On the overlap of multidimensional and income poverty

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Abstract:

The multidimensionality of poverty is now widely recognised and accepted. From a theoretical point of view, the contribution of multidimensional approaches of poverty such as Townsend's relative deprivation or Sen's capability approach seems to be clear. However, from an empirical perspective, these approaches face some difficulties that question their practical use compared to the more commonly used income approach. Hence, as far as the information necessary to operationalise multidimensional approaches is costly in terms of time, resources, and data, one has to determine if the results of these two approaches are substantially different or not. If the results are the same, then the practical interest of multidimensional approaches is low and the use of income poverty as a proxy of multidimensional poverty is justified. If there is a mismatch, the two approaches can be said to be complementary in the explanation of the concept of poverty.

Among the different ways to study this question, one consists in assessing the degree of overlap of the income and multidimensional approaches of poverty. The way to proceed is usually to determine a poverty line for the income measure and the multidimensional one and then to determine if the persons identified as poor by both approaches are the same. By so doing, *the result is conditional to the threshold chosen for each measure*. In this paper, I propose to overcome this constraint by using an innovative methodology called *Receiver Operating Characteristics* (ROC) curve, which allows assessing the overlap of multidimensional and income poverty, *independently of the threshold used to define multidimensional poverty*. After having computed several indexes of multidimensional poverty, I apply the ROC methodology to 12 countries of the second wave of the ECHP. The results are in line with the literature by showing that the link between the two approaches exists but is not strong enough to determine that one can be used as a proxy to the other.

After having reviewed the literature pertaining to the overlap of income and multidimensional poverty (section 1), I will present the methodology as well as the data used (section 2), and then the results (section 3).

Introduction

> "The difference between [poverty as a low level of income and poverty as a failure of achieving a range of basic capabilities] is, however, not just one of dimensions – one being uni-dimensional and the other multi-dimensional. A more fundamental difference is between means and ends. The income approach focuses on the means, while the capability approach focuses on the ends. Income is nothing but a means, which together with other means (such as public services) helps achieve the ends of capabilities.[2] The foundational question of what constitutes poverty, as distinct from the operational question of what causes poverty, should be answered in terms of the ends that people value but are unable to achieve, not in the means to achieve them. Hence the superiority of the capability approach".
> Osmani S. R. (2005: 207-8), "Poverty and Human Rights", *Journal of Human Development*, Vol. 6, n°2, July

Poverty can be conceptualized in several ways. Following the distinction introduced by Sen (1979, 1981) and Ringen (1987, 1988), poverty can be handled either indirectly as a lack of resources or directly on the basis of the achievements of the individuals. The indirect approach focuses on the *means* constituted by the resources at disposal of the individuals in order to satisfy the needs considered as essential or as part of an ordinary living pattern in the society under study. Hence, we are informed on the *potential satisfaction* of the needs by focusing on what people actually *have or do not have* in order to meet their needs (Alcock, 1997). On the other hand, the direct method is gaining more and more ground since the beginning of the eighties and bases its measurement of poverty on non monetary indicators to measure deprivation (Townsend, 1979; Mack and Lansley, 1985; Dickes, 1989; Nolan and Whelan, 1996), or to assess failure to achieve a range of basic functionings (Sen, 1985; Chiappero Martinetti, 2000). In this case, the researcher observes directly the *ends*, that is the *effective or factual satisfaction* of the needs and the measure of poverty lies on what people actually *do or do not do* (Alcock, 1997; Boltvinik, 1999).[3]

The traditional income approach is an indirect method, which consists in assessing poverty on the basis of a lack of income. As it relies on a unique measurement variable, it is sometimes considered to be a *unidimensional* approach. Direct approaches, such as Sen's capability approach or Townsend's relative deprivation, refer by definition to several types of information and can be considered to be *multidimensional* approaches of poverty[4]. However,

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[2] "Capabilities, in turn, should not be seen as a means towards achieving the ends of well-being, for capabilities are the constituents of well-being – they are the ends!"

[3] In Sen's capability approach, another space of evaluation can be considered, the space of the capabilities, mentioned by Osmani (2005), where we focus on what people can do or can not do. This space won't be treated in this paper.

[4] However, there is an exception. The "unidimensional" approach that bases its measurement of poverty on the sole variable of consumption is also a direct approach (Ringen, 1987).

as pointed out by Osmani (2005) in the above quotation, the difference between the income approach and the direct method is not only one of unidimensionality against multidimensionality. Indeed, the very question raised by the coexistence of these two conceptions of poverty regards our definition of poverty, whose answer will, in the end, determine the relevant informational space that we will use for its evaluation.[5]

If Ringen (1988:355) considers that the choice between a direct or an indirect conception is ideological, there is some ground to consider that the direct approaches are more satisfying than the indirect one. The main critique to indirect approaches is that, in practice, poverty is not simply about depleted wallets but it refers to a situation implying a "multifaceted combination of deprivations and unmet needs that prevent from participating in society in the same ways that others do" (Alcock, 1997:85). Moreover, by focusing on the means, the indirect approaches prevent from taking into account human diversity; there is a natural heterogeneity among individuals regarding their personal, socio-economic and environmental characteristics that clearly affect the translation of the means into achievements. A focus on individuals' accomplishments allows taking this into account as this heterogeneity is contained in the results. These arguments lead to the conclusion that "in an obvious sense, the *direct method* is superior to the *income method* since the former is not based on particular assumptions of consumption behaviour which may or may not be accurate." Hence, "it could be argued that *only* in the absence of direct information regarding the satisfaction of the specified needs can there be a case for bringing in the intermediary of income, so that the income method is at most a second best" (Sen, 1979: 290).

However, if the theoretical contribution of these approaches seems to be clear, on the other hand, the difficulties raised by the empirical operationalisation of the multidimensional approaches of poverty lead us to wonder what is their concrete added value. Does the conceptual contribution of multidimensional approaches of poverty end up in differences in terms of the identification of the poor? This question is important as far as the information needed for the measurement of multidimensional poverty is difficult to collect and can be costly in terms of time, resources and data (Klasen, 2000; Kuklys, 2004).[6] One has then to

[5] Indeed, as pointed out by Sen (1979: 291), "the *direct method* and the *income method* are, in fact, not two alternative ways of measuring the same thing but represent two alternative conceptions of poverty. The direct method identifies those whose actual consumption fails to meet the accepted conventions of minimum needs, while the income method is after spotting those who do not have the abilities to meet these needs within the behavioural constraints typical in that community".

[6] For example, talking about the capability approach Kuklys (2004) notes that "it is not obvious that Sen's approach really leads to a more meaningful measure of individual welfare, i.e. that the cost of elaborate data collection and analysis is justified".

determine if the results of the two approaches are substantially different or not (Lachaud, 1999). On one hand, if the identification of the poor is the same with the two approaches, there is no need to gather this information and the use of income as a proxy for multidimensional poverty is then justified (Dekkers, 2003). On the other hand, if the results are significantly different, one has then to choose the most relevant definition or to consider that these approaches are complementary in the explanation of the concept of poverty (Costa, 2003).

These questions have been addressed by several contributions that studied the overlap of multidimensional and income poverty. As for Perry (2002: 104), a "key finding of recent poverty research is that there is a significant mismatch between poverty measured using an income approach and poverty measure directly in terms of observed deprivation [..]". Indeed, the main conclusion is often that individuals identified as poor on the basis of income and on the basis of living conditions only partially overlap (Dickes, 1989; Nolan and Whelan, 1996a; Layte *et alii*, 2001; Perry, 2002). Non monetary indicators are often correlated with monetary measures, but not enough to consider that approaches based on income or on living conditions are equivalent.

The aim of my paper is to propose an extension to a methodology frequently used for the analysis of the degree of overlap/mismatch of the indirect/monetary and direct/multidimensional measures of poverty. The application of the method of the *Receiver Operating Characteristics* (ROC) curve on the data of several countries from the European Community Household Panel for the year 1995 will give further evidence to the main conclusion reached in the literature. After having briefly reviewed the literature pertaining to the overlap of income and multidimensional poverty (section 1), I will present the methodology of the ROC curve (section 2), and then the empirical application (section 3).

Section 1. The overlap of multidimensional and income poverty

Several methods have been used to assess the degree of overlap of multidimensional and income poverty. Lachaud (1999, 2000) or Dekkers (2003) use econometric tests to verify if the mismatch between income and multidimensional poverty is significant. Lachaud (2000: 49), using data from Burkina-Faso (1994-1995), tries to determine if the capability approach (multidimensional approach) and the utility-based approach (income approach) can be considered as complementary or substitutable. He concludes that the capability space doesn't necessarily substitute the utility space, and that the coexistence of the two approaches introduces valuable additional information. Hence, the two approaches can be considered to

be complementary and not opposite. On the contrary, starting from an analysis of the ECHP data, Dekkers (2003) concludes that income poverty can be used as a proxy for multidimensional poverty.

