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# Multidimensional Approaches to Poverty Measurement: An Empirical Analysis of Poverty in Belgium, France, Germany, Italy and Spain, based on the European Panel

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## Abstract

This paper has three goals. First, we wish to compare three multidimensional approaches to poverty and check to what extent they identify the same households as poor. Second, we aim at better understanding the determinants of poverty by estimating Logit regressions with five categories of explanatory variables: size of the household, age of the head of the household, her gender, marital status and status at work. Third, we introduce a decomposition procedure proposed recently in the literature, the so-called Shapley decomposition, in order to determine the exact marginal impact of each of the categories of explanatory variables. Our empirical analysis is based on data made available by the European Community Household Panel (ECHP). We used its third wave and selected five countries: Belgium, France, Germany, Italy and Spain.

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**Keywords:** Multidimensional Poverty, ECHP.

# 1 Introduction

Recent years have witnessed an enlargement of the attributes analyzed in the studies of poverty in OECD countries and particularly so in the EU member-states. Poverty is interpreted not only as lack of income, but more generally as deprivation in various life domains. These include financial difficulties, basic needs, housing conditions, durables, health, social contacts, participation, and life satisfaction.

On the one hand, more detailed information on households has become available thanks to new datasets that allow adopting a wider concept of human well-being. On the other hand, social policy gained a key role in the EU political debate, and since the European Council of Lisbon (March 2000), it was placed at the center of the EU strategy to become “the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with better jobs and greater social cohesion”. To monitor social cohesion, multidimensional aspects of well-being were necessary. It was then acknowledged that “the number of people living below the poverty line and in social exclusion in the Union is unacceptable”.

Various official reports were produced to extend the analysis of monetary poverty into a dynamic framework and to examine the interaction with non-monetary aspects of deprivation (Eurostat, 2000 and 2002). The present paper goes also in that direction. Its aim is a systematic examination of various multidimensional approaches to poverty measurement on the basis of the same data set by answering the following questions:

1. To what extent are the same households identified as poor by the various approaches?
2. Are there differences between the approaches in the determinants of household poverty?
3. Which explanatory variables have the greatest *marginal impact* as determinants of poverty.

We first review (Section 2) very succinctly the relevant theoretical literature on multidimensional poverty, describing three multidimensional approaches to poverty measurement: the “Fuzzy” approach, an approach derived from Information Theory and the more recent axiomatic approaches to poverty measurement.<sup>1</sup> Then we give (Section 3) the informational basis of our analysis (the variables that were selected). In Section 4 we check

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<sup>1</sup>More details are given in Deutsch and Silber (2005) who, in this paper, used also the so-called efficiency analysis approach.

to what extent the different approaches identify the same households as poor while in Section 5 we analyze, on the basis of Logit regressions, the determinants of poverty. Finally, using the so-called Shapley decomposition procedure, we attempt to determine the *marginal* impact on poverty of the various categories of explanatory variables that were introduced in the Logit regressions (Section 6). Concluding comments are given at the end.

## 2 Theoretical Background

### 2.1 The “Fuzzy Set” Approach

The general idea is that in some cases an individual is in such a state of deprivation that she certainly should be considered as poor while in others her level of welfare is such that she certainly should not be classified as poor. There are however also instances where it is not clear whether a given person is poor or not. This is especially true when one takes a multidimensional approach to poverty measurement, because according to some criteria one would certainly define her as poor whereas according to others one should not regard her as poor. Such a fuzzy approach to the study of poverty has taken various forms in the literature. We concentrate here on the so-called TFR (Totally Fuzzy and Relative) Approach originally proposed by Cheli et al. (1994) and Cheli and Lemmi (1995). This TFR approach has the double advantage of not requiring defining threshold values and of taking a relative approach to poverty, the one which is taken in most developed countries.

$\mathbb{R}_+$  is the set of all non-negative real numbers. Let  $\xi_j \in \mathbb{R}_+^n$  be the set of polytomous variables  $\xi_{1j}, \dots, \xi_{nj}$  which measure the state of deprivation of the various  $n$  individuals with respect to indicator  $j$  and let  $F_j$  be the cumulative distribution of this variable. Let  $\xi_{j(m)}$  with  $m = 1, \dots, s$  refer to the various values, ordered by increasing risk of poverty, which the variable  $\xi_j$  may take. Thus  $\xi_{j(1)}$  represents the lowest risk of poverty and  $\xi_{j(s)}$  the highest risk of poverty associated with the deprivation indicator  $j$ . The authors propose then to define the degree of poverty of individual (household)  $i$  as

$$\mu_{\Xi_j}(i) = 0 \text{ if } \xi_{ij} = \xi_{j(1)},$$

and

$$\mu_{\Xi_j}(i) = \mu_{\Xi_j}(\xi_{j(m-1)}) + \frac{F_j(\xi_{j(m)}) - F_j(\xi_{j(m-1)})}{1 - F_j(\xi_{j(1)})} \text{ if } \xi_{ij} = \xi_{j(m)}, m > 1. \quad (1)$$

To aggregate the various deprivation indicators it is necessary to select weights. Let  $w_j$  represent the weight one wishes to give to indicator  $j$ . The overall (over all indicators  $j$ ) membership function  $\mu_P(i)$  for individual  $i$  is then defined as

$$\mu_P(i) = \sum_{j=1}^k w_j \mu_{\Xi_j}(i), \quad (2)$$

where

$$w_j = \frac{\ln\left(\frac{1}{\mu b_{\Xi_j}}\right)}{\sum_{j=1}^k \ln\left(\frac{1}{\mu b_{\Xi_j}}\right)} = \frac{\ln(\mu b_{\Xi_j})}{\sum_{j=1}^k \ln(\mu b_{\Xi_j})}, \quad (3)$$

where  $\mu b_{\Xi_j} = (1/n) \sum_{i=1}^n \mu_{\Xi_j}(i)$  represents the fuzzy proportion of poor individuals (households) according to the deprivation indicator  $\xi_j$ . One may observe that the weight  $w_j$  is an inverse function of the average degree of deprivation in the population according to the deprivation indicator  $\xi_j$ . Thus the lower the frequency of poverty according to a given deprivation indicator, the greater the weight this indicator will receive. The idea, for example, is that if owning a TV is much more common than owning a car, a greater weight should be given to the former indicator so that if an individual does not own a TV, this rare occurrence will be taken much more into account in computing the overall degree of poverty than if some individual does not own a car, a case which is assumed to be more frequent.

