purpose of this paper to analyze the influence of equivalence scales on income poverty, but to see the way in which a set of indicators can be aggregated (for further discussion on equivalence scales, see, for instance, Buhmann, Rainwater, Schmaus and Smeeding, 1988; Burkhauser, Smeeding and Merz, 1996; Coulter, Cowell and Jenkins, 1992, or Casas, Domínguez and Núñez, 2003, in the Spanish case).

Moreover, in order to face a comparative study of poverty in the European countries, in a cross-sectional as well as in a longitudinal sense, net household income has been transformed into US dollars, using exchange rates obtained from EUROSTAT, and time series have been deflated using the European Union harmonized consumer price index for each country.

A full description of the ECHP dataset in terms of sampling, response rates, weighting procedures, etc., can be found in specialized literature (Nicoletti and Peracchi, 2002, Ayala and Sastre, 2002), but it is necessary to point out that we had to exclude some households from the dataset in our analysis because they presented missing values for total net household income[9]. Table 1 shows the initial number of cases in each country and the number of households that were finally selected. It is interesting to notice the large amount of households from Sweden for which this variable is not available. Despite Layte, Maître, Nolan and Whelan (2000) indicate that they had excluded Luxembourg because it must be frequently treated as an exceptional case, we haven't found empirical evidence to discard this case, or any other. Although Austria, Finland and Sweden were not included in the first waves of the ECHP, we have decided to include them in those waves where their data are available, in order to enrich the comparative results.

[9] As usual, we have trimmed the sample, by the elimination of 1% of extreme cases in each tail, in order to avoid the presence of outliers.

Finally, in this paper, we have taken into account the information from waves 1 to 8, which correspond to years 1994 to 2001. As it is well known, income data of each wave is always referred to the previous year, thus they give us information about years 1993 to 2000.

Table 1

Total sample sizes and effective trimmed sample sizes for households with total net income information, in brackets. ECHP Countries, Waves 1 to 8.

Country	Code	Wave 1 1993	Wave 2 1994	Wave 3 1995	Wave 4 1996	Wave 5 1997	Wave 6 1998	Wave 7 1999	Wave 8 2000
Denmark	DK	3482 (3414)	3223 (3152)	2955 (2893)	2745 (2681)	2512 (2454)	2387 (2326)	2281 (2230)	2283 (2222)
Netherlands	NL	5187 (5052)	5110 (4931)	5179 (5003)	5049 (4921)	4963 (4826)	5023 (4892)	5008 (4888)	4851 (4734)
Belgium	BE	3490 (3391)	3366 (3277)	3210 (3133)	3039 (2951)	2876 (2801)	2712 (2641)	2571 (2504)	2362 (2295)
France	FR	7344 (6968)	6722 (6556)	6600 (6424)	6176 (6025)	5866 (5730)	5610 (5489)	5345 (5228)	5345 (5165)
Ireland	IE	4048 (3947)	3584 (3503)	3173 (3103)	2945 (2883)	2729 (2666)	2378 (2322)	1951 (1903)	1760 (1714)
Italy	IT	7115 (6767)	7128 (6857)	7132 (6880)	6713 (6482)	6571 (6342)	6370 (6138)	6052 (5864)	5606 (5416)
Greece	GR	5523 (5375)	5220 (5074)	4907 (4760)	4604 (4462)	4211 (4099)	3986 (3886)	3918 (3823)	3916 (3828)
Spain	ES	7206 (7010)	6522 (6338)	6267 (6025)	5794 (5610)	5485 (5338)	5418 (5219)	5132 (4952)	4966 (4883)
Portugal	PT	4881 (4692)	4916 (4787)	4849 (4709)	4802 (4675)	4716 (4580)	4683 (4554)	4633 (4515)	4614 (4488)
Austria	AT	- (-)	3380 (3299)	3292 (3213)	3142 (3062)	2960 (2895)	2815 (2751)	2644 (2580)	2544 (2490)
Finland	FI	- (-)	- (-)	4139 (4031)	4106 (3964)	3920 (3771)	3822 (3689)	3104 (2998)	3115 (3014)
Sweden	SE	- (-)	- (-)	- (-)	5891 (5184)	5807 (5116)	5732 (5067)	5734 (5020)	5680 (4987)
Germany	DE	6207 (6091)	6336 (6242)	6259 (6116)	6163 (6074)	5962 (5836)	5847 (5729)	5693 (5613)	5563 (5462)
Luxembourg	LU	1011 (-)	2978 (2924)	2472 (2422)	2654 (2597)	2523 (2471)	2552 (2501)	2373 (2331)	2428 (2383)
United Kingdom	UK	5126 (4930)	5032 (4890)	5011 (4870)	4965 (4837)	4996 (4842)	4951 (4793)	4890 (4726)	4819 (4635)