Another procedure often used for comparing monetary poverty and the multidimensional one consists, in the first place, to identify the poor on the basis of the two approaches, then, in the second place, to study the overlap between the two identified populations. As a consequence, the first step to join in is to determine a cut off point on the two indicators, i.e. an income as well as a multidimensional poverty line. In the case of income poverty, there have been lengthy debates on where to draw the line. A common practice in the European countries is to adopt a relative poverty line that corresponds to 60% of the median of the distribution of equivalent income. Individuals below this threshold are said to be at risk of poverty because the further is an individual's equivalent income from the average of a society the higher is his probability not to participate fully in this society. As debatable and arbitrary this threshold can be, it gained some legitimacy through its official adoption as a Laeken indicator of social inclusion by the European institutions in the framework of the Social Inclusion Process (Atkinson *et alii*, 2002 and 2005).

On the other hand, there is no consensus on the threshold to be used for the identification of the poor on the basis of multidimensional poverty. Several methods have been used to separate poor from non poor.[7] One of the most used consists simply in setting the deprivation threshold in order to obtain the same proportion of deprived people and of income poor individuals. This choice is the one made by Layte *et alii* (2001) on the data of the ECHP, and by Perry (2002) on data from New-Zealand. Layte *et alii* (2001) use data of 11 countries of the ECHP for the year 1994 to determine the population of the "consistent poor", i.e. those who are both income and deprivation poor.[8] For income poverty, they use a threshold of 40%, 50% and 60% of the median of the distribution of equivalent incomes. Their measure of deprivation, called *current lifestyle deprivation*, is composed of 13 items of deprivation that are aggregated into a composite index of deprivation, where every item is weighted by the

[7] We consider here only the approaches that must determine a threshold on the basis of an index of well being or deprivation in order to discriminate between poor and non poor. Other methodologies allow identifying a group of disadvantaged people without having to specify a poverty line, e.g. cluster analysis (Dekkers, 2003) or latent class models (Pérez-Mayo, 2003; De Wilde, 2004).

[8] The concept of consistent poverty has been introduced by the researchers from the Irish center ESRI (see, Callan *et alii*, 1993 or Nolan and Whelan, 1996). They consider that the best way to operationalise the definition of poverty as "exclusion from the ordinary life of society due to a lack of resources" is to incorporate into the measure of poverty both income and deprivation. The consistent poor are the individuals actually suffering from generalised deprivation *and* on low income.

proportion of household possessing the item in the country under study.[9] In every country, the proportion of deprived is then equalized with the proportion of income poor.[10] At the threshold of 60% of the median, the overlap for every country is in the range of 39% to 46%, at the exception of Denmark (17%) and Portugal (52.2%). These figures are computed as follows. In France, 15 % of individuals live below the threshold of 60% and when we equalize the proportion of income and deprivation poor only 5.9% of individuals are deprived in the two dimensions. Hence, the overlap is of 39.3% (5.9% / 15%).

The results of Perry (2002), based on the *New Zealand Living Standard Survey*, are of the same nature. He uses the same income poverty line and a scale of deprivation called ELSI which is a weighted aggregation of 37 items of the Mack and Lansley type, plus three other items of self evaluation of disadvantage.[11] The proportion of income poor is of 17%. After having equalized the proportion of individuals in situation of deprivation, the author find that that 7% of the population is at the same time income poor and deprivation poor. The overlap is then of 40 %. This leads him to conclude that "the mismatch is substantial and is typically in the range of 50% or 60%. This means that around half of those whose living standards are judged to be unacceptably low have incomes that are above the chosen income poverty line. Similarly, around half those who have incomes below the poverty line report consumption and living conditions that place them above the deprivation poverty line" (Perry, 2002: 104).

Another possibility is to work explicitly on the basis of an arbitrary threshold constituted by a predetermined proportion in the lowest part of the distribution of the two measures and to compare the two identified populations. As pointed out by Delhausse and Sluse (2004) this only requires, for each measure, to rank the individuals in increasing order of well-being and to select a proportion of disadvantaged people. The use of the same proportion can be justified in order to obtain a clear intersection of the populations. Using data from Belgium (PSBH), they chose the proportion of 15% in order to compare relative income poverty, subjective income poverty, and relative deprivation. They find that for the years 1992, 1997 and 2002, the proportion of the total population suffering from both material

[9] The items are the enforced lack of a car, a colour TV, a video recorder, a microwave, a dishwasher and a telephone and the inability to afford keeping its home adequately warm, paying for a week's annual holiday away from home, replacing worn-out furniture; buying new, rather than second hand clothes, eating meat, chicken or fish every second day if you want to, having friends or family for a drink or meal at least once a month and the last item refers to inability to pay a scheduled payment during the last 12 month.

[10] This is done in order "to assess the mismatch between poverty defined in relative income and relative deprivation terms-which could then vary from 0 to 100 percent (Layte *et alii*, 2001: 433).

[11] In their study, Mack and Lansley (1985) ask the respondents to report on the possession of an item or on the participation to an activity. But as the lack of an item can be the expression of a choice they go one step further by asking individuals if they lack an item because they cannot afford it or whether it is due to other reasons. The absence of an item is considered to be a sign of deprivation only when there is an "enforced lack" of this item.

deprivation and relative income poverty is between 6% and 7% (overlap of 40-45%). Lollivier and Verger (1997) used this method in order to compare the structure of the population defined as poor according to income poverty, subjective poverty, and poverty of living conditions. They identify the proportion of monetary poor according to a poverty line of half the median of the distribution of the equivalent income and then isolate the same proportion (approximately 10 %) on their indexes of subjective and living conditions poverty. Only 1.7% of the population is confronted to the three aspects of poverty and 4.3% are both income and living conditions poor. Bradshaw and Finch (2003) studied, on the basis of English data (*Survey of Poverty and Social Exclusion* of 1999), the overlap between subjective monetary poverty, an approach based on the enforced lack of necessities socially defined and a relative income approach. The degree of overlap of the population identified as poor on these three definitions/dimensions is low (33% of the population is poor on at least one definition and only 5,7% is poor according to the three definitions). They conclude on the necessity to rely not only on one measure and to adapt surveys in order to obtain several measures of poverty. They recommend aiming policies for poverty alleviation that the attention of policies at the population suffering of more than one type of poverty.[12]

Hence, there can be several ways of defining implicitly or explicitly the threshold of the multidimensional index of poverty, in order to study the overlap of the income poor as well as of the multidimensional poor populations. However, whatever choice is made, we have a one and only case (to the given threshold) on which we can observe the overlap of the populations of poor. As a consequence, *the result is conditional to the threshold chosen for each measure*. In this paper, I propose to overcome this constraint by using an innovative methodology called *Receiver Operating Characteristics* (ROC) curve which allows assessing the overlap of multidimensional and income poverty, *independently of the threshold used to define multidimensional poverty*.

[12] Following the same procedure, but this time in order to compare the results of different multidimensional approaches (fuzzy sets theory, axiomatic approach and information theory), D'Ambrosio *et alii* (2004) study the more disadvantaged quartile of the population of each measure. This procedure leads them to the conclusion that only 80 % of the households defined as poor by two multidimensional measures out of three are the same. Another option is to determine an arbitrary threshold on the index of deprivation independently of the income approach. This is the choice made by Nolan and Whelan (1996) when they determine that people lacking one item among the 8 that compose their base dimension of deprivation suffer from "generalised deprivation" or by Tsakloglou and Papadopoulos (2002) who set the threshold values for their index of deprivation in the domain of "living conditions" and "necessities of life" at 80% and 60% of the national median of the distribution of these indexes.