Having computed for each individual  $i$  the value of her membership function  $\mu_{\Xi_j}(i)$ , that is, her “degree of belonging to the set of poor”, the Totally Fuzzy and Relative Approach, following in fact Cerioli and Zani (1990), defines the average value  $P$  of the membership function as

$$P = \frac{1}{n} \sum_{i=1}^n \mu_P(i). \quad (4)$$

## 2.2 The Information Theory Approach

Assume  $n$  welfare indicators have been selected, whether they be of a quantitative or qualitative nature. Call  $x_{ij}$  the value taken by indicator  $j$  for individual (or household)  $i$ , with  $i = 1, \dots, n$  and  $j = 1, \dots, m$ . The various elements  $x_{ij}$  may be represented by a  $n \times m$  matrix  $X = (x_{ij})_{i \in \{1, \dots, n\}, j \in \{1, \dots, m\}}$  where the  $i^{th}$  row will give the welfare level of individual  $i$  according to the various  $m$  indicators, while the  $j^{th}$  column the distribution among the  $n$  individuals of the welfare level corresponding to indicator  $j$ .

Following Maasoumi (1986) the idea is to replace the  $m$  pieces of information on the values of the different indicators for the various individuals by a composite index  $x_c$  which will be a vector of  $n$  components, one for each individual. In other words the vector  $(x_{i1}, \dots, x_{im})$  corresponding to individual  $i$  will be replaced by the scalar  $x_{ci}$ . This scalar may be considered either as representing the utility that individual  $i$  derives from the various indicators or as an estimate of the welfare of individual  $i$ , as an external social evaluator sees it.

The question then is to select an “aggregation function” that would allow to derive such a composite welfare indicator  $x_{ci}$ . Maasoumi (1986) suggested finding a vector  $x_c$  that would be closest to the various  $m$  vectors  $x_{ij}$  giving the welfare level the various individuals derive from these  $m$  indicators. To define such a “proximity” Maasoumi proposed a multivariate generalization of the generalized entropy index  $D_\gamma$  that is expressed as

$$D_\gamma(x_c, X; \alpha) = \frac{1}{\gamma(\gamma + 1)} \sum_{j=1}^m \alpha_j \sum_{i=1}^n x_{ci} \left[ \left( \frac{x_{ci}}{x_{ij}} \right)^\gamma - 1 \right], \quad (5)$$

with  $\gamma \neq 0, -1$ , and where  $\alpha_j$  represents the weight to be given to indicator  $j$ .

The minimization of the “proximity” defines a composite index  $x_{ci}$  as

$$x_{ci} \propto \left[ \sum_{j=1}^m \delta_j (x_{ij})^{-\gamma} \right]^{-\frac{1}{\gamma}}. \quad (6)$$

In the specific case, when  $\gamma \rightarrow 0$ , one gets

$$x_{ci} \propto \prod_{j=1}^m (x_{ij})^{\delta_j}, \quad (7)$$

while in the case where  $\gamma \rightarrow -1$ , one obtains

$$x_{ci} \propto \left[ \sum_{j=1}^m \delta_j (x_{ij}) \right]. \quad (8)$$

In expressions (6) to (8)  $\delta_j$  is defined as the normalized weight of indicator  $j$ , that is  $\delta_j = \frac{\alpha_j}{\sum_{j=1}^m \alpha_j}$ .

Thus it turns out that the composite indicator  $x_c$  is a weighted (harmonic, geometric or arithmetic) mean of the different indicators.

Although Information Theory has been applied several times to the analysis of multi-dimensional inequality (see, the survey by Maasoumi, 1999), it seems to have been used only rarely in the study of multidimensional poverty (see, however, Miceli, 1997, and



Deutsch and Silber, 2005). Miceli has suggested deriving the measurement of multidimensional poverty from the distribution of the composite index  $x_c$  whose definition is given in expressions (6) to (8). Such a choice implies evidently that a decision has to be made concerning the selection of the weights  $\delta_j$  to be given to the various indicators  $x_{ij}$  (the subindex  $i$  referring to the individual while the subindex  $j$  denotes the indicator) as well as to the parameter  $\gamma$ . We decided to give an equal weight ( $\frac{1}{m}$ ) to all the indicators  $j$  (where  $m$  refers to the total number of indicators) and we assumed that the parameter  $\gamma$  was equal to  $-1$  (the case of an arithmetic mean).

Once the composite indicator  $x_c$  is defined, one still has to define a procedure to identify the poor. Here again we will follow Miceli (1997) and adopt the so-called “relative approach” which is commonly used in the uni-dimensional analysis of poverty. In other words we will define the “poverty line” as being equal to some percentage of the median value of the composite indicator  $x_c$ . More precisely we have chosen as cutting points a “poverty line” assumed to be equal to 70% the median value of the distribution of the composite index  $x_c$ . In other words any household  $i$  for which the composite index  $x_{ci}$  will be smaller than the “poverty line” will be identified as poor.