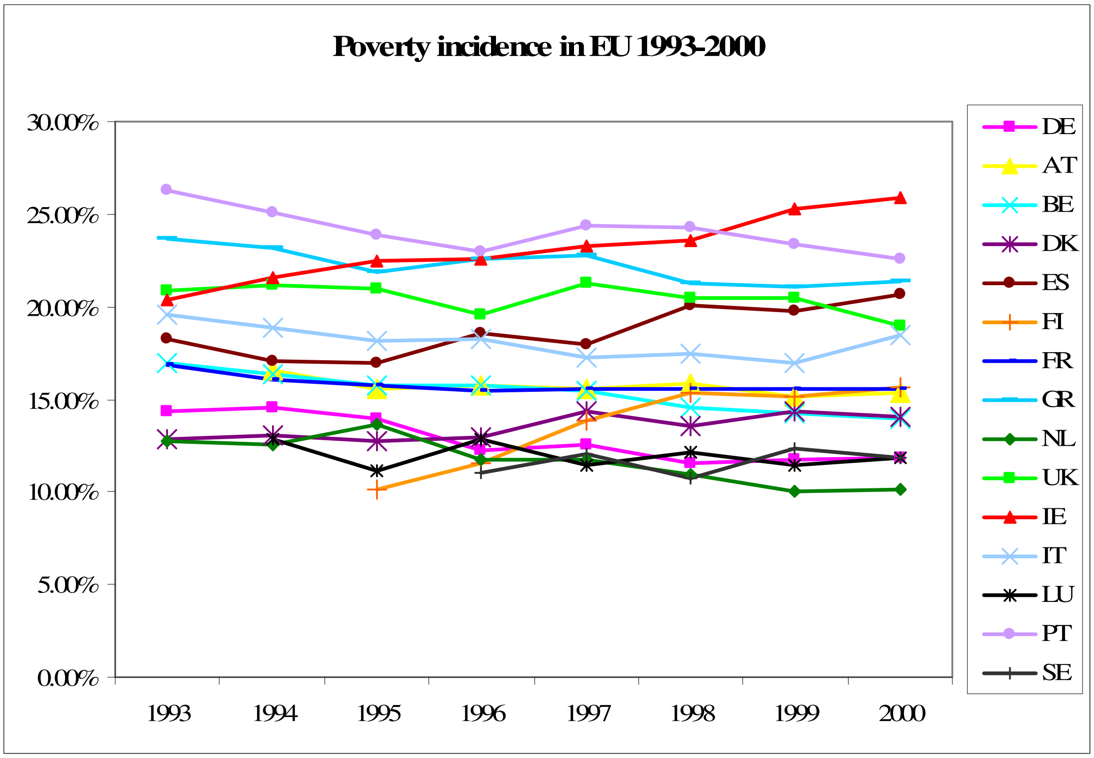
4. ANALYSIS OF THE RESULTS

In order to carry out poverty analysis in the EU-15 countries, we shall start with a description of poverty incidence in the period 1993-2000, using the headcount ratio indicator. Next, we develop the study of the intensity of poverty in two cases; the first one deals with the whole period, whereas the second case only uses the period 1996-2000, when all countries are included in the sample.

4.1. Poverty incidence.

Figure 1 shows values of the headcount ratio index for each country, using 60% of the median income in each country belonging to the European Union as poverty lines, all of them expressed in US dollars (1993). We observe how there are not uniform patterns in the evolution of the incidence of poverty in European countries.

Figure 1
Headcount ratio values for EU-15 countries, along 1993-2000.



In Denmark, Spain, Finland, Ireland and Sweden, an increasing trend along the whole period can be observed. However, poverty incidence diminishes continuously in Belgium. On the other hand, countries with higher headcount ratios are Portugal, Greece and Ireland. After them, United Kingdom, Spain and Italy evolve closely and near to a 20% of poor households. It is also remarkable that, nearly always, The Netherlands and Luxembourg show the lowest incidence of poverty.

4.2. Poverty intensity along the period 1993-2000.

The corresponding weighting coefficients to compute the PCA-based synthetic poverty index are presented in Table 2, for each cross-sectional wave. We can appreciate how these weighting schemes are quite stable. So, it might be possible to consider that correlation structures are all the same over the analysed period, as a hint.

Table 2
Weighting schemes for the computation of the cross-sectional synthetic poverty indexes based on the first Principal Component.

Poverty Indexes	Wave 1 1993	Wave 2 1994	Wave 3 1995	Wave 4 1996	Wave 5 1997	Wave 6 1998	Wave 7 1999	Wave 8 2000
SEN	0.1013	0.0932	0.0891	0.0855	0.0822	0.0783	0.0739	0.0680
THON	0.0743	0.0705	0.0669	0.0646	0.0612	0.0573	0.0546	0.0511
FGT2	0.2009	0.2083	0.2110	0.2088	0.2125	0.2196	0.2154	0.2158
FGT3	0.2701	0.2777	0.2916	0.3113	0.3251	0.3354	0.3620	0.3840
EXP	0.1920	0.1939	0.1919	0.1857	0.1823	0.1805	0.1712	0.1656
CHAK075	0.1614	0.1564	0.1495	0.1440	0.1367	0.1289	0.1230	0.1155

In order to prove the validity of our intuition, we shall test the equality of the correlation matrices obtained from data matrix in each wave. Nevertheless, applying M-Box Test on standardized data, we must reject the null hypothesis about correlation matrices equality (see Tables 3a and 3b, below). This fact leads us to take the second alternative proposed indicator, which is the Common Space-based synthetic one.