Section 2. The Receiver Operating Characteristics curve

The *Receiver Operating Characteristic* (ROC) analysis is a procedure stemming from the theory of signal detection that was introduced in the Second World War in order to manage to recognise radar and sonar signals affected by noise. This technique has then been transposed in many other fields such as performance evaluation of vision, weather forecasting, radiography in dental care, medical decision-making, etc. (Wodon, 1997). As pointed out by Baulch (2002), a ROC curve is a graphic and non-parametric way of portraying the ability of a diagnosis test to distinguish between a binary outcome. For instance, in order to detect the presence or absence of a disease, it is necessary to carry out a diagnosis test. To bear a conclusion on the basis of this test we then need to select a cut-off point. Values of the test above this threshold will be considered to reveal the presence of the disease and values below will show its absence (it can also be other way around). In this type of procedure, diagnosis errors are likely to happen, i.e. diagnosing the disease when it is actually absent or not detecting it when it is actually present. The ROC curve aims precisely at testing the accuracy of such a diagnosis test, i.e. its ability to correctly distinguish between people having or not the disease for all the possible cut-off points.[13] In this paper, I will use the same logic, the index of multidimensional poverty being used as the diagnosis test in order to detect "income poverty". As a consequence, the use of the ROC curve will allow assessing the extent to which the index of multidimensional poverty confirms or not the classification between income and non income poor obtained by a given poverty line, *independently of the threshold used on the deprivation scale*.[14]

To explain how it works, let's start by noticing that, given the partition between income poor and non income poor realised by an income poverty line, for every given deprivation threshold, say (Z), going from 0 to the maximum value of the multidimensional index, say (S_i), four populations can be identified (see table 1). The first one is the population of the "True Positives" (TP) who are the individuals whose status of poverty, determined by the income measure, is confirmed by the multidimensional measure to the given deprivation threshold Z. The second group is the population of the "True Negatives" (TN) constituted by the individuals who are not income poor and who are correctly identified as such by the index

[13] As a consequence, the ROC curve can also help in finding the best cut-off point.

[14] To my knowledge, the ROC methodology has been applied in the field of poverty only by Wodon (1997) and Baulch (2002). Wodon (1997) applies it on data from Bangladesh to compare the performance of targeting indicators to identify the poor. On the same line, Baulch (2002) use it to identify and assess the accuracy of poverty monitoring and targeting indicators on Vietnamese data.

of deprivation at the given deprivation threshold Z.[15] The two other populations are the "False Positives" (FP), who are the individuals classified as poor by the index of deprivation when they are not income poor, and the "False Negatives" (FN) who are the individuals identified as non poor by the index of deprivation but who are income poor.

Table 1: The overlap of the population for a given threshold of deprivation Z

	Deprived (index greater than Z)	Non deprived (index smaller than Z)	
Monetary poor	Consistent Poverty Fraction of True Positive (TP) (Sensibility)	Monetary Poverty Fraction of False Negative (FN)	TP + FN = 1[16]
Non monetary poor	Deprivation Fraction of False Positives (FP)	Consistent non poverty Fraction of False Negatives (TN) (Specificity)	FP + TN = 1

For given income and multidimensional threshold, there is an analogy between this table and the case of consistent poverty (Nolan and Whelan, 1996). It can be illustrated by the case of France in 1995. Details on the data and computations are given in section 3:

Table 2: Consistent poverty (en %) in France (poverty line: 60% of the median)

		pauvreté multidimensionnelle (Si)		
		P	NP	total
pauvreté monétaire	P	4.44	9.82	14.27
	NP	9.83	75.9	85.73
	total	14.27	75.9	100.00

Source: ECHP-UDB version December 2003, year 1995

The income poverty rate for a poverty threshold of 60 % of the median in 1995 corresponds to a value of 14.27%. By construction, we equalize the proportion of individuals in situation of multidimensional poverty. We then assess to what extent these two populations overlap. Only 4.44% of the total population is poor on the two measures. This is the rate of consistent poverty. Starting from these figures we can compute the fraction of TP (sensibility) and of TN (specificity)[17] :

[15] The terms of "sensibility" and "specificity" are used to qualify the populations of the TP and the TN. Sensibility (resp. specificity) refers to the fraction of positive cases (resp. negative) of income poverty that are correctly identified by the index of deprivation. Hence, sensibility (resp. specificity) is the probability that an individual, identified as income poor (resp. non income poor) by the multidimensional index is actually in this situation.

[16] We have to bear in mind that the fractions of TP and FN sum to 1. Income poor can be either True Positives (TP), i.e. correctly identified by the index of deprivation at the given threshold Z, either False Negatives (FN), i.e. misclassified as non poor by the index of deprivation. The same reasoning can be done with non income poor that can be either True Negatives (TN), i.e. correctly identified as non poor by the index of deprivation, either as False Positives (FP), i.e. wrongly identified as poor by the index of deprivation. Hence, fractions of True Negatives and of False Positives also sum to 1.

[17] Thanks to the formula TP+FN=1 and TN + FP=1.

Table 3: Sensibility and specificity in France at the threshold of 60% of the median

		pauvreté multidimensionnelle (Si)		
		P	NP	total
pauvreté monétaire	P	0.31	0.69	1.00
	NP	0.11	0.89	1.00

Source: ECHP-UDB version December 2003, year 1995

We can give the following interpretation: the proportion of income poor correctly identified by the multidimensional index, i.e. the sensibility, is of 31% (= 0,0444 / 0,1427). The proportion of non income poor correctly identified by the index of deprivation, i.e. the specificity, is of 89% (= 0,759 / 0,8573). This example could be used alone to give an answer to the question of the extent of the overlap of the two approaches. Following the example of Perry, the result would be that the overlap is of 31 %. However, this result is conditional to the validity of the income poverty threshold *and* of the multidimensional poverty one.

The methodology of the ROC curve allows overcoming this drawback, the case of consistent poverty being only one of the cases among all the possibilities. In order to verify the overlap of these two measures, the ROC curve plots the fraction of false positives (FP = 1 – TN) on the horizontal axis and the fraction of true positives (TP) on the vertical axis for all possible thresholds Z of the index of deprivation (see figure 1). For $Z = \max_{i \in I} s_i$, we are located at the origin. Indeed, if $Z = \max_{i \in I} s_i$, the scores of all individual i = 1..n are lower than the threshold Z; as a consequence, nobody is considered as deprived so that none of the income poor is correctly identified by the index of deprivation (TP = 0) and all the non income poor are correctly identified (TN = 1). When the ROC curve puts into relation the TP and the FP = 1 - TN, this case corresponds to the point (0, 0). If we lower the threshold Z, some individuals are now considered as deprived by the index of deprivation. If these individuals are actually income poor, the proportion of TP increases and the curve goes up. On the contrary, if they are non income poor, the proportion of TP doesn't change and the proportion of False Positives (FP = 1-TN) increases so that the ROC curve moves to the right. This algorithm is repeated until we reach the minimal value of the threshold Z = 0. At this specific threshold, the scores of all the individuals i=1..n are greater than Z and the whole population is considered as deprived. This implies that all the income poor are correctly identified (TP = 1), and, at the same time that all the non income poor are not correctly identified (FP = 1). Hence, we are located at the point of coordinates (1, 1).

Figure 1 shows an example of the ROC curve applied to the French part of the ECHP on the basis of an income poverty threshold of 60% of the median of the distribution of equivalent income and of a multidimensional index S_i (see below - equation 7).

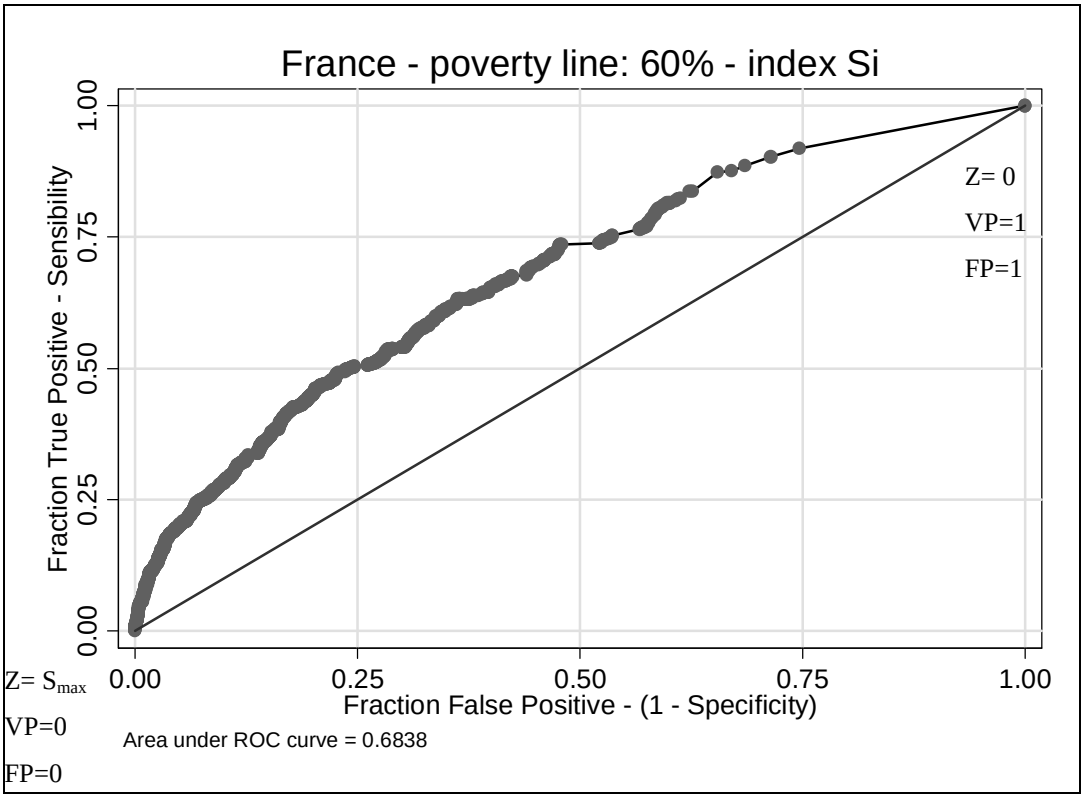

Figure 1: Curve of the *Receiver Operating Characteristic* for France
Source: ECHP-UDB version December 2003, year 1995, author's computation

On figure 1, the example taken from table 3 is represented by the point of coordinates (0,11 ; 0,31). The other points correspond to the couple of fraction (FP, TP) for all the possible threshold Z. Hence the ROC curve gives a more global picture of the overlap.