### 2.3 The Axiomatic Approach

Very few studies have attempted to derive axiomatically multidimensional indices of poverty (see, however, Chakravarty, Mukherjee and Ranade, 1998, and Tsui, 2002). The basic idea of both studies is as follows. Both studies view a multidimensional index of poverty as an aggregation of shortfalls of all the individuals where the shortfall with respect to a given need reflects the fact that the individual does not have even the minimum level of the basic need. Let  $z = (z_1, \dots, z_k) \in \mathbb{R}_+^k$  be the  $k$ -vector of the minimum levels of the  $k$  basic needs and  $x^i = (x_{i1}, \dots, x_{ik}) \in \mathbb{R}_+^k$  the vector of the  $k$  basic needs of the  $i^{\text{th}}$  person. Let  $X$  be the  $n \times k$  matrix of the quantities  $x_{ij}$  which denote the amount of the  $j^{\text{th}}$  attribute accruing to individual  $i$ .

Chakravarty et al. (1998) defined then a certain number of desirable properties that a multidimensional poverty measure should have, on the basis of which they derived axiomatically two families of multidimensional poverty indices.

The first family of indices may be expressed as

$$P(X; z) = \frac{1}{n} \sum_{j=1}^k \sum_{i \in S_j} a_j \left[ 1 - \left( \frac{x_{ij}}{z_j} \right)^e \right], \quad (9)$$

where  $S_j$  is the set of poor people with respect to attribute  $j$  and  $a_j > 0$  is the weight

attached to attribute  $j$ , such that  $\sum_{j=1}^k a_j = 1$ . The parameter  $e$ ,  $0 \leq e \leq 1$ , reflects different perception of poverty. This index is a multidimensional extension of the subgroup decomposable index suggested by Chakravarty (1983).

The second family of indices is expressed as

$$P_\alpha(X; z) = \frac{1}{n} \sum_{j=1}^k \sum_{i \in S_j} a_j \left[ 1 - \left( \frac{x_{ij}}{z_j} \right) \right]^\alpha, \quad (10)$$

where  $\alpha \geq 1$ . This index is a multidimensional generalization of the Foster, Greer and Thorbecke (1984) subgroup decomposable index (the FGT index).

In the empirical investigation that will be reported below we used this multidimensional generalization of the FGT index with the parameter  $\alpha = 2$ . We assumed that for each indicator the ‘‘poverty line’’ was equal to half the mean value of the indicator. We also decided to give an equal weight to all the indicators. Finally an individual was considered as poor when the expression  $\sum_{j=1}^k a_j \left[ 1 - \left( \frac{x_{ij}}{z_j} \right) \right]^2$  was greater than the value of this expression for the 75<sup>th</sup> percentile (in other words we assumed that 25% of the individuals were poor).

### 3 The Data

The empirical analysis that will be presented below is based essentially on the third wave of the European Community Household Panel. The following 18 indicators<sup>2</sup> have been taken into account to derive multidimensional measures of poverty:

1. *Indicators of Income:*

- Total net household income.

2. *Indicators of Financial Situation:*

- Ability to make ends meet.
- Can the household afford paying for a week’s annual holiday away from home?
- Can the household afford buying new rather than second-hand clothes?
- Can the household afford eating meat, chicken or fish every second day, if wanted?

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<sup>2</sup>For a discussion on the choice of indicators see, among others, Pérez-Mayo (2005).

- Has the household been unable to pay scheduled rent for the accommodation for the past 12 months?
- Has the household been unable to pay scheduled mortgage payments during the past 12 months?
- Has the household been unable to pay scheduled utility bills, such as electricity, water or gas during the past 12 months?

3. *Indicators of quality of accommodation:*

- Does the dwelling have a bath or shower?
- Does the dwelling have shortage of space?
- Does the accommodation have damp walls, floors, foundations, etc...?

4. *Indicators on ownership of durables:*

- Possession of a car or a van for private use.
- Possession of a color TV.
- Possession of a telephone.

5. *Indicators of health:*

- How is the individual's health in general?
- Is the individual hampered in her daily activities by any physical or mental health problem, illness or disability?

6. *Indicators of social relations:*

- How often does the individual meet friends or relatives not living with her, whether at home or elsewhere?

7. *Indicators of satisfaction:*

- Is the individual satisfied with her work or main activity?

Multidimensional measures of poverty have been computed for Belgium, France, Germany, Italy, Spain.

## 4 Do the Different Multidimensional Indices Identify the Same Households as Poor?

To check the degree of overlapping between the various multidimensional poverty indices we have assumed that 25% of the individuals were poor, whatever the index that was selected. We then checked to which degree two indices identified the same households as poor. The results of this analysis are given in Table 1.

It appears that, on average, when comparing two of the three approaches, only 80% (19.8% out of the 25%) of the households defined as poor are the same households. The highest common percentage (20.5% out of 25%) is observed when comparing, for the five countries examined, the TFR with the Information Theory approaches. In the two other cases the common percentages are somehow lower (19.3% when comparing the TFR and FGT approaches and 19.5% when comparing the Information theory and FGT approaches). Note also that the common percentage is highest for Belgium (20.5% out of 25%) and lowest for France (19.1 out of 25%).<sup>3</sup>

In the next section an attempt is made, for each of the three approaches, to determine the impact of the various explanatory variables on the probability that an individual is considered as poor.

(insert Table 1 here)

## 5 The Results of the Logit Regressions

The following exogenous variables have been taken into account in the regressions: the size of the household and its square, the age of the individual and its square, the gender, the marital status (three dummy variables) and the status at work (two dummy variables) of the individual.

In each Logit regression the dependent variable is the probability that an individual is considered as poor (the variable is equal to 1 if she is poor, to 0 otherwise). The results of these estimations are given for Belgium, France, Germany, Italy and Spain in Tables 2-A to 2-E, giving in each case the coefficients of the regression obtained on the basis of the three multidimensional approaches to poverty measurement: the Totally Fuzzy and

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<sup>3</sup>Similar results were obtained when computing the correlation coefficients between any two approaches.