Table 3a
Box's M Test on equality of correlation matrices.

Wave	Rank	Log of determinant
1993 correlation matrix	4	-45.463
1994 correlation matrix	4	-46.936
1995 correlation matrix	4	-48.418
1996 correlation matrix	4	-49.243
1997 correlation matrix	4	-49.614
1998 correlation matrix	4	-49.753
1999 correlation matrix	4	-49.802
2000 correlation matrix	4	-50.024
Pooled correlation matrix	4	-47.571

Table 3b

Results of M-Box Test.

Box's M		130.502
F	Approx.	1.623
	df1	70
	df2	13848.319
	Sig.	.001

Once Common Space Analysis procedure has been used, the following common space-based synthetic inequality indicator is obtained using the resulting eigenvector. As we know, this synthetic indicator is a convex linear combination of the simple ones forming the selected initial set, and so it can be used to develop dynamic poverty intensity analysis.

$$Z^*(r,t) = 0.0892\ SEN(r,t) + 0.0670 THON(r,t) + 0.2119\ FGT2(r,t) + 0.2933 FGT3(r,t) + 0.1898\ EXP(r,t) + 0.1488\ CHAK075(r,t).$$

Furthermore, Table 4 shows the angles between the obtained eigenvector using the Common Space Analysis procedure and each one of the eigenvectors associated to the first component of each correlation matrix.

Table 4: *Angles between common-space and each cross-sectional eigenvectors*

YEAR	RADIANS	DEGREES
1993	0.0093	0.53
1994	0.0022	0.13
1995	0.0027	0.15
1996	0.0053	0.30
1997	0.0019	0.11
1998	0.0133	0.76
1999	0.0028	0.16
2000	0.0040	0.23

It should be noticed how all of these angles are quite small, with the greatest value around 0.01 radians (0.76º). So, we can admit the common-based indicator to be close enough to all the cross-sectional first component analysis indicators, as a result of the proposed method.

Keeping in mind the construction of this global synthetic indicator (equation 3), it is easy to note how its weighting scheme depends on the standard deviations associated to the simple indexes compounding the initial set. So, Table 5 shows the sample standard deviations of these simple indexes, using all the cases involved, with no temporal consideration.

It is remarkable how the smaller the standard deviation of the simple index, the greater its weight into the global synthetic indicator. In this sense, the smallest standard deviation is associated to the Foster, Greer and Thorbecke index of order 3 (FGT3) and its weight into the global synthetic indicator is found to be the greatest. The second index, in decreasing order, is found out to be Foster, Greer and Thorbecke index of order 2 (FGT2) and the third one is the Exponential poverty index (EXP). However, the greatest standard deviation corresponds to the Thon index (THON) and, consequently, it shows the smaller participation (6,7%) on the global synthetic indicator's system of coefficients.

Table 5: *Poverty indexes standard deviations.*

Poverty Indexes	Standard Deviation (s_i)
SEN	0.0208
THON	0.0276
FGT2	0.0088
FGT3	0.0059
EXP	0.0099
CHAK075	0.0125

