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Michał Brzeziński

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MICHAŁ BRZEZIŃSKI
Faculty of Economic Sciences
University of Warsaw
e-mail: mbrzezinski@wne.uw.edu.pl

Abstract

We use data from the British Household Panel Survey to analyse changes in poverty of self-reported health from 1991 to 2008. Recently introduced ordinal counterparts of the classical Foster, Greer, Thorbecke (1984) (FGT) poverty measures are used to decompose changes in self-reported health poverty over time into within-group health poverty changes and population shifts between groups. We also provide statistical inference for these ordinal FGT indices. Results suggest that the health poverty rate increased independently of health poverty threshold chosen. In case of other ordinal FGT indices, which are sensitive to depth and distribution of health poverty, results depend on the health poverty threshold. The subgroup decompositions of changes in total health poverty in Britain suggest that the most important poverty-increasing factors include a rise of both health poverty and population shares of persons cohabiting and couples with no children as well as an increase of the population of retired persons.

Keywords:
health poverty, ordinal FGT measures, self-reported health, statistical inference, British Household Panel Survey

JEL:
I32, D63, I14

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1. Introduction

In recent years there has been a growing interest in analysing the distribution of self-rated health statuses in a population and its changes over time. The problem that has received most attention is the appropriate measurement of health inequality that accounts for the ordinal nature of self-reported data (see, e.g., Allison and Foster 2004, Abul Naga and Yalcin 2008, Zheng 2008, Cowell and Flachaire 2012). A related, but different distributional problem of health *poverty* has been less studied. As noticed by Allison and Foster (2004, p. 519), the most popular poverty measure using self-rated data is poverty rate defined as the proportion of a population whose health status is below a chosen threshold.[1] In case of studies using data based on five-point scale of self-assessed health with categories of “poor”, “fair”, “good”, “very good” and “excellent”, the health poverty rate has been usually defined as the share of population with poor or fair health. However, such a simple measure takes into account only poverty incidence, but it is insensitive to poverty depth and distribution among the poor (poverty severity) as it weights equally both respondents with poor and with fair health. Poverty measurement literature delivers several families of poverty indices, which are sensitive to the poverty incidence, depth and severity – most notably the FGT family, introduced in Foster et al. (1984). The FGT indices are, however, designed for cardinally measureable and interpersonally comparable variables like income and they are not meaningful when applied to ordinal data like self-rated health statuses (Foster et al. 2010).[2] The main reason for this is that they are not invariant to order-preserving transformations applied to the numerical values representing self-reported health statuses and the poverty threshold. To overcome this difficulty, Bennett and Hatzimasoura (2011) have recently proposed ordinal counterparts of the FGT

[1] Another popular approach to analyze health poverty with self-reported data is based on translating ordinal information into cardinal one (see, e.g., Madden 2011) using methods established in health economics literature (Van Doorslaer and Jones 2003).
[2] The only exception is poverty rate (headcount ratio), which is a member of the FGT class with poverty aversion parameter set to 0. However, as stated before, the poverty rate is not sensitive to poverty depth and severity.

poverty measures, which are invariant to order-preserving transformations and possess many attractive features of the original FGT measures. From the policy perspective, the most attractive feature of the FGT indices, both the original ones and their ordinal counterparts, is their subgroup decomposability. This property means that for any division of the population into nonoverlapping subgroups, total poverty measured by an FGT index can be expressed as a sum of the subgroup poverty indices weighted with population shares of subgroups.[3] The ordinal FGT indices can be therefore used to identify the subgroups, which are more affected by health poverty and to design policies that may be most effective in reducing overall health poverty.

The purpose of this paper is to analyse trends in self-reported health poverty in Britain using ordinal FGT measures of Bennett and Hatzimasoura (2011) and data from the British Household Panel Survey (BHPS) for the period between 1991 and 2008. We also provide statistical inference for the ordinal FGT indices to verify if the observed changes in health poverty are due to sampling variability or if they correspond to the true changes in the population. Finally, we borrow from the literature on decomposing poverty indices using the Shapley value concept (Shorrocks 1999) to provide decompositions of changes in total self-rated health poverty in UK between 1991 and 2008 into changes in subgroups' population shares and changes in health poverty levels within subgroups.