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4 Relative (TFR), the information theory and the axiomatic approaches (generalization of  
5 the FGT index).  
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7 To have an idea of the goodness of fit of the logit regressions we used a criterion that  
8 is similar to the R-square used in linear regressions. The idea is to compute the maximal  
9 value of the log-likelihood ( $\ln L$ ) and compare it with the log likelihood obtained when  
10 only a constant term is introduced ( $\ln L_0$ ). The likelihood ratio, LRI, is then defined as  
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$$13 \quad \text{LRI} = 1 - (\ln L / \ln L_0). \quad (11)$$

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16 The bounds of this measure are 0 and 1 (see, Greene, 1993, pages 651-653).  
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18 The value of the likelihood ratio LRI is given in Tables 2-A to 2-E.  
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20 These tables indicate that in most cases there is, *ceteris paribus*, a U-shaped relation-  
21 ship between the size of the household to which the individual belongs and the probability  
22 that she will be considered as poor. Such a link is observed for the five countries, when-  
23 ever the generalized FGT approach is adopted. The TFR approach does not show such a  
24 relationship in the case of Belgium and France. The Information theory approach shows  
25 such a U-shaped relationship only in the cases of Germany and Italy.  
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28 There seems also to be a U-shaped relationship between the age of the individual and  
29 the probability that she will be considered as poor. The FGT approach gives such a link  
30 for all the five countries examined. The TFR approach shows similar results in four of the  
31 five cases, Germany being the only country for which such a relationship is not observed.  
32 The Information Theory approach however indicates such a U-shaped link only in the  
33 case of Italy. Moreover for Germany it curiously gives an inverted-U relationship between  
34 the age of the individual and the probability that she is considered as poor.  
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37 As far as the other explanatory variables are considered we have introduced interac-  
38 tion terms between the gender of the individual and her marital status so that the joint  
39 impact of these variables on the probability that the individual is considered as poor is  
40 analyzed. This impact varies actually from one country to the other and sometimes there  
41 are even differences between the approaches adopted. For Belgium (see, Table 2-A) the  
42 following observations may be made, assuming the vector of the coefficients of these vari-  
43 ables and their interaction is significantly different from zero. First only the generalized  
44 FGT approach shows really a higher probability of being poor among single males than  
45 among single females. This probability is also higher among married females according  
46 to the FGT and information theory approach but the result is the opposite for the FGT  
47 approach. The three approaches indicate a higher probability of being poor among di-  
48 vorced men than among divorced women, the same being true when comparing widower  
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4 and widows. Finally the probability of being considered as poor is the lowest for married  
5 individuals and the highest for singles.  
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7 For France (see, Table 2-B) the probability of being poor seems to be higher among  
8 single males than among single females. The same differences between the genders are  
9 observed when comparing married men and married women. For divorced individuals,  
10 poverty is higher among women according to the TFR and Information Theory approach  
11 but the contrary is true according to the FGT approach. Finally it seems that the  
12 probability of being considered as poor is higher among widowers than among widows. It  
13 appears also that in France poverty is highest among divorced individuals, whatever their  
14 gender, and lowest among married people.  
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19 When we look at the results for Germany (see, Table 2-C) we see that for those who  
20 are single the probability of being poor is highest among males. This gender difference is  
21 also observed when comparing married men and women as well as widowers and widows.  
22 Among divorced individuals the TFR and Information theory approach show a higher  
23 degree of poverty among females but the contrary is true when using the FGT approach.  
24 In Germany the probability of being poor is the lowest among married and the highest  
25 among divorced individuals.  
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30 The results for Italy (see, Table 2-D) indicate that the probability of being poor is  
31 higher among single men than among single women. The contrary is observed among  
32 married individuals, whatever the approach that is used. Among divorced individuals the  
33 probability of being considered as poor is higher among males, this being also the case  
34 when comparing widowers with widows. No clear conclusions however may be drawn as  
35 far as the impact of the marital status on the probability of being poor is concerned, the  
36 gender playing here an important role.  
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41 Finally when looking at the Spanish data (see, Table 2-E) we observe that only the  
42 FGT approach seems to show a higher probability of being poor among single males  
43 than among single females. All three approaches show however a higher probability of  
44 being considered as poor among married males than among married females. Among  
45 divorced individuals this probability is higher among females according to the TFR and  
46 Information theory approach but the opposite is true when using the FGT approach.  
47 Among widowers and widows the impact of the gender depends also on the approach  
48 adopted: the probability of being poor is higher among widows according to the TFR  
49 approach but the opposite is true when adopting the Information theory or FGT approach.  
50 As far as the impact of the marital status is concerned the probability of being poor is  
51 highest among divorced and lowest among married individuals.  
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Concerning the effect of the work status we observe in all countries that the probability of being poor is highest, as expected, among unemployed individuals (the category of reference in the regressions). It is lowest (in most cases) among self-employed.

To better analyze the impact of the explanatory variables on the probability of being poor we apply in the next section the so-called Shapley decomposition procedure, a technique that will allow us determining the exact *marginal* impact on the probability of being poor of each of the five categories of explanatory variables: household size, age, gender, marital status and work status.

(insert Tables 2-A to 2-E here)

## 6 The Shapley Decomposition and its Implications for Multidimensional Poverty Analysis

The concept of Shapley decomposition is now quite well known and we summarize it in a few sentences. Let  $I(a, b)$  be a function depending on two variables  $a$  and  $b$ . Such a function need not be linear. Although Chantreuil and Trannoy (1999) and Sastre and Trannoy (2002), who came up with the idea of Shapley decomposition, limited their application of the Shapley value to the decomposition of income inequality, Shorrocks (1999) has shown that such a decomposition could be applied to any function. The idea of the Shapley value is to consider all the possible sequences allowing us to eliminate the variables  $a$  and  $b$ . Let us start with the elimination of the variable  $a$ . This variable may be the first one or the second one to be eliminated. If it is eliminated first, the function  $I(a, b)$  will become equal to  $I(b)$  since the variable  $a$  has been eliminated so that in this case the contribution of  $a$  to the function  $I(a, b)$  is equal to  $I(a, b) - I(b)$ . If the variable  $a$  is the second one to be eliminated, the function  $I$  will then be equal to  $I(a)$ . Since both elimination sequences are possible and assuming the probability of these two sequences is the same, we may conclude that the (marginal) contribution  $C(a)$  of the variable  $a$  to the function  $I(a, b)$  is equal to