To assess the quality of this overlap, we then need to have a criterion of evaluation. This criterion is given by the comparison of the ROC curve with the diagonal line on the graph going from (0,0) in the lower left corner to (1,1) in the upper right corner. If the two curves are superimposed, it means that the index of deprivation is not a good "signal" of income poverty, i.e. it has no discriminating power. Indeed, in this case, when the threshold Z varies from its maximal to its minimal value, the probability to find a True Positive (to go up) or a False Positive (to go on the right) is the same. On the contrary, when the curve goes strongly up in the first place and then flattens, the overlap of the two populations is much higher. The decreasing of Z allows, in a first place, a correct identification of the TP, while for lower values of Z, where there are less and less TP and more and more FN, the curve flattens. In summary, the closer the curve is from the diagonal, the less efficient is the index of

deprivation to discriminate between the income poor and the non income poor. On the other hand, the closer the curve gets to the point (0,1), the better the overlap.

The global evaluation of the extent to which the index of deprivation corroborates the results from the income approach is then obtained by calculating the area under the ROC curve. This area corresponds to the probability that the index of deprivation of one individual in situation of income poverty, chosen randomly, is higher than the index of deprivation of an individual who is not in situation of income poverty, again chosen randomly. This area represents the capacity of the index of deprivation to correctly classify the individuals considered as poor by the criteria of income. The more its value is close to 0.5, the weaker is the association between the two values (case where the ROC curve is confounded with the diagonal). Indeed, in this case, the index of deprivation has one chance out of two to be higher for the income poor than for the non income poor. On the other hand, the closer the value of the area is to 1, the better the index of deprivation can be considered to confirm the results coming from income poverty. A value equal to 1 means that for two individuals randomly chosen, one income poor and the other non income poor, the index of deprivation of the income poor will always be higher than the index of deprivation of the non income poor. Finally, if its value is lower than 0.5, this means that the index of deprivation is not at all a good signal of income poverty; on the contrary, it tends to have a higher value for non income poor than for income poor.

The following reference values are sometimes retained: between 0,9 and 1 the association is excellent, between 0,8 and 0,9 it is good, between 0,7 and 0,8 it is medium; between 0,6 and 0,7 it is poor, and between 0,5 and 0,6 it is insufficient.[18]

Section 3. Empirical application to the European Community Household Panel

As already stated, the practical utility of the multidimensional approach of poverty, compared to the monetary approach can be shown comparing the results of these two approaches. If the results are the same, the practical utility is low; if they are different, one has to support the development of the multidimensional measure of poverty and to adopt differentiated strategies of poverty reduction according to the results of the different approaches. After having presented the database (i) and the income measure of poverty (ii), I will expand more on the construction of the multidimensional measure of poverty (iii) and then compare these two approaches by applying the ROC curve (iv).

[18] For more details, see the lecture of Thomas Tape - University of Nebraska – Medical Center on *Interpreting Diagnostic Test* (http://gim.unmc.edu/dxtests/Default.htm, last consultation - 7 April 2006).

(i) The ECHP

The empirical application has been carried out on the data of the ECHP, the first comparative database within the European Union. This survey has been carried for 8 years from 1994 to 2001 and has now been replaced by the EU-*Survey on Income and Living Conditions* (EU-SILC). The aim of the ECHP is to collect data on income and living conditions of the European households. As pointed out by Eurostat (1996: 7), the three main features of the ECHP are the use of standardised questionnaires and methodologies yielding comparable information across countries, the longitudinal or panel design in which information on the same set of households and persons is gathered to study changes over time at the micro level and the multidimensional coverage of a range of topics *simultaneously* such as housing amenities, possession of durable goods, social relations, health, education, etc.

This last property is important for our purpose, as the presence of information on different domains of life pertaining to the same individuals allows the computation of multidimensional measures of poverty and the study of cumulative disadvantage. In 1994, the first wave of the ECHP gathered information on around 60000 households and 130000 adults of more than 16 years old for 12 countries: Germany, Denmark, Netherlands, Belgium, Luxembourg, France, United-Kingdom, Ireland, Italy, Greece, Spain and Portugal. Three countries joined afterwards: Austria in 1995, Finland in 1996 and Sweden in 1997. It must also be said that three countries stopped the harmonised surveys in 1996 and used from 1997 on their existing national panels. These countries are Germany (GSOEP), Luxembourg (PSELL-2) and United-Kingdom (BHPS).

My analysis will be carried on the data of the second wave of the ECHP pertaining to the year 1995. The advantage of this year is that it presents a low level of attrition and the data relates to 13 countries. The unit of analysis will be the individual of more than 16 years old.

(ii) Income poverty

On the basis of the European definition of poverty, individuals or households are considered to be at risk of income poverty if the equivalent income of the household is lower than 60 % of the median of the distribution of equivalent income. The concept of income used is the one of annual net disposable equivalent income at the level of the household. One of the characteristics of the ECHP is that the net disposal income of wave t corresponds to the income of the year t-1. On the contrary, the other variables such as demographic characteristics of the households or the position on the labour market refer to the individual or the household at the moment of the survey. In order to have a correspondence between the household and individual characteristics and the period to which the income data relate, I

matched the information concerning the characteristics of the household at the year t, i.e. 1995, with the income of the year t + 1, i.e. 1996.[19] In order to take into account the differences in size and composition of the households, I used the modified OECD equivalence scale for which the first adult counts as 1 unit of consumption, other members of the household of more than 14 years old for 0.5 unit of consumption, and every children of less than 14 years for 0.3 unit of consumption. The equivalent income of one household was then distributed to all its members making a hypothesis of common standard of living between all the members of the household. The first and last percentile at the top and the bottom of the income distribution were eliminated in order to eliminate outliers.

Starting from the distribution of equivalent income and given the aforementioned poverty line, several indexes of poverty could be computed relative to the incidence, the intensity or the severity of poverty (Ravallion, 1992). For the purpose of this paper, I will only use the partition made by the poverty line. Individuals whose equivalent income is below the poverty line are assigned a value of 1; the others are assigned a value of 0. In the framework of the ROC methodology, this partition will be considered as the good one and I will verify to what extent it is confirmed by the multidimensional index.

(iii) Multidimensional poverty

The different steps leading to the computation of a multidimensional measure of poverty are the choice of the relevant dimensions/domains and the set of elementary indicators representing them, the evaluation of deprivation on each of these items and dimensions, the aggregation of the elementary indicators into a composite index for each dimension and, if considered relevant, the aggregation of the different dimensions into an overall index of deprivation (Chiappero Martinetti, 2000; Nolan et Whelan, 1996). These are the points we will briefly expose here.

(iii.1) the dimensions and elementary indicators

The dimensions or domains selected correspond for the main part to the dimensions and items used by Layte *et alii* (2001) or Eurostat (2002). When possible we used the same vocabulary as these authors. The different domains are "the inability to afford most basic requirements", "the inability to meet payment schedules", "the absence of basic housing facilities", "the problems with accommodation", "the problems of environment" and "the enforced lack of widely desired possessions". The choice was made naturally according to the

[19] This choice is also the one made by Tsakloglou and Papadopoulos (2002), who, in some cases, proceeded to a reconstruction of the household's income variable, or Van Kerm (2003) on the data from CHER.

modules of questions of the ECHP.[20] This set of dimensions can give a good picture of the concept of material deprivation (Townsend, 1979).