Table 6: *Values of Common-Space Poverty Indicator for each Country in the ECHP*

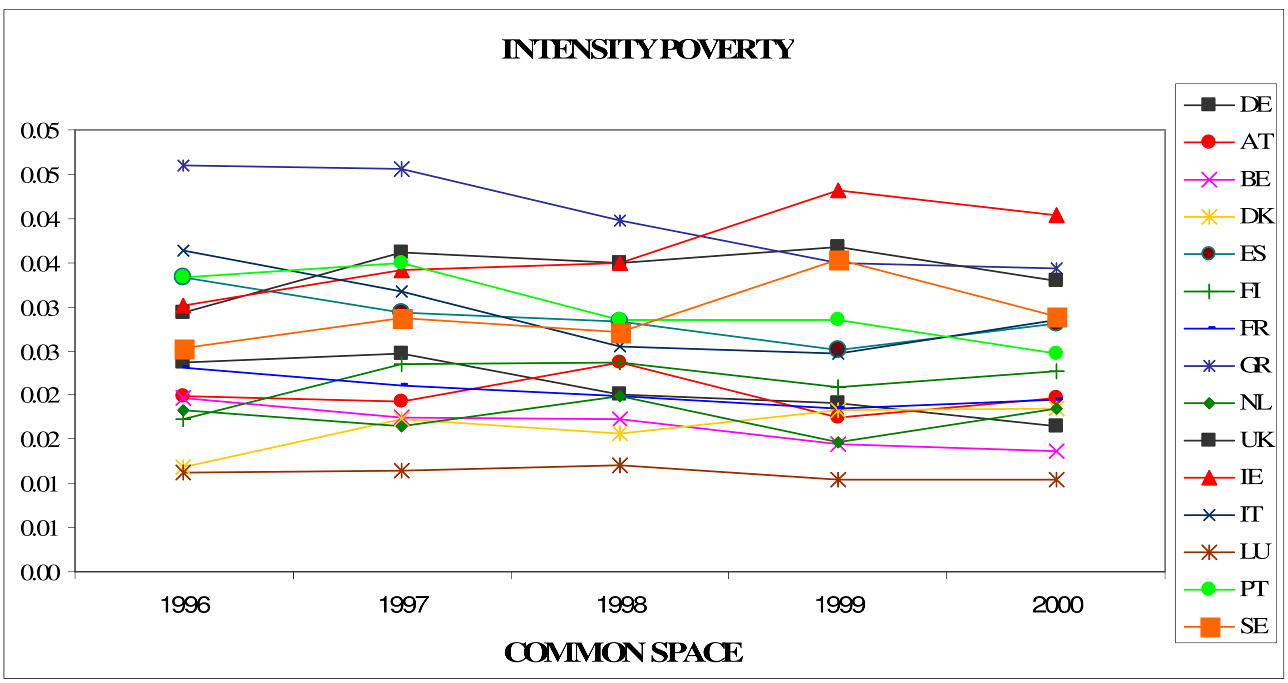
COUNTRY	YEARS							
	1993	1994	1995	1996	1997	1998	1999	2000
DE	0.0486	0.04811	0.03391	0.02371	0.02478	0.02012	0.01916	0.01649
AT	-	0.02379	0.02319	0.01988	0.01928	0.0237	0.01743	0.01964
BE	0.03248	0.03166	0.02434	0.01974	0.01749	0.01727	0.01442	0.01356
DK	0.01246	0.01109	0.01264	0.01175	0.01732	0.01568	0.01826	0.0184
ES	0.03156	0.02856	0.02922	0.03324	0.02936	0.02833	0.02507	0.0282
FI	-	-	0.01759	0.01733	0.02342	0.02363	0.02087	0.02266
FR	0.03495	0.02622	0.02147	0.02313	0.02114	0.01983	0.01839	0.01939
GR	0.06861	0.05375	0.04732	0.04592	0.04565	0.03968	0.03501	0.03439
NL	0.02277	0.02952	0.02951	0.01822	0.01652	0.01994	0.01473	0.01838
UK	0.04441	0.03898	0.0356	0.02923	0.03622	0.03503	0.03675	0.033
IE	0.03013	0.03165	0.03133	0.03021	0.03411	0.03502	0.04324	0.04038
IT	0.0458	0.03961	0.03885	0.03629	0.03173	0.02558	0.02477	0.02845
LU	-	0.01528	0.01142	0.01124	0.01148	0.01197	0.01048	0.01041
PT	0.04775	0.04114	0.03355	0.03331	0.03496	0.02844	0.02856	0.02469
SE	-	-	-	0.02527	0.02865	0.02705	0.03535	0.02888

Figure 2 displays the observed trends in poverty intensity, measured through the common-space synthetic poverty index, over the 15 countries in the EU. An increasing trend can be traced in Denmark, Ireland and United Kingdom. However, the opposite effect is observed in Belgium, Germany, Portugal and Greece. Nevertheless, Luxembourg appears to have quite stable and low poverty figures, from wave 5 to the last of the period.

Furthermore, according to the temporal evolution of the common space-based poverty indicator, a clustering method was used to confirm the group structure present in the dataset, from wave 4 to wave 8 (omission of the three first waves is necessary because Austria, Finland an Sweden did not appear, thus not being comparable) [10]. The resulting dendrogram is shown in Figure 3.

Figure 2

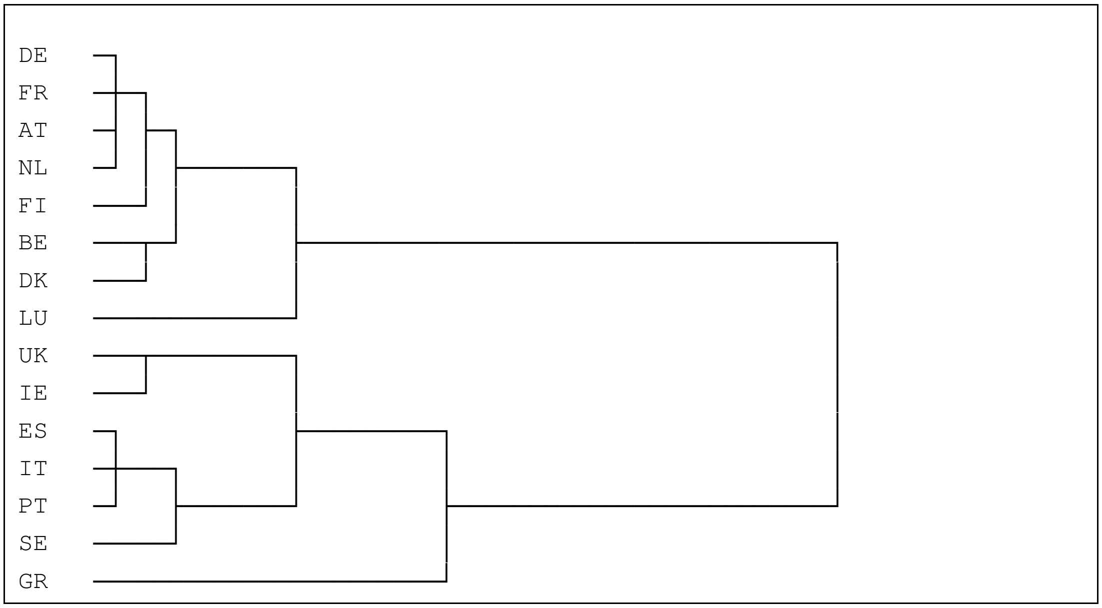
Common Space Poverty Indicator values for each Country in the ECHP.