$$C(a) = \frac{1}{2}[I(a, b) - I(b)] + \frac{1}{2}I(a). \quad (12)$$

Similarly one can prove that the (marginal) contribution  $C(b)$  of the variable  $b$  to the function  $I(a, b)$  is



$$C(b) = \frac{1}{2}[I(a, b) - I(a)] + \frac{1}{2}I(b). \quad (13)$$

Combining (12) and (13) we observe that

$$C(a) + C(b) = I(a, b). \quad (14)$$

The Shapley decomposition just described has been applied to the various Logit regressions that were estimated in order to find out what the marginal contributions of the different variables are. To simplify the computations, we did not compute the *marginal* impact of each variable but the *marginal* impact of each category of explanatory variables: household size, age, gender, marital status and work status.

As indicated before, the likelihood ratio LRI that was defined previously will serve as indicator of the goodness of fit of the logit regressions. The marginal impact of each category of variables that was estimated using the Shapley decomposition procedure will then give their (marginal) contribution to this Likelihood Ratio and the sums of these contributions will be equal, as was just mentioned, to the Likelihood Ratio itself.

## 6.1 The Empirical Investigation

Table 3 reports for each country and approach the *marginal* impact of each of the five categories of explanatory variables on the Likelihood Ratio LRI that was defined previously. This marginal impact is given both in absolute value and in percentage terms.

As far as the Likelihood Ratio is concerned we may observe that the best results are obtained for Belgium and Germany with the Information Theory and Generalized FGT approaches. The greatest marginal impacts are those of the work status and of the marital status, the impact of the former category of variables being generally higher than that of the latter. This is not too surprising given that one expects a very important effect of unemployment (one of the dummy variables of the status at work) on poverty. The impact of the marital status is not surprising either, because it is well-known that married individuals have generally a higher level of welfare than singles, divorced or widowers (widows). The relative importance of the other three categories of explanatory variables depends both on the country examined and the approach adopted. Among these three categories of variables, the impact of the gender is generally the weakest and that of the size of the household the strongest but there are many exceptions.

In fact there is one variable, the level of education, that we had planned to introduce as explanatory variable but could not for two reasons. First education is generally measured



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4 differently from one country to the other. Second when a common definition was adopted  
5 there were too many missing observations so that finally we had to drop this variable. It  
6 is in fact very likely that education has an important impact on poverty (see, Deutsch and  
7 Silber, 2005). Moreover it is quite possible that its introduction in the Logit regressions  
8 would have modified the impact of gender on poverty. We suspect that, had we been able  
9 to introduce this variable, there would have been less cases where the probability of being  
10 poor is, *ceteris paribus*, higher among males. One should not forget that today in many  
11 Western countries the average level of education is higher among females.  
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(insert Table 3 here)

## 20 21 22 23 **7 Concluding Comments** 24 25

26 This paper had three goals. First we wanted to compare three multidimensional ap-  
27 proaches to poverty and check to what extent they identified the same households as  
28 poor. Second we planned to better understand the determinants of poverty by estimating  
29 Logit regressions with five categories of explanatory variables: size of the household, age  
30 of the head of the household, her gender, marital status and status at work. Third we  
31 wished to introduce a decomposition procedure proposed recently in the literature, the  
32 so-called Shapley decomposition, in order to determine the exact marginal impact of each  
33 of the categories of explanatory variables. Our empirical analysis was based on ECHP  
34 data. We used its third wave and selected five countries: Belgium, France, Germany, Italy  
35 and Spain.  
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41 The following conclusions may be drawn. First the three multidimensional approaches  
42 adopted (the Totally Fuzzy and Relative Approach, that based on Information Theory  
43 and the axiomatically derived approach using the generalized FGT index) indicate that,  
44 on average, 80% of the households defined as poor by two approaches are identical.  
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48 Second the impact of the explanatory variables introduced in the Logit regressions  
49 may be summarized as follows. There seems generally to be a U-shaped relationship  
50 between poverty and the size of the household as well as between poverty and the age of  
51 the individual. Unemployed individuals have a much higher probability, *ceteris paribus*,  
52 of being poor while the probability of being poor seems to be lower among self-employed  
53 than among salaried workers. Finally, *ceteris paribus*, married individuals, whatever their  
54 gender, have a lower probability of being poor than singles, divorced or widowers (widows).  
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4 Differences between the three other categories of marital status seem to depend both on  
5 the country examined and on the approach adopted.  
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7 Finally the Shapley decomposition procedure indicates clearly that work and marital  
8 status have the greatest marginal impact on poverty, this being true generally for all the  
9 five countries and for the three approaches examined.  
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11 In future work we plan to increase the number of indicators used in measuring multi-  
12 dimensional poverty, adopting thus recent recommendations of the European Union. We  
13 also plan to include additional approaches in our analysis and take a closer look at the  
14 marginal impact of each category of indicators on the value taken by the multidimensional  
15 indices of poverty.  
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Table 1: Degree of overlapping between the various multidimensional poverty indices (Percentage of households defined as poor by two multidimensional indices, assuming 25% of the households are poor).

|  | Belgium | France | Germany | Italy | Spain | Average of binary comparisons |
|--|---------|--------|---------|-------|-------|-------------------------------|
| TFR index and information theory based index                   | 19.5    | 19.0   | 18.3    | 19.7  | 19.9  | 19.3                          |
| TFR index and Generalization of FGT index                      | 21.6    | 19.4   | 21.7    | 19.8  | 19.8  | 20.5                          |
| Information theory based index and Generalization of FGT index | 20.5    | 18.9   | 19.2    | 18.8  | 20.3  | 20.3                          |
| Average of countries   | 20.5    | 19.1   | 19.7    | 19.4  | 20.0  | 19.8                          |