A list of 26 items has been selected in six dimensions (table 5):

Tableau 4: **List of items**

Inability to afford most basic requirements (basic needs):	
hf003	… keeping its home adequately warm
hf004	… paying for a week's annual holiday away from home
hf005	… replacing any worn-out furniture
hf006	… buying new, rather than second-hand, clothes
hf007	… eating meat, chicken or fish every second day, if wanted
hf008	… having friends or family for drink or meal at least once a month
Inability to meet payment schedules (arrears):	
hflog	… rent for the accommodation (hf009) or mortgage payments (hf010)
hf011	… utility bills, such as electricity, water, gas
hf012	… hire purchase instalments or other loan repayments
Absence of basic housing facilities:	
ha009	... a bath or shower
ha010	... an indoor flushing toilet
ha011	… hot running water
ha012	… heating or electric storage heaters
Problems with accommodation:	
ha014	… shortage of space
ha016	... too dark/not enough light
ha017	… lack of adequate heating facilities
ha018	… leaky roof
ha019	… damp walls, floors, foundations, etc.
ha020	… rot in window frames or floors
Problems with the environment:	
ha015	… noise from neighbours or outside
ha021	… pollution, grime or other environmental problems caused by traffic or industry
ha022	… crime or vandalism in the area
Enforced lack of widely desired possessions (durable goods):	
hb001	… a car or van (available for private use)
hb002	… a colour TV
hb003	… a video recorder
hb006	… a telephone

Source: ECHP-UDB version December 2003

[20] Another possible method to group the items in dimensions could have been the use of a statistical method such as factor analysis (see Schockkaert and van Ootegem, 1990 or Dekkers, 2003) or the Rasch model (Dickes, 1989). In this paper, I didn't make use of such method.

The first two dimensions are related to the financial conditions of the households. The first one concerns the "inability to afford most basic requirements (basic needs)". This dimension gathers six binary items. Households are asked whether they can afford keeping their home adequately warm, paying for a week's holiday away from home, replacing worn-out furniture, buying new rather than second-hand clothes, eating meat, chicken or fish every second day, if wanted and having friends or family for drink or meal at least once a month. These activities are considered as elementary and their absence is considered a priori as a disadvantage.

The second dimension concerns the "inability to meet payment schedules (arrears)". It gathers information on three binary elementary indicators related to financial arrears. Households are asked if, during the past twelve months, they were unable to pay scheduled rent for the accommodation or scheduled mortgage payments, scheduled utility bills such as water, gas or to pay hire purchase instalments or other loan repayment. Nevertheless, a non payment is not necessarily a sign of deprivation. For example, a well off individual will maybe answer positively to one of these questions simply because he forgot to pay one of his bills; an individual with expensive tastes will maybe be confronted to financial difficulties because of a high standard of living. In these precise cases, a positive answer to these questions can not be considered as a sign of deprivation. On the other side, if several financial arrears occur, i.e. when there is an accumulation of disadvantages, one can consider that a situation of deprivation is identified.

The third and fourth dimensions are both related to the housing conditions of the households. The third dimension deals with the "lack of basic housing facilities". Deprivation is assessed on the basis of four dichotomous items related to the presence in the dwelling of a bath or a shower, indoor flushing toilets, running hot water, heating or electric storage heaters. The hypothesis is that everybody would like to possess these items so that the lack of one of them is a sign of disadvantage. The fourth dimension refers to "problems with accommodation". It gathers six dichotomous items that informs us on the shortage of space and light of the accommodation, the lack of heating facilities, the presence of leaky roof, of damp walls, floors or foundations, and of rot in window frames or floors. These items stand for problems that everyone would like to avoid.

The fifth dimension pertains to the "problems in the environment". This form of deprivation is linked to the notion of poor areas (Townsend, 1979). A flat in a crowded town constitute an environment poorer than an identical flat placed in a neighbourhood with great parks. Poor areas are places where multiple forms of deprivation combine with a big numbers

of individuals living with a low income (Alcock, 1997). I measured the deprivation of the environmental dimension on the basis of three binary items concerning the existence of noise, pollution or crimes in the neighbourhood.

The sixth dimension gathers six dichotomous items concerning the "enforced lack of widely desired possessions (durable goods)". We place there the information on the possibility to buy a set of durable goods (a car, a colour television, a video recorder, a telephone).

Two remarks must be done concerning the items chosen to represent these dimensions. Firstly, all the variables have been distributed from the households to the individuals as the analysis is at the level of the individuals aged 16 or more. Again, the hypothesis is that households share a common standard of living and by so doing, the intra household allocation of resources is neglected and all individuals are treated the same way. Secondly, all the variables have been ranked so that a higher value describes a higher state of deprivation. In our case, all the items are dichotomous and the variables are coded 0 for the modality showing an absence of disadvantage and 1 for the modality denoting a disadvantage.

These 26 indicators spread in 6 domains/dimensions represent the basis on which we are going to establish our direct measure of poverty.[21] Observations presenting missing values have been omitted. The final database contains information on 108880 individuals of more than 16 years old distributed as follows:

Table 5: Number of observations per countries in 1995

Country	frequency*
Austria	6 316
Belgium	5 212
Denmark	4 513
France	11 297
Germany (ECHP)	7 973
Greece	10 659
Ireland	6 165
Italy	16 227
Luxembourg (ECHP)	1 795
Netherlands	8 119
Portugal	10 594
Spain	13 648
UK (ECHP)	6 362
Total	108 880

Source: ECHP-UDB version December 2003, computation from the author
*individuals of more than 16 years old

[21] It is important to note that before choosing these items, a set of criteria were applied in order to check the content validity of the items, i.e. their ability to be considered as items of deprivation (control by the frequency or by the consensus), and also the ability of the items belonging to the same dimension to measure the same thing (Cronbach alpha or tetrachoric correlation). See Pérez-Maio (2003) for an example of such procedure.

(iii.2) the aggregation by dimensions

In order to apply the ROC methodology, I computed aggregated indexes of multidimensional poverty on the basis of the 26 items and 6 dimensions aforementioned. For each country, the point of departure is the matrix of attributes X (n x m) containing the responses of the i=1..n individuals of the population to the j=1..26 indicators of living conditions belonging to q=1..6 dimensions. The procedure to follow consists in aggregating the items pertaining to the same dimension and then to aggregate the different dimension in an overall index of deprivation.

For each answer x_{ij} of individual i to item j, a note $\xi_j^D(i)$ representing the degree of deprivation of individual i for indicator j is given. In my case, as far as the 26 items are dichotomous, the degree can only take the value of 0 or 1, with 0 denoting an absence of disadvantage and 1 a deprivation.[22] For each individual of each country, a weighted score S_{iq} for each dimension q=1..6 can be computed:

$$S_{iq} = \sum_{j=1}^{m_q} w_j \xi_j^D(i) \qquad [1]$$

m_q represents the number of items belonging to dimension q, and w_j represents the weight of item j with $w_j \geq 0$ and $\sum_{j=1}^{m_q} w_j = 1$. These weights, in the comparative framework of the ECHP, correspond to the relative importance of items in every country. I chose to use the normalised structure of weights proposed by Cerioli and Zani (1990) or Cheli and Lemmi (1995):

$$\begin{cases} w_j = \dfrac{\ln\left(\dfrac{1}{\overline{\xi}_j^D}\right)}{\sum_{j=1}^{m_q} \ln\left(\dfrac{1}{\overline{\xi}_j^D}\right)} & \text{with} \quad \overline{\xi}_J^D > 0 \\ w_j = 0 & \text{if} \quad \overline{\xi}_j^D = 1 \quad \text{or} \quad \overline{\xi}_j^D = 0 \end{cases} \qquad [2]$$

where $\overline{\xi}_j^D$ is the proportion of persons presenting a disadvantage at the level of variable j. This weighting structure is an inverse function of the proportion of people deprived

[22] When all the items are not measured on the same measurement scale, the first step to join in is the normalisation of the items. The fuzzy sets approach is an example of how this can be done. For each item j, the degrees of deprivation are normalized and belong to the interval [0, 1]. A degree of deprivation of 0 stands for the total absence of disadvantage of individual i for item j, and a degree of 1 a total disadvantage of individual i for item j. A value between 0 and 1 shows a partial deprivation (Cerioli and Zani, 1990; Cheli and Lemmi, 1995; Chiappero Martinetti, 2000).

in the population. It can be justified by reference to a relative approach of poverty and more precisely by the subjective feeling of relative deprivation (Runciman, 1966).

Scores for each dimension belong to the interval [0, 1]. For the individual, a score of 0 indicates the absence of disadvantage on all items of the dimension; a score of 1, a disadvantage on all items of the dimension. If the individual presents some disadvantages, he will have a score between 0 and 1 in the considered dimension. Hence, the index corresponds to the mean degree of deprivation on all the items of the dimension (Guio, 2005).