[10] The centroid agglomeration method of hierarchical clustering has been used over the squared euclidean distance dissimilarity matrix.

Figure 3

Dendrogram of the countries' common space-based poverty index referred to waves 4, 5, 6, 7 and 8.



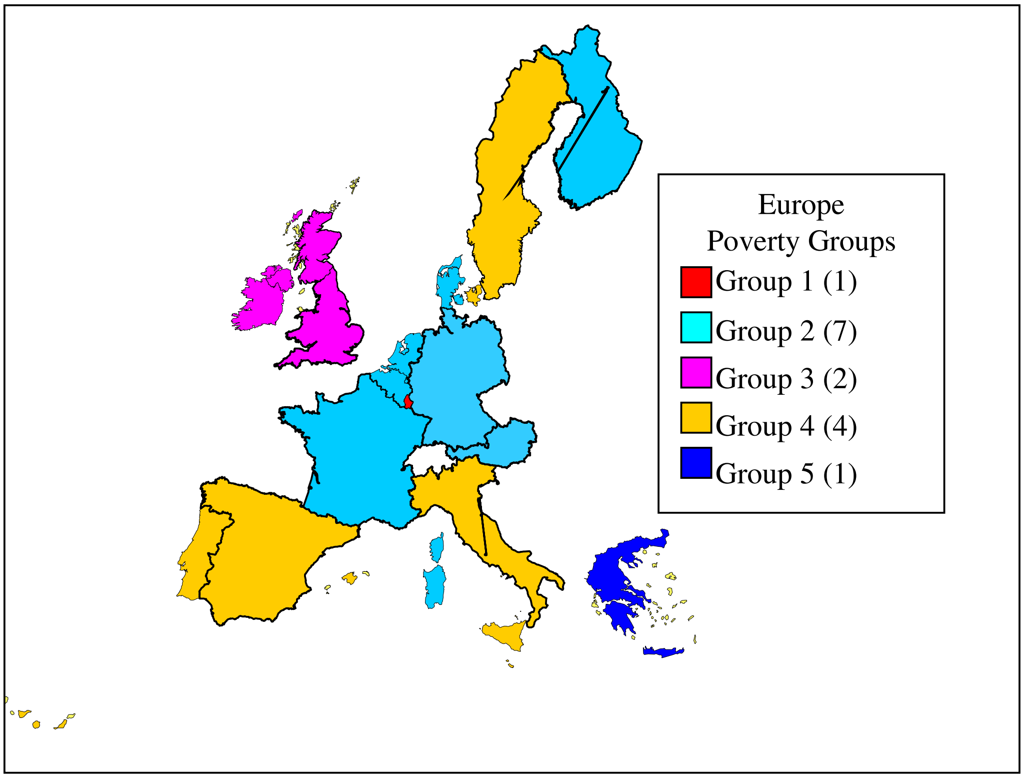
So, from Figure 3, we can find out the following groups:

- The first group includes Luxembourg. This country presents the lowest intensity of poverty rates in the EU.
- The second group comprises Germany, France, Austria, Finland, The Netherlands, Denmark and Belgium. All of them are countries where poverty intensity is stable and located in the middle of the set of countries.
- The third group is formed by United Kingdom and Ireland, with comparatively high rates of poverty intensity.
- The fourth group is composed by Italy, Spain, Sweden and Portugal, located in the upper half of intensity of poverty rates.
- The fifth group includes only Greece, and presents the greatest poverty indicator levels in the EU, until 1998.

These results are completely similar to those observed in Figure 2. The geographical situation of these groups is represented in the following Figure 4.

Figure 4

Groups of countries derived from the classification according to their poverty level.



4.3. Poverty intensity along the period 1996-2000

One of the main possible reasons to explain the lack of stability of the correlation matrices along the whole period might be the different sets of countries involved in the first half of period, if we speak about data used. Therefore, we are going to consider now only the period 1996-2000, where all countries are present in the database.

Thus, let us consider only data from wave 4 to wave 8. Again, we test the equality assumption of the correlation matrices obtained using data from the initial set of poverty indicators at each wave. Applying the Box's M Test on standardized data, equality of correlation matrices will be assumed as the null hypothesis (see Tables 7a and 7b). Results lead us to accept the equality assumption and thus to obtain the Global First Principal Component, using the pooled correlation matrix without temporal consideration.

Table 7a

Box's M Test on equality of correlation matrices.

Wave	Rank	Log of determinant
1996 correlation matrix	4	-49.243
1997 correlation matrix	4	-49.614
1998 correlation matrix	4	-49.753
1999 correlation matrix	4	-49.802
2000 correlation matrix	4	-50.024
Pooled correlation matrix	4	-49.311

Table 7b

Results of M-Box Test.

Box's M		26.345
F	Approx.	.575
	df1	40
	df2	10808.824
	Sig.	.986

Weights to compute the synthetic indexes based on Global First Principal Component and Common Space Analysis are presented in Table 8.