Table 2-A: Results of the Logit Regressions for Belgium.

| Explanatory variables            | TFR: coef. | TFR: t-values | Inf.Th.: coef. | Inf.Th. t-val. | F.G.T.: coef. | F.G.T.: t-values |
|----------------------------------|------------|---------------|----------------|----------------|---------------|------------------|
| constant                         | 2.05309    | 2.39          | 0.77765        | 0.69           | 3.87636       | 6.13             |
| Household size                   | -0.12100   | -0.64         | -0.22763       | -0.97          | -0.34960      | -2.33            |
| Square of household size         | 0.04211    | 1.71          | 0.05259        | 1.76           | 0.05866       | 2.87             |
| Age                              | -0.10416   | -3.48         | -0.07112       | -1.83          | -0.15955      | -7.36            |
| Square of age                    | 0.00073    | 2.63          | 0.00047        | 1.32           | 0.00150       | 7.14             |
| Male                             | 0.08752    | 0.33          | -0.00280       | -0.01          | 0.60513       | 2.81             |
| Married                          | -0.58326   | -0.73         | -0.01044       | -0.01          | -0.29108      | -0.58            |
| Divorced                         | 0.30657    | 0.27          | -1.45477       | -0.66          | -0.96248      | -1.10            |
| Widower                          | -0.34303   | -0.40         | -1.33642       | -1.08          | -0.86668      | -1.44            |
| Interaction Married/ Male        | -0.23089   | -0.34         | -0.69015       | -0.63          | -0.29181      | -0.70            |
| Interaction Divorced/ Male       | 0.37116    | 0.57          | 1.40434        | 1.22           | 1.00108       | 1.83             |
| Interaction Widower/ Male        | 0.49156    | 1.02          | 1.29518        | 1.94           | 0.79772       | 2.22             |
| Salaried Worker                  | -1.80857   | -3.70         | -3.22800       | -4.35          | -0.81437      | -2.43            |
| Self-employed                    | -2.52832   | -2.80         | -4.75431       | -2.95          | -1.11522      | -1.86            |
| Interaction: Salaried/ Male      | 0.01264    | 0.04          | 0.66678        | 1.46           | -0.22716      | -0.97            |
| Interaction: Self-employed/ Male | 0.79855    | 1.19          | 1.92892        | 1.96           | 0.14192       | 0.29             |
| Likelihood Ratio LRI             | 0.13390    |               | 0.20304        |                | 0.15808       |                  |
| Number of Observations           | 2395       |               | 2395           |                | 2395          |                  |

Table 2-B: Results of the Logit Regressions for France.

| Explanatory variables               | TFR:<br>coef. | TFR:<br>t-values | Inf.Th.:<br>coef. | Inf.Th.<br>t-val. | F.G.T.:<br>coef. | F.G.T.:<br>t-values |
|-------------------------------------|---------------|------------------|-------------------|-------------------|------------------|---------------------|
| constant                            | -0.29848      | -0.70            | -2.81969          | -5.33             | 1.08906          | 3.22                |
| Household size                      | -0.00055      | -0.01            | 0.26864           | 2.67              | -0.35365         | -3.70               |
| Square of household size            | 0.03323       | 2.53             | 0.00565           | 0.52              | 0.07375          | 5.72                |
| Age                                 | -0.04876      | -3.09            | 0.00086           | 0.05              | -0.07042         | -5.80               |
| Square of age                       | 0.00039       | 2.61             | 0.00004           | 0.21              | 0.00066          | 5.75                |
| Male                                | 0.10311       | 0.72             | 0.31901           | 1.87              | 0.51112          | 4.47                |
| Married                             | -1.75107      | -2.80            | -1.24785          | -1.48             | -0.80734         | -1.51               |
| Divorced                            | 1.86307       | 2.61             | 1.80340           | 1.97              | 0.63829          | 0.97                |
| Widower                             | 0.50634       | 1.12             | 0.28871           | 0.53              | 0.59320          | 1.64                |
| Interaction Married/<br>Male        | 0.82957       | 1.43             | 0.37081           | 0.47              | 0.15497          | 0.31                |
| Interaction Divorced/<br>Male       | -0.66499      | -1.37            | -0.86732          | -1.37             | 0.02641          | 0.06                |
| Interaction Widower/<br>Male        | -0.07635      | -0.28            | 0.20379           | 0.64              | -0.09370         | -0.42               |
| Salaried Worker                     | -1.41815      | -5.00            | -1.65631          | -4.53             | -1.22752         | -5.74               |
| Self-employed                       | -1.82291      | -2.50            | -2.06412          | -2.12             | -1.94644         | -3.64               |
| Interaction: Salaried/<br>Male      | 0.23432       | 1.18             | 0.07176           | 0.28              | -0.04473         | -0.30               |
| Interaction: Self-employed/<br>Male | 0.71900       | 1.19             | 0.53647           | 0.66              | 0.78749          | 1.74                |
| Likelihood Ratio LRI                | 0.08293       |                  | 0.10842           |                   | 0.14247          |                     |
| Number of Observations              | 6284          |                  | 6284              |                   | 6284             |                     |

Table 2-C: Results of the Logit Regressions for Germany.