For each country and dimension, the mean of individual scores of deprivation allows obtaining an evaluation of the deprivation at the national level. Table 6 displays the results by dimension and by country:

Table 6: Composite indexes by dimensions and countries

	Financial conditions		Housing conditions		environment	durable goods
Country	basic needs	arrears	facilities	problems		
Austria	0,11	0,02	0,05	0,08	0,11	0,03
Belgium	0,10	0,04	0,05	0,10	0,16	0,03
Denmark	0,05	0,02	0,01	0,05	0,10	0,03
France	0,11	0,04	0,03	0,10	0,20	0,03
Germany (ECHP)	0,08	0,02	0,03	0,06	0,15	0,03
Greece	0,41	0,09	0,13	0,16	0,14	0,11
Ireland	0,10	0,05	0,05	0,06	0,10	0,07
Italy	0,20	0,03	0,03	0,09	0,23	0,04
Luxembourg (ECHP)	0,05	0,01	0,03	0,07	0,14	0,01
Netherlands	0,06	0,01	0,02	0,07	0,18	0,02
Portugal	0,26	0,02	0,15	0,27	0,19	0,18
Spain	0,15	0,03	0,03	0,11	0,24	0,07
UK (ECHP)	0,12	0,06	0,01	0,11	0,22	0,03
weighted mean*	0,13	0,03	0,04	0,10	0,19	0,04

Source: ECHP-UDB version December 2003, computation from the author
*weighted by the population of more than 16 years old of the different countries
The grey cases (resp. yellow) stand for the less (resp. more) deprived countries in the dimension.
Interpretation: The mean degrees of deprivation for Luxembourg and Greece in the dimension "inability to afford most basic requirements (basic needs)" are of 0.05 and 0.41. Greece is the most deprived country in this domain whereas Luxembourg is the less deprived country.

The results presented in this table are estimates of the index of deprivation on the different dimensions computed from the sample.[23] Table 6 shows that Luxembourg is, in average, the less deprived nation in terms of possession of "durables goods" and "financial conditions", and Denmark is the less deprived country in terms of "housing conditions" and "environment". Greece is the most deprived country in terms of "financial conditions"

[23] They don't take into account the statistical uncertainty. The reason why I didn't compute the variance of the estimates is that the ECHP is a complex database for which there is no consensus on the methodology to use, analytic (asymptotic) approximation or re-sampling based methods, in order to do it. Hence, the interpretation of the results must be cautious, particularly for the subgroups of low frequency.

whereas Portugal is the worst country for the others dimensions except for the environmental dimension for which Spain is the last country.

In most of the cases, the indexes are low, showing a low degree of deprivation in these domains in Europe. Several explanations can be given to that. Firstly, this result can be considered to be the consequence of the high standard of living of the countries involved in the ECHP. Table 7 displays the frequencies of deprivation by dimensions showing this.

Table 7: Proportion of deprived people by dimensions

	Au	B	DK	F	GE	GR	Ir	It	L	NL	Po	Sp	UK	Weighted mean*
Inability to afford most basic requirements (basic needs):														
non deprived	51	65	74	54	71	18	54	31	84	79	16	26	59	51
deprived in 1 item	23	15	14	18	12	14	23	23	6	7	11	16	14	16
deprived in 2 items	12	9	8	14	8	14	10	18	5	5	13	20	12	13
deprived in 3 items	7	5	3	7	5	14	7	12	3	5	18	25	7	10
deprived in 4 items	5	3	1	4	3	15	4	7	1	3	24	9	4	6
deprived in 5 items	2	1	0	2	1	12	2	4	1	1	13	3	3	3
deprived in 6 items	0	2	0	1	0	14	0	4	1	0	4	1	1	2
Inability to meet payment schedules (arrears):														
non deprived	97	92	96	91	97	68	89	93	98	97	96	93	87	92
deprived in 1 item	2	4	3	6	2	25	7	5	1	2	4	5	7	5
deprived in 2 items or more	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Absence of basic housing facilities:														
non deprived	63	70	88	55	80	21	77	70	78	55	7	25	86	64
deprived in 1 item	25	22	10	36	14	41	17	22	16	41	54	53	13	26
deprived in 2 items	7	5	2	7	4	27	3	6	4	3	23	20	1	7
deprived in 3 items or more	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Problems with accommodation:														
non deprived	68	63	74	63	76	44	75	64	74	69	35	49	56	61
deprived in 1 item	20	21	19	20	16	27	15	20	18	21	21	29	26	21
deprived in 2 items	7	10	5	9	5	14	5	8	5	7	14	14	10	10
deprived in 3 items	3	4	2	5	2	7	2	4	2	3	12	5	6	5
deprived in 4 items	1	2	0	2	1	5	1	2	1	1	8	3	2	2
deprived in 5 items or more	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Problems with the environment:														
non deprived	73	64	78	59	64	69	78	58	70	58	62	54	53	60
deprived in 1 item	20	25	17	25	23	20	16	21	19	31	23	24	29	24
deprived in 2 items	6	8	5	12	11	9	5	15	8	10	12	15	15	12
deprived in 3 items	1	2	1	4	2	2	1	7	2	2	3	7	4	4
Enforced lack of widely desired possessions (durable goods):**														
non deprived	90	92	86	88	89	61	76	84	94	92	55	75	90	85
deprived in 1 item	8	6	12	10	10	26	17	13	5	6	22	17	8	11
deprived in 2 items	1	2	1	2	1	10	6	2	1	1	14	6	2	3
deprived in 3 items or more	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: ECHP-UDB version December 2003, computation from the author

*weighted by the population of more than 16 years old of the different countries

** in the case of durable goods, people are considered as non deprived if they own the goods or if they don't own it for other reasons than a lack of financial means.

In most of the dimensions, the proportion of non-deprived individuals is really high. This is the case for the dimensions "financial arrears" and "durable goods" for which, in mean at the European level, 92% and 85% of the individuals of more than 16 years old don't show any deprivation. In the others dimensions, more than 80% of the individuals present, at most,

one deprivation in one item: this is the case of the dimensions "equipments of the housing" (90%), "inconvenient of the housing" (82%), and "problems in the environment" (84%).

Another reason to the low indexes of deprivation is more technical and is related to the weighting system. The attribution of higher (lower) weights to the items the most (less) widespread "take" the weighted mean on the low direction.

Results of table 6 could let us conclude that, for example, deprivation in the domain of environment (0.19) is higher, in Europe, than the one linked to the absence of basic housing facilities (0.04). This conclusion looses some of its relevance as soon as one realise that the differences of results can also be due to the method of construction of the indexes.[24] The indexes of deprivation can be used to compare the situation of different countries or, at a disaggregated level, of different subgroups of the population. Hence, as pointed out by Brandolini and D'Alessio (1998), more than the absolute values of these indexes, what is important is the relative performance between countries and groups. The decomposition of these indexes of poverty is out of the scope of this paper.

(iii.3) the overall score of deprivation

The next step consists in aggregating the score on each dimension into an overall score of poverty. Several methods making use of different operator of aggregation exist in order to do so, e.g. fuzzy sets approach, axiomatic approach, theory of information or efficiency theory (Deutsch and Silber, 2005). In this paper I computed three indexes of multidimensional poverty. Firstly, I computed two axiomatic indexes of poverty proposed by Chakravarty *et alii* (1998). These indexes have the particularity to respect a precise axiomatic that can be defined as a set of desirable properties that a multidimensional index of poverty should respect.[25] For i=1..n individuals and j=1..m items, the first index is an extension of the subgroup decomposable index proposed by Chakravarty (1983) and can be written:

$$P_e(X;z) = \left(\frac{1}{n}\right)\sum_{j=1}^{m}\sum_{i\in D_j} a_j\left[1-\left(\frac{x_{ij}}{z_j}\right)^e\right] \qquad [3]$$

[24] Moreover, as the case is made by Alkire (2002), dimensions could also, by definition, be considered as non commensurable, non hierarchical, irreducible to a common denominator and non compensatory: a deprivation in terms of environment can not be compensated by advantages in terms of housing. Adopting this position imply not to make any comparisons between the dimensions.

[25] The 13 axioms defined by Chakravarty *et alii* (1998) are related to properties of "symmetry", "focus", "monotonicity", "principle of population", "continuity", "non-poverty growth", "non-decreasingness in subsistence levels of basic needs", "scale invariance", "normalisation", "subgroup decomposability", "factor decomposability", "transfer axiom" and "non decreasing poverty under correlation increasing arrangement". For further discussion of these axioms, refer to Bourguignon and Chakravarty (2003) or Deutsch and Silber (2005).