Table 8

Weighting schemes for the computation of the longitudinal poverty indexes based on the Global First Principal Component and the Common Space Analysis.

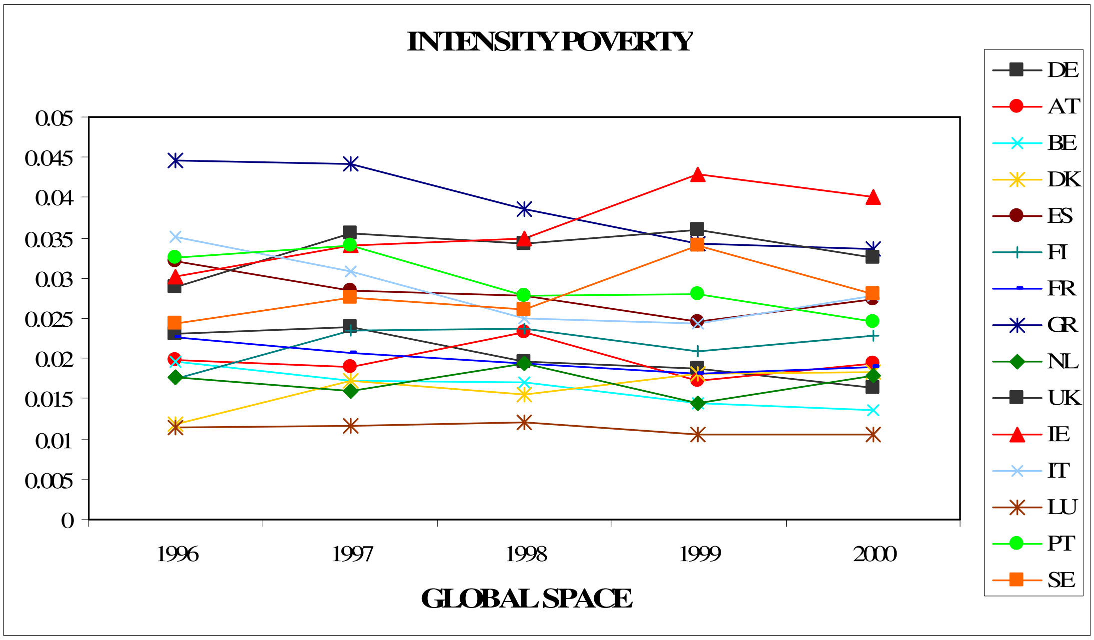
Poverty Index	Global Principal Component Indicator	Common Space Indicator 93-00	Common Space Indicator 96-00
SEN	0.0785	0.0892	0.0784
THON	0.0585	0.0670	0.0585
FGT2	0.2154	0.2119	0.2154
FGT3	0.3369	0.2933	0.3374
EXP	0.1793	0.1898	0.1791
CHAK075	0.1314	0.1488	0.1313

As we can readily see, the corresponding weighting schemes are almost identical, which implies that both methods to build summary indexes lead to the same results, when correlation matrices are assumed not to be different.

Figure 5 below shows poverty intensity trends in the 15 EU countries, using the Global First Principal Component-based synthetic indicator. Results turn out to be quite similar to those of Figure 2, using the whole period dataset and the Common space-based synthetic indicator. This fact may be considered as a proof of good performance when the proposed methods are used.

Figure 5

Global Space Poverty Indicator values for each Country in the ECHP.



5. CONCLUSION

Throughout this paper, we have proposed a methodology to build a synthetic indicator, which comprises the information of a set of poverty intensity indicators verifying a set of good properties. As an advantage of the exposed methodology, we can evaluate intensity of poverty among countries, not only in the same period of time, but also in a longitudinal sense, with the same synthetic indicator. This approach allows us to overcome the problem related to the choice of a best poverty intensity measure among the great number of proposed indicators. Moreover, both synthetic indicators turn out to be convex linear combinations of the initial simple indexes and so most of their properties are easily transferred to the synthetic ones.

This methodology has proved to be useful to compare among cases, such as EU countries in this study. The unique drawback we find is the lack of economic interpretation of its results, because of its structure as a convex linear combination of simple indicators. Nevertheless, the possibility to compare cases taking into account information from a set of accepted indicators, without an explicit selection of one of them, may overcome this problem. Further research could be attempted to explore the theoretical properties of the synthetic indicators proposed here, looking for economic implications of their results.

We have checked out that when correlation matrices can be assumed to be statistically identical, each of them calculated over a set of variables measured on different groups or along time, then Krzanowski's Common Space Analysis adaptation produces the same results than Global First Principal Component-based synthetic indicator applied on the pooled correlation matrix. Furthermore, their respective coefficients have been proved to be close enough to each other.

Using household's total net income data provided by the ECHP, from 1994 to 2000 waves, we have also analysed poverty in European countries. On the one hand, we have considered poverty incidence through the headcount ratio index. Results show that there are increasing trends in Denmark, Spain, Finland, Ireland and Sweden, along the whole period. On the contrary, poverty incidence diminishes continuously in Belgium. It can be observed how countries with higher headcount ratios are Portugal, Greece and Ireland, while The Netherlands and Luxembourg show low incidences of poverty.