| Explanatory variables            | TFR: coef. | TFR: t-values | Inf.Th.: coef. | Inf.Th. t-val. | F.G.T.: coef. | F.G.T.: t-values |
|----------------------------------|------------|---------------|----------------|----------------|---------------|------------------|
| constant                         | -0.55457   | -0.73         | -5.52145       | -4.58          | 1.81527       | 3.67             |
| Household size                   | -0.32875   | -1.99         | -0.72504       | -3.10          | -0.62671      | -4.60            |
| Square of household size         | 0.07735    | 3.48          | 0.13747        | 4.51           | 0.10922       | 5.48             |
| Age                              | 0.00627    | 0.19          | 0.19490        | 4.04           | -0.11097      | -5.46            |
| Square of age                    | -0.00036   | -1.06         | -0.00221       | -4.54          | 0.00111       | 5.23             |
| Male                             | 0.16318    | 0.74          | 0.45502        | 1.41           | 1.19530       | 7.44             |
| Married                          | -0.35122   | -0.70         | 0.54989        | 0.71           | 0.50780       | 1.68             |
| Divorced                         | 0.68598    | 0.69          | 1.82271        | 1.31           | -0.48413      | -0.66            |
| Widower                          | 0.52661    | 0.80          | 1.25362        | 1.40           | 0.41231       | 0.89             |
| Interaction Married/ Male        | -0.69558   | -2.10         | -1.28033       | -2.55          | -0.96564      | -5.04            |
| Interaction Divorced/ Male       | -0.39932   | -0.66         | -1.22406       | -1.37          | 0.46450       | 1.01             |
| Interaction Widower/ Male        | -0.11565   | -0.31         | -0.49800       | -1.00          | 0.04267       | 0.16             |
| Salaried Worker                  | -1.85829   | -4.64         | -3.06154       | -4.92          | -0.32709      | -1.34            |
| Self-employed                    | -2.49428   | -2.76         | -2.86997       | -3.94          | -0.69513      | -1.26            |
| Interaction: Salaried/ Male      | 0.24471    | 0.97          | 0.61487        | 1.59           | -0.50270      | -3.16            |
| Interaction: Self-employed/ Male | 0.95473    | 1.58          | -1.28033       | -2.55          | -0.33825      | -0.82            |
| Likelihood Ratio LRI             | 0.11926    |               | 0.17594        |                | 0.16212       |                  |
| Number of Observations           | 4396       |               | 4396           |                | 4396          |                  |

Table 2-D: Results of the Logit Regressions for Italy.

| Explanatory variables               | TFR:<br>coef. | TFR:<br>t-values | Inf.Th.:<br>coef. | Inf.Th.<br>t-val. | F.G.T.:<br>coef. | F.G.T.:<br>t-values |
|-------------------------------------|---------------|------------------|-------------------|-------------------|------------------|---------------------|
| constant                            | 0.78306       | 1.53             | -1.15255          | -1.85             | 2.06227          | 5.28                |
| Household size                      | -0.55139      | -5.00            | -0.36531          | -3.28             | -0.77544         | -8.52               |
| Square of household size            | 0.08990       | 6.34             | 0.06668           | 4.75              | 0.10476          | 8.52                |
| Age                                 | -0.07341      | -4.42            | -0.04762          | -2.48             | -0.08481         | -6.79               |
| Square of age                       | 0.00065       | 4.41             | 0.00053           | 3.23              | 0.00080          | 7.16                |
| Male                                | 0.17322       | 1.11             | 0.45808           | 2.62              | 0.41638          | 3.38                |
| Married                             | -0.21050      | -0.57            | 0.48566           | 1.13              | 0.38341          | 1.41                |
| Divorced                            | 0.05216       | 0.06             | 1.48376           | 1.72              | -0.07586         | -0.12               |
| Widower                             | -1.13976      | -0.72            | 0.26080           | 0.16              | -0.61068         | -0.60               |
| Interaction Married/<br>Male        | -0.20808      | -0.81            | -0.71432          | -2.33             | -0.51747         | -2.76               |
| Interaction Divorced/<br>Male       | 0.34086       | 0.69             | -0.43221          | -0.81             | 0.25481          | 0.63                |
| Interaction Widower/<br>Male        | 0.58028       | 0.65             | -0.29014          | -0.30             | 0.24933          | 0.42                |
| Salaried Worker                     | -0.31695      | -0.94            | -0.76584          | -1.84             | -0.21291         | -0.93               |
| Self-employed                       | -0.82192      | -1.74            | -1.20771          | -2.01             | -0.30616         | -0.81               |
| Interaction: Salaried/<br>Male      | -0.46297      | -1.76            | -0.35997          | -1.09             | -0.46250         | -2.63               |
| Interaction: Self-employed/<br>Male | 0.03371       | 0.09             | 0.03428           | 0.07              | -0.59514         | -1.82               |
| Likelihood Ratio LRI                | 0.06820       |                  | 0.10906           |                   | 0.10172          |                     |
| Number of Observations              | 7063          |                  | 7063              |                   | 7063             |                     |



Table 2-E: Results of the Logit Regressions for Spain.

| Explanatory variables            | TFR: coef. | TFR: t-values | Inf.Th.: coef. | Inf.Th. t-val. | F.G.T.: coef. | F.G.T.: t-values |
|----------------------------------|------------|---------------|----------------|----------------|---------------|------------------|
| constant                         | -0.09133   | -0.19         | -1.86868       | -3.14          | 1.82823       | 5.09             |
| Household size                   | -0.17296   | -1.64         | -0.09067       | -0.78          | -0.24172      | -3.00            |
| Square of household size         | 0.03539    | 2.97          | 0.02381        | 1.88           | 0.02903       | 2.98             |
| Age                              | -0.04396   | -2.64         | 0.00188        | 0.10           | -0.07669      | -6.23            |
| Square of age                    | 0.00039    | 2.49          | 0.00003        | 0.17           | 0.00075       | 6.29             |
| Male                             | -0.03969   | -0.26         | -0.01316       | -0.08          | 0.30671       | 2.56             |
| Married                          | -1.12560   | -3.12         | -1.13306       | -2.73          | -0.67259      | -2.60            |
| Divorced                         | 0.99732    | 1.35          | 1.69096        | 2.08           | 0.58653       | 0.94             |
| Widower                          | 0.13689    | 0.11          | -1.07070       | -0.68          | 0.21249       | 0.24             |
| Interaction Married/ Male        | 0.68228    | 2.46          | 0.77730        | 2.52           | 0.38947       | 1.96             |
| Interaction Divorced/ Male       | -0.19864   | -0.44         | -0.61016       | -1.20          | 0.02060       | 0.05             |
| Interaction Widower/ Male        | -0.08729   | -0.12         | 0.79087        | 0.91           | -0.21452      | -0.41            |
| Salaried Worker                  | -0.83704   | -2.53         | -1.41602       | -3.57          | -1.16326      | -5.48            |
| Self-employed                    | -1.47648   | -3.17         | -2.18810       | -3.68          | -1.85094      | -5.78            |
| Interaction: Salaried/ Male      | -0.36464   | -1.43         | -0.08100       | -0.27          | -0.17017      | -1.08            |
| Interaction: Self-employed/ Male | 0.31376    | 0.89          | 0.54786        | 1.27           | 0.36380       | 1.49             |
| Likelihood Ratio LRI             | 0.07360    |               | 0.09108        |                | 0.14178       |                  |
| Number of Observations           | 6004       |               | 6004           |                | 6004          |                  |