For a given matrix of attributes X, x_{ij} is the quantity of attribute j possessed by individual i and z_j is the threshold of deprivation on item j; a_j is the weight of attribute j with $a_j>0$ and $\sum_{j=1}^{m} a_j = 1$; D_j is the set of deprived people in j (i.e. $x_{ij}<z_j$) and e is a parameter reflecting the different perceptions of poverty; if e increases (tends to 0), P_e increases (tends to 0) as well.

Another alternative is to use a generalisation of the family of decomposable indexes proposed by Foster, Greer and Thorbecke (1984):

$$P_\alpha(X;z) = \left(\frac{1}{n}\right)\sum_{j=1}^{m}\sum_{i\in D_j} a_j\left[1-\left(\frac{x_{ij}}{z_j}\right)\right]^\alpha \qquad [4]$$

For α=1 and e=1, the two indexes are identical and correspond to a weighted sum of the poverty gap on each item.

Chakravarty *et alii* (1998) applied the indexes P_e and P_α to a survey done in 1995 on the satisfaction of basic needs of five districts in the West Bengal (India). The survey is on 2598 households and contains information on 17 indicators of poverty. These indicators are mainly qualitative and related to health care, housing, etc. Three quantitative indicators are used: (i) the number of saris per adult women, (ii) the height of the ceiling, (iii) and the number of month of the previous year for which the members of the household have had two meals per day. They then determine three absolute threshold of poverty and identify 603 households in situation of poverty on the basis of this information. The application of indexes P_e and P_α enable them to establish poverty profile per region and per attributes. The reason why the authors didn't use the qualitative items at their disposal is that they were dichotomous (Bourguignon and Chakravarty, 2003).

However, by so doing, and as soon as one notices that the information pertaining to the living conditions of individuals is often qualitative, one restrains the informational basis he is able to use. To overcome this difficulty, we can start from the structure in dimensions previously presented. Indeed, weighted scores by dimension (S_{iq}) constitute a valuable quantitative information to which one can apply the indexes of Chakravarty *et alii* (1998)[26]. The formulas (3) and (4) can then be written:

$$P_e(X;z) = \left(\frac{1}{n}\right)\sum_{q=1}^{k}\sum_{i\in D_q} a_q\left[1-\left(\frac{x_{iq}}{z_q}\right)^e\right] \qquad [5]$$

[26] Brandolini and D'Alessio (1998) or Lachaud (1999, 2000, 2004) use the same option.

q = 1..k is the number of dimensions, z_q is the threshold of deprivation on dimension q and x_{iq} is the score of each individual i on dimension q. In the formulation of Chakravarty *et alii* (1998), variables are ranked in decreasing order of deprivation, the higher values being associated to the lower level of deprivation. Indexes S_{iq} are ranked the other way around. Hence, I used the following transformation : $x_{iq} = 1 - S_{iq}$. Equation (5) corresponds to an index of poverty aggregated to the level of the population. At the level of the individual, the multidimensional poverty index is $P_{e,i}(X;z) = \sum_{q=1}^{k} a_q \left[1 - \left(\frac{x_{iq}}{z_q} \right)^e \right]$

Identically, the multidimensional extension of the FGT index is now written :

$$P_\alpha(X;z) = \left(\frac{1}{n}\right) \sum_{q=1}^{k} \sum_{i \in D_q} a_q \left[1 - \left(\frac{x_{iq}}{z_q} \right) \right]^\alpha \qquad [6]$$

The notations are here the same and the individual poverty index can be written $P_{\alpha,i}(X;z) = \sum_{q=1}^{k} a_q \left[1 - \left(\frac{x_{iq}}{z_q} \right) \right]^\alpha$

Finally, I compute also for each individual a composite index, S_i, simple mean of the scores S_{iq} on each dimension:

$$S_i = \frac{1}{q} \sum_{q=1}^{k} S_{iq} \qquad [7]$$

Starting from the six dimensions previously determined, I give to each of them an equal weight $a_q = 1/q = 1/6$. Moreover, following D'Ambrosio *et alii* (2004), I adopted relative thresholds $z=(z_1,.., z_6)$ equal to half of the mean of the distribution of each index x_{iq}.

The results by countries for P_α ($\alpha = 2$), P_e ($e = 0.5$) and S_i are presented in table 8:

Table 8: Indexes of multidimensional poverty

Pays	Pα (α=2)	Pe (e=0,5)	Si
Autriche	0.69%	0.81%	0.065
Belgique	1.40%	1.57%	0.080
Danemark	0.39%	0.47%	0.043
France	1.23%	1.41%	0.086
Allemagne	0.64%	0.72%	0.060
Grèce	3.94%	4.18%	0.171
Irlande	1.08%	1.24%	0.073
Italie	2.30%	2.48%	0.104
Luxembourg	0.84%	0.96%	0.051
Pays-Bas	0.53%	0.64%	0.062
Portugal	4.62%	4.91%	0.177
Espagne	1.55%	1.70%	0.105
Royaume-Uni	1.27%	1.46%	0.092
moyenne pondérée*	1.43%	1.59%	0.089

Source: ECHP-UDB version December 2003, computation from the author
*weighted by the population of more than 16 years old of the different countries

At the national level, these results correspond to those obtained through the analysis by dimensions and the rankings obtained with S_i or the two axiomatic indexes are almost identical. The less deprived countries are Denmark and Luxembourg whereas the countries of Southern Europe, mainly Portugal and Greece, display the higher indexes. These two countries as well as Spain, Italy and United-Kingdom present mean indexes of deprivation higher than the weighted mean at a European level.

(iv) Application of the method of the ROC curve

I will now use the individual indexes S_i, $P_{e,i}$ and $P_{\alpha,i}$ to determine to what extent they confirm the results of the monetary approach. In order to do so I applied the method of the ROC curve, presented in section 2, to these indexes.

Table 9: Area under the ROC curve for a threshold of 60% of the median

Pays	Pα (α=2)	Pe (e=0,5)	Si
Autriche	0.5616	0.5617	0.6502
Belgique	0.5853	0.5854	0.6555
Danemark	0.5420	0.5420	0.5678
France	0.5836	0.5841	0.6838
Allemagne	0.5687	0.5687	0.6548
Grèce	0.6547	0.6552	0.7071
Irlande	0.5747	0.5748	0.6810
Italie	0.6073	0.6074	0.7033
Luxembourg	0.6335	0.6334	0.7380
Pays-Bas	0.5651	0.5652	0.6829
Portugal	0.6503	0.6512	0.7077
Espagne	0.5456	0.5457	0.6508
Royaume-Uni	0.5749	0.5752	0.6697
moyenne pondérée*	0.5806	0.5808	0.6725

Source: ECHP-UDB version December 2003, computation from the author

According to the reference values mentioned in section 2, the results are medium for the two axiomatic indexes P_α and P_e and slightly better for S_i. Greece displays the higher values for the overlap with the axiomatic indexes P_α (0,65) and P_e (0,66) whereas Denmark displays the lowest (0,54 and 0,54). For the index S_i, the values are higher and vary between 0,57 in Denmark and 0,74 in Luxembourg. This means that on the basis of my computations of the indexes S_i for the twelve countries under study, when I randomly withdraw a income poor and a non income poor, the probability for the index of deprivation S_i to be higher for the income poor than for the non income poor varies between 0.57 in Denmark and 0.74 in Luxembourg. This figure is a medium value. Hence my results show a low overlap between the populations identified as poor on the basis of a threshold of income poverty of 60% of the median of equivalent incomes and the indexes of multidimensional poverty. The link between these indexes exists, this is particularly true for S_i, but it is not high enough to assimilate both measures.