On the other hand, we have analysed poverty intensity from the battery of measures that have been chosen. Results allow us to establish five groups. The first group includes Luxembourg, which exhibits the lowest poverty rates in the EU. In the opposite, Greece presents the greatest poverty indicator levels, with the exception of Ireland from 1998 to 2000.

6 REFERENCES

Ahamdanech, I.; García, C. (2007). "Welfare, inequality and poverty rankings in the European Union using an inference-based stochastic dominance approach". *Inequality and Poverty. Research on Economic Inequality, 14* (J.A. Bishop & Y. Amiel, eds.), JAI Press, Oxford, 159-181.

Álvarez-García, S.; Prieto-Rodríguez, J.; Salas, R. (2002) "The Evolution of Income Inequality in the European Union". *Papeles de Trabajo, 10/02.* Instituto de Estudios Fiscales, Serie Economía. Madrid. [Available at http://www.ief.es/Publicaciones/papelest/02/pt10_02.pdf].

Arnold, B.C. (1987). *Majorization and the Lorenz order: A brief introduction.* Lecture Notes in Statistics. Springer Verlag, New York.

Atkinson, A. B. (1970). "On the measurement of inequality". *Journal of Economic Theory*, 2, 244-263.

Atkinson, A.B. (1987). "On the measurement of poverty". *Econometrica*, 55(4), 749-764.

Ayala, L.; Navarro, C. (2004). "Multidimensional indices of housing deprivation with application to Spain". *Papeles de Trabajo, 12/04.* Instituto de Estudios Fiscales.

Ayala, L.; Sastre, M. (2002) "What determines Income Mobility differences across the European Union?". *Working Papers of the Institute for Social and Economic Research, 2002-27*. Colchester: University of Essex.

Bishop, J.A.; Formby, J.P.; Smith, W.J. (1994). "International comparisons of welfare and poverty: Dominance orderings for ten countries". *Canadian Journal of Economics,* 26, 707-726.

Brandolini, A.; D'Alessio, G. (2000). "Measuring well-being in the functionings space". *26th General Conference of the International Association for Research in Income and Wealth (IARIW).* Cracovia. [Available at http://www.iariw.org].

Buhmann, B.; Rainwater, L.; Schmaus, G.; Smeeding, T.M. (1988) "Equivalence Scales, Well-Being, Inequality and Poverty: Sensitivity estimates across ten countries using the Luxembourg Income Study (LIS) Database". *Review of Income and Wealth*, 42, 381-399.

Burkhauser, R.V.; Smeeding, T.M.; Merz, J. (1996). "Relative inequality and poverty in Germany and the United States using alternative equivalence scales". *Review of Income and Wealth*, 42, 381-399.

Casas, J. M.; Domínguez, J.; Núñez, J. J. (2001). "Sobre la utilización de las escalas de equivalencia en el estudio de la desigualdad y la pobreza. El caso de España". *Anales de Economía Aplicada* (CD-ROM). XV Reunión Anual de ASEPELT-España. La Coruña.

Casas, J.M.; Domínguez, J.; Núñez, J.J. (2003). "La pobreza en España: Estudio a partir de curvas I.I.D. y su sensibilidad frente a escalas de equivalencia". *Información Económica y Técnicas de Análisis en el Siglo XXI* (Casas, J.M. y Pulido, A., eds.). INE, Madrid, 161-173.

Coulter, F.; Cowell, F.; Jenkins, S. (1992). "Equivalence scales relativities and the extent of inequality and poverty". *Economic Journal,* 102, 1067-1082.

Dagum, C. (1989). "Poverty as perceived by the Leyden income evaluation project. A survey of Hagenaars' contribution on the perception of poverty". *Economic Notes,* 1, 101-111.

Dalton, H. (1920). "The measurement of the inequality of incomes". *Economic Journal*, 30, 348-361.

Del Río, C.; Ruiz-Castillo, J. (2001). “TIP's for poverty analysis. The case of Spain, 1980-81 to 1990-91”. *Investigaciones Económicas,* XXV, 1, 63-91.

Domínguez, J. (2003). *Análisis dinámico de la pobreza y la estructura de los hogares.* Tesis Doctoral (PhD Thesis). University of Granada.

Domínguez, J.; Núñez, J.J. (2007). “The evolution of economic inequality in the EU countries during the nineties. A new methodological approach”. *Inequality and Poverty. Research on Economic Inequality, 14* (J.A. Bishop & Y. Amiel, eds.), JAI Press, Oxford, 137-157.

Duclos, J.-Y.; Mercader-Prats, M. (1999). "Household needs and poverty: with application to Spain and the U.K.". *Review of Income and Wealth*, 45, 1, 77-98.

Foster, J.E. (1984) “On economic poverty: A survey of aggregated measures”. *Advances in Econometrics*, 3 (Basmann, R.L. and Rhodes, G.F., eds.), JAI Press, Connecticut, 212-251.

Foster, J.E.; Sen, A.K. (1997). *On economic inequality. Expanded edition: Annexe.* Clarendon Paperbacks. Oxford.

Foster, J.E.; Shorrocks, A.F. (1988a). “Poverty orderings”. *Econometrica*, 56 (1), 173-177.