Table 3: Shapley Decompositions for the Logit Regressions. Marginal Impact<sup>1</sup> of the Five Categories of Explanatory Variables on the Likelihood Ratio LRI.

| Country | Multi-dimensional Poverty Index | Marg. Impact of the Size of Household | Marg. Impact of the Age | Marg. Impact of the Gender | Marg. Impact of the Marital Status | Marg. Impact of the Status at Work | Likelihood Ratio LRI |
|---------|---------------------------------|---------------------------------------|-------------------------|----------------------------|------------------------------------|------------------------------------|----------------------|
| Belgium | TFR                             | 1.1                                   | 1.7                     | 1.7                        | 3.7                                | 5.3                                | 13.4                 |
|         |                                 | (8.2)                                 | (12.6)                  | (12.6)                     | (27.4)                             | (39.3)                             | (100)                |
| Belgium | Inf. Th.                        | 1.3                                   | 1.2                     | 3.8                        | 5.1                                | 8.9                                | 20.3                 |
|         |                                 | (6.4)                                 | (5.9)                   | (18.7)                     | (25.1)                             | (43.8)                             | (100)                |
| Belgium | FGT                             | 1.9                                   | 3.5                     | 3.2                        | 3.4                                | 3.8                                | 15.8                 |
|         |                                 | (12.0)                                | (22.2)                  | (20.3)                     | (21.5)                             | (24.1)                             | (100)                |
| France  | TFR                             | 1.3                                   | 0.7                     | 0.9                        | 2.9                                | 2.5                                | 8.3                  |
|         |                                 | (15.7)                                | (8.4)                   | (10.8)                     | (34.9)                             | (30.1)                             | (100)                |
| France  | Inf. Th.                        | 1.2                                   | 1.0                     | 1.3                        | 2.4                                | 4.9                                | 10.8                 |
|         |                                 | (11.1)                                | (9.3)                   | (12.0)                     | (22.2)                             | (45.4)                             | (100)                |
| France  | FGT                             | 2.4                                   | 2.1                     | 2.1                        | 2.9                                | 4.7                                | 14.2                 |
|         |                                 | (16.9)                                | (14.8)                  | (14.8)                     | (20.4)                             | (33.1)                             | (100)                |
| Germany | TFR                             | 2.0                                   | 1.2                     | 1.0                        | 4.4                                | 3.3                                | 11.9                 |
|         |                                 | (16.8)                                | (10.1)                  | (8.4)                      | (37.0)                             | (27.7)                             | (100)                |
| Germany | Inf. Th.                        | 3.8                                   | 1.4                     | 1.2                        | 4.2                                | 7.0                                | 17.6                 |
|         |                                 | (21.6)                                | (8.0)                   | (6.8)                      | (23.9)                             | (39.8)                             | (100)                |
| Germany | FGT                             | 2.9                                   | 2.3                     | 2.9                        | 4.5                                | 3.6                                | 16.2                 |
|         |                                 | (17.9)                                | (14.2)                  | (17.9)                     | (27.8)                             | (22.2)                             | (100)                |
| Italy   | TFR                             | 1.9                                   | 1.1                     | 0.6                        | 1.3                                | 1.9                                | 6.8                  |
|         |                                 | (27.9)                                | (16.2)                  | (8.8)                      | (19.1)                             | (27.9)                             | (100)                |
| Italy   | Inf. Th.                        | 1.6                                   | 2.7                     | 0.9                        | 1.7                                | 4.0                                |                      |
|         |                                 | (14.7)                                | (24.8)                  | (8.3)                      | (15.6)                             | (36.7)                             |                      |
| Italy   | FGT                             | 2.5                                   | 2.3                     | 0.8                        | 1.6                                | 2.9                                |                      |
|         |                                 | (24.8)                                | (22.8)                  | (7.9)                      | (15.8)                             | (28.7)                             |                      |
| Spain   | TFR                             | 0.9                                   | 0.9                     | 0.4                        | 1.0                                | 4.1                                |                      |
|         |                                 | (12.3)                                | (12.3)                  | (5.5)                      | (13.7)                             | (56.2)                             |                      |
| Spain   | Inf. Th.                        | 0.8                                   | 1.2                     | 0.6                        | 0.9                                | 5.6                                |                      |
|         |                                 | (8.8)                                 | (13.2)                  | (6.6)                      | (9.9)                              | (61.5)                             |                      |
| Spain   | FGT                             | 1.6                                   | 3.1                     | 1.2                        | 1.3                                | 7.0                                |                      |
|         |                                 | (11.3)                                | (21.8)                  | (8.5)                      | (9.2)                              | (49.3)                             |                      |

<sup>1</sup> The numbers in parenthesis on the separate lines give the marginal impact in relative terms.