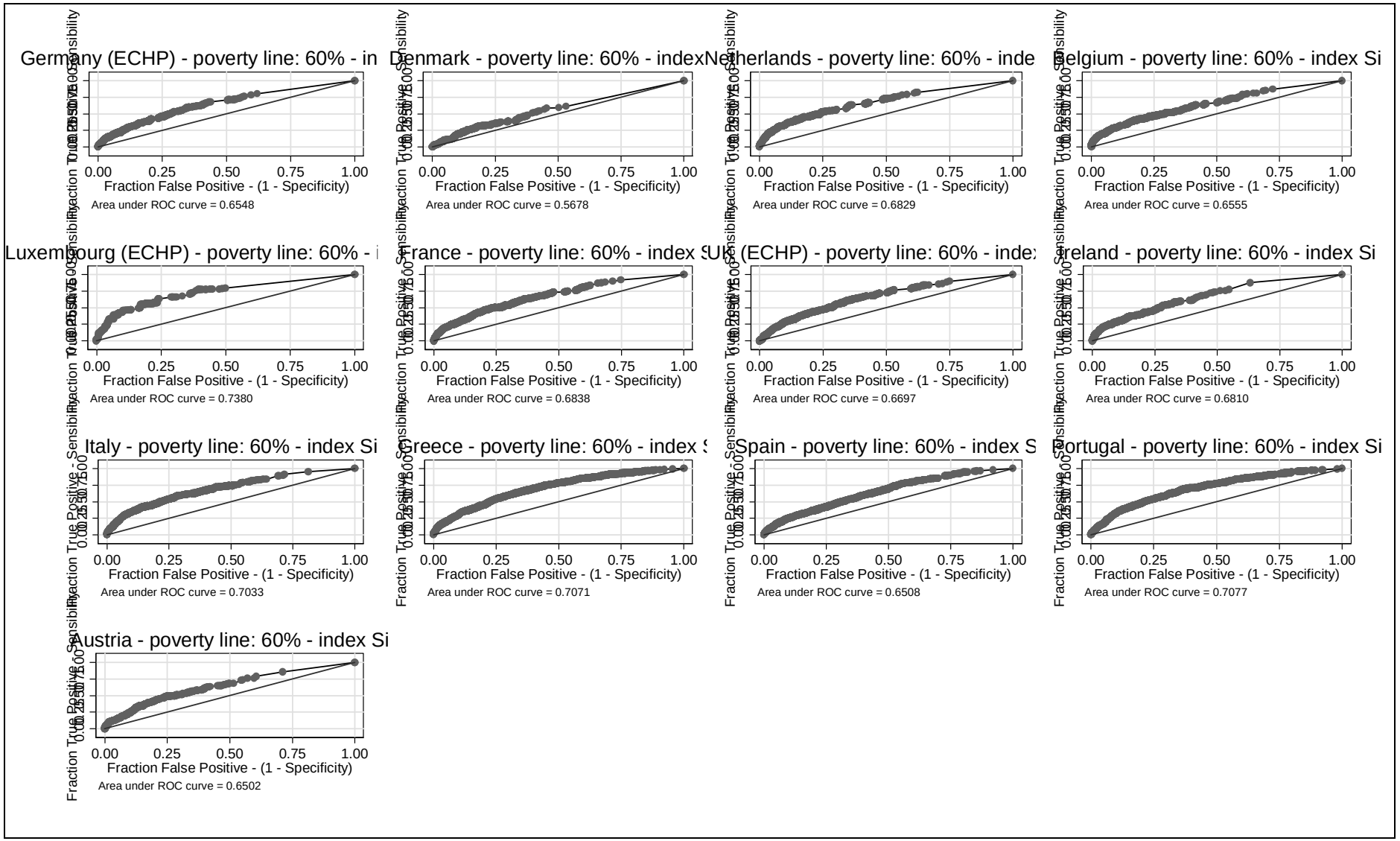

Figure 2: ROC curves by country (income poverty line 60% of the median and composite index S_i)

Figure 2 shows the ROC curves corresponding to table 9 for the 13 countries under study. This result corresponds to the one found by Layte *et alii* (2001) on the data of the ECHP and, as mentioned in the introduction, is in line with the conclusions of Dickes (1989), Whelan *et alii* (2004) or Perry (2002) who stated that there is a *mismatch* between income poverty and multidimensional poverty.

This method allows verifying the relation between the index of deprivation and *the partition of the population monetary poor according to the threshold of 60% of the median of the distribution of equivalent incomes*. The implicit hypothesis underlying this procedure is that the poverty line of 60% of the median is adequate. However, the limits of the use of a unique poverty line are widely known. To give further evidence to the conclusion, I applied the same procedure to the income poverty thresholds of 50 % and 70 % of the median:

Table 10: Area under the ROC curve for thresholds of 50 and 70% of the median

	seuil 50%			seuil 70%		
Pays	Pα (α=2)	Pe (e=0,5)	Si	Pα (α=2)	Pe (e=0,5)	Si
Autriche	0.5623	0.5622	0.6555	0.5582	0.5583	0.6299
Belgique	0.5962	0.5963	0.6595	0.5713	0.5714	0.6591
Danemark	0.5497	0.5498	0.6148	0.5316	0.5317	0.5850
France	0.6053	0.6062	0.7067	0.5750	0.5755	0.6771
Allemagne	0.5907	0.5907	0.6660	0.5590	0.5590	0.6514
Grèce	0.6640	0.6646	0.7140	0.6432	0.6437	0.7033
Irlande	0.5688	0.5688	0.6509	0.5773	0.5775	0.6889
Italie	0.6163	0.6164	0.7185	0.5921	0.5922	0.6918
Luxembourg	0.5999	0.5998	0.7045	0.5795	0.5794	0.6647
Pays-Bas	0.5606	0.5607	0.6744	0.5516	0.5516	0.6789
Portugal	0.6630	0.6638	0.7154	0.6381	0.6391	0.7015
Espagne	0.5614	0.5615	0.6646	0.5343	0.5344	0.6416
Royaume-Uni	0.5775	0.5775	0.6628	0.5771	0.5773	0.6752

Source: ECHP-UDB version December 2003, computation from the author

For these two others income poverty threshold, the results are of the same nature than for the threshold of 60 %. The conclusions are then confirmed. To the threshold of 50%, the probability that the index of deprivation S_i is a good signal of monetary poverty is not higher than 0.72 (Italy, Portugal and Greece), whereas at the income poverty line of 70 %, it is equal to 0.70 (Greece and Portugal). This leads to the conclusion that if there is an overlap, it is not strong enough to assimilate the two phenomena. Hence, we can conclude that, on the basis of my empirical study, *income and multidimensional poverty are not substitutable*.

Several reasons can explain this mismatch. At a practical level, measurement errors of income and deprivation certainly play a role (Whelan and Maître, 2005). Indeed, there are reasons not to be fully confident that income is well measured in a household survey (see Atkinson *et alii*, 2002). Indeed, intentional or non intentional mis-reporting, difficulties to

assess income from home production, from self-employment or capital are all reasons that affect the reliability of the measurement of income and specially of low incomes. Similarly, for the multidimensional approach, measurement errors related to the latent character of the phenomenon can also have an impact on the result.

Beside these practical reasons, and as briefly stated in the introduction, several reasons can be added to explain that the resources don't automatically translate into result (Sen, 1985; Layte *et alii*, 2001). As for Perry (2002:105), "the link between current income and actual living conditions is therefore not straightforward as there are many factors other than current income that significantly affect consumption and therefore current material well-being".[27] For example, the differences in terms of needs or in terms of preference, linked to the personal characteristics of the individuals, can influence the relation between income and standard of living, when the non income poor individuals don't allocate their resources to their basic needs. Finally, this low overlap can equally be explained at a conceptual level. Indeed the possibility that income and multidimensional poverty be two distinct phenomena or two different dimensions of the same phenomenon is another possible explanation that cannot be ignored (Nolan and Whelan, 1996: 3 or Perry, 2002). As pointed out by Sen (1979: 291), "both concepts are of some interest on their own in diagnosing poverty in a community [..]" and in the end, the question at stake is what do we mean by poverty.

As pointed out by Perry (2002: 122), this result constitute an encouragement for further developing the analytical and conceptual instrument of poverty, that is, to improve the identification of poverty and to understand the processes leading to poverty. In this framework, one can think that income poverty and multidimensional approach should be used in a complementary rather than in a substitutable way for the treatment of the phenomenon of poverty (Lachaud 1999). Hence, this conclusion also calls for the use of several measures of poverty in order to better grasp the complexity of the phenomenon of poverty (Perry, 2002; Bradshaw and finch, 2003).

Conclusion

The aim of this paper was to introduce an original method, the Receiver Operating Characteristic curve, to study the overlap of income and multidimensional poverty, independently of the deprivation threshold used. The results obtained through my application to the ECHP give further evidence to the main conclusion found in the literature stating that

[27] See the figure proposed by Perry (2002: 106) on the reason why a same current income can lead to different actual living conditions.

this overlap is low. Indeed, if we randomly select a income poor and a non income poor, the probability that the income poor has a higher index of deprivation S_i lies between 0.58 in Denmark and 0.74 in Luxembourg. According to the reference values of the area of the ROC curve, this result corresponds to a medium overlap. The use of others multidimensional indexes as well as of different income poverty thresholds (50 % and 70 %) gives even lower values. Hence, one can conclude that the multidimensional indicator is correlated with the income measure, but not enough to consider that the approaches based on resources and on living conditions are equivalents, neither to say that one could be used as a proxy of the other. This result is really important as far as one realises that the fact that income and multidimensional poverty are not confounded implies that these two definitions are related to two different phenomena or to two dimensions of one phenomenon. This leads to the conclusion that if there is an overlap, it is not strong enough to assimilate the two phenomena. Hence, we can conclude that, on the basis of my empirical study, income and multidimensional approaches can be said to be complementary in the explanation of the concept of poverty.

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