Foster, J.E.; Shorrocks, A.F. (1988b). “Poverty orderings and welfare dominance”. *Social Choice and Welfare*, 5, 179-198.

Friedman, J.H. (1987). “Exploratory Projection Pursuit”. *Journal of the American Statistical Association,* 82, 397, 249-266.

García, C.; Núñez, J.J.; Rivera, L.F.; Zamora, A.I. (2002). “Análisis comparativo de la desigualdad a partir de una batería de indicadores. El caso de las Comunidades Autónomas españolas en el período 1973-1991”. *Estudios de Economía Aplicada*, 20-I, 137-154.

Hagenaars, A.J.M. (1986). *The perception of poverty.* North Holland. Amsterdam.

Hagenaars, A.J.M. y Van Praag, B. (1985). “A synthesis of poverty line definitions”. *Review of Income and Wealth*, 31, 139-154.

Huber, P.J. (1985). “Projection Pursuit”.*Annals of Statistics,* 13,2, 435-475.

I.N.E. (1991). *Indicadores Sociales.* I.N.E. Madrid.

Jenkins, S.P.; Lambert, P.J. (1997). "Three I's of poverty curves, with an analysis of UK poverty trends". *Oxford Economic Papers,* 49, 317-327.

Jenkins, S.P.; Lambert, P.J. (1998a). "Ranking poverty gap distributions: further TIPs for poverty analysis". *Research on Economic Inequality,* 8, JAI Press, Greenwich, 31-38.

Jenkins, S.P.; Lambert, P.J. (1998b). "Three I's of poverty curves and poverty dominance: TIPs for poverty analysis". *Research on Economic Inequality,* 8, JAI Press, Greenwich, 39-56.

Krzanowski, W.J. (1979). “Between-group comparison of principal components”. *Journal of the American Statistical Association*, 74, 703-707; correction note (1981): 76, 1022.

Krzanowski, W.J. (1984). “Principal component analysis in the presence of group structure”. *Applied Statistics*, 33, 164-168.

Laderchi, C.R. (1997) “Poverty and its many dimensions: The role of income as an indicator”. *Oxford Development Studies*, 25 (3), 345-360.

Layte, R.; Maître, B.; Nolan, B; Whelan, C.T. (2000). “Persistent and Consistent Poverty in the 1994 and 1995 Waves of the European Community Household Panel Study”. *26th General Conference of the International Association for Research in Income and Wealth (IARIW).* Cracow. [Available at http://www.iariw.org].

Marshall, A.W.; Olkin, I. (1979). *Inequalities: Theory of Majorization and its Applications*. Academic Press. New York.

Martinez, R.; Ruiz-Huerta, J. (2000). "Income, multiple deprivation and poverty: An empirical analysis using Spanish data". *26th General Conference of the International Association for Research in Income and Wealth (IARIW).* Cracow. [Available at http://www.iariw.org].

Nicoletti, C.; Peracchi, F. (2002) "A Cross-Country comparison of Survey Participation in the ECPH", *Working Papers of the Institute for Social and Economic Research, 2002-32*. Colchester: University of Essex.

Núñez, J. J. (2006) "Inequality measures, Lorenz curves and generating functions". *Distribution models theory* (Herrerías, R.; Callejón, J.; Herrerías, J.M., eds.). World Scientific Publishing Co. Singapore, 189-220.

OECD (1982)*: The OECD list of social indicators.* París.1982.

Pena, J.B. (1977). *Problemas de la medición del bienestar y conceptos afines***.** I.N.E., Madrid.

Peña, D. (2002)**.** *Análisis de datos multivariantes.* McGraw-Hill. Madrid.

Pérez-Mayo, J. (2005). "Identifying deprivation profiles in Spain: A new approach". *Applied Economics,* 37, 843-855.

Rencher, A.C. (1995). *Methods of Multivariate Analysis.* Wiley Series in Probability and Mathematical Statistics. New York.

Ruíz-Castillo, J. (1987). "La medición de la pobreza y la desigualdad en España 1980-81". *Estudios Económicos,* 42. Banco de España. Madrid.

Sen, A.K. (1973) *On Economic Inequality.* Clarendon Press. Oxford.

Sen, A.K. (1976). **"**Poverty: An ordinal approach to measurement". *Econometrica,* 44, 219-31.

Sen, A.K. (1983). "Poor, relatively speaking". *Oxford Economic Papers,* 35 (2), 153-169.

Subramanian, S. (2004). "Indicators of inequality and poverty". *WIDER Research Paper 2004/25.* United Nations.

Tinbergen, J. (1991)**.** "On the measurement of welfare". *Journal of Econometrics,* 50, pp. 7-13.

Townsend, P. (1985). "A sociological approach to the measurement of poverty: A rejoinder to Prof. Amartya Sen". *Oxford Economic Papers*, 37(4), 659-668.

Thurow, L.C. (1969). *Poverty and Discrimination.* The Brookings Institution. Washington, D.C.

Zheng, B. (1997). "Aggregate poverty measures". *Journal of Economic Surveys,* 11, 123-163.

Zheng, B. (2000). "Poverty orderings". *Journal of Economic Surveys,* 14, 4, 427-466.