2. Measures of self-rated health poverty

Bennett and Hatzimasoura's (2011) ordinal FGT family of poverty indices may be defined in the context of self-rated health data as follows. Let self-rated health of a population consisting of n persons be represented by a vector of S ordered categories $Y = (y_1, y_2, ... y_S)$, with $y_i > y_j$ if

[3] See Chakravarty (2009), for a recent overview of various poverty indices and their properties.

and only if health status i is preferred to health status j. In practice y_1 may represent, for example, poor self-rated health status, while y_S – excellent self-rated health status. If category k is chosen as a poverty threshold, then Bennett and Hatzimasoura (2011) propose the following class of ordinal poverty measures:

$$\pi_\alpha(Y;k) = \sum_{j=1}^{k} p_j \left(\frac{k-j+1}{k}\right)^\alpha, \tag{1}$$

where p_j is the share of population with self-rated health y_j and $\alpha \geq 0$ is a parameter. Notice that p_j can be interpreted as a probability of having self-rated health y_j and hence (1) can be viewed as a weighted sum of the probabilities of having self-rated health below the chosen health poverty threshold with weights determined by k (the number of self-rated health categories below or equal to the poverty threshold) and the parameter α. If $\alpha = 0$, then (1) reduces to the standard poverty rate (headcount ratio), while if $\alpha > 0$, then (1) gives more weight to the categories with lower self-rated health. For example, when $k = 2$ and $\alpha = 1$, the weights for p_1 and p_2 are, respectively, 1 and 1/2. Higher values of parameter α lead to lower weights attached to p_2, ..., p_k. Using alternative representation of (1) in terms of normalized health ranks, Bennett and Hatzimasoura (2011) show that the ordinal FGT are sensitive both to depth (when $\alpha > 0$) and depth and distribution (when $\alpha > 1$) of health poverty.

Bennett and Hatzimasoura (2011) provide also an axiomatic characterization of the ordinal FGT indices using Ebert and Moyes's (2002) axioms for the continuous FGT indices, appropriately modified for the purposes of ordinal data. By construction, poverty measures defined in (1) are insensitive to order-preserving transformations of ordinal variables and the poverty threshold. The authors also show that their ordinal FGT indices are subgroup decomposable in the sense that the overall poverty is a weighted average of subgroup poverty with weights given by the subgroup population shares.

2.1. Statistical inference

The family of ordinal FGT poverty indices (1) is a linear function of k parameter estimates, $X = (p_1, \ldots, p_k)^T$, following a multinomial distribution:

$$\pi_\alpha(Y;k) = cX, \tag{2}$$

with $c = \left[1, \left(\frac{k-1}{k}\right)^\alpha, \ldots, \left(\frac{1}{k}\right)^\alpha\right]$. Therefore, variance estimator of (1) is given by:

$$\widehat{Var}(\pi_\alpha(Y;k)) = c\Sigma c^T, \tag{3}$$

where Σ is a covariance matrix of X given by:

$$\Sigma = \frac{1}{n}\begin{bmatrix} p_1(1-p_1) & -p_1p_2 & \ldots & -p_1p_k \\ -p_2p_1 & p_2(1-p_2) & \ldots & -p_2p_k \\ \vdots & \vdots & \vdots & \vdots \\ -p_kp_1 & -p_kp_2 & \ldots & p_k(1-p_k) \end{bmatrix}. \tag{4}$$

Variance estimator given in (3) may be used to construct confidence intervals for estimated self-rated health poverty indices and to test hypotheses about the estimated indices. In particular, the asymptotic 95% confidence interval is equal to:

$$\left[\hat{\pi}_\alpha(Y;k) - d_{0.975}\widehat{Var}\big(\hat{\pi}_\alpha(Y;k)\big)^{1/2}; \hat{\pi}_\alpha(Y;k) + d_{0.975}\widehat{Var}\big(\hat{\pi}_\alpha(Y;k)\big)^{1/2}\right], \tag{5}$$

where $d_{0.975}$ is a critical value from the Student's t distribution with appropriate number of degrees of freedom. In order to test the hypothesis that two distributions of self-rated health, X and Y, have the same value of a given ordinal FGT index, we may use the following statistic:

$$\tau = \frac{\hat{\pi}_\alpha(X;k) - \hat{\pi}_\alpha(Y;k)}{\sqrt{\widehat{Var}\big(\hat{\pi}_\alpha(X;k)\big) + \widehat{Var}\big(\hat{\pi}_\alpha(Y;k)\big) - 2\widehat{Cov}(\hat{\pi}_\alpha(X;k), \hat{\pi}_\alpha(Y;k))}}. \tag{6}$$

If the samples X and Y are independent, the covariance term in the denominator of (6) is zero. However, the samples taken from two different waves of the BHPS are dependent as the BHPS is a longitudinal survey, which interviews annually the same individuals belonging to a representative sample chosen in 1991. The dependence of two BHPS samples taken from two different survey waves is only partial due to sample attrition and inclusion of new entrants after wave 1 (see Taylor et al. 2010). An appropriate method of accounting for partial sample dependency was proposed by Zheng (2004) in the context of the the inference for continuous additively separable poverty measures (including the continuous FGT indices).[4] In this paper, we use Zheng's (2004) approach to calculate the covariance term in (6).

2.2. Subgroup decomposition of changes in self-reported health poverty over time

In order to identify how various subgroups contribute to changes in self-reported health poverty over time, we can use "dynamic" decompositions of poverty changes proposed in the distributional literature concerned with continuous outcome variables. For subgroup decomposable ordinal FGT measures defined in (1), changes in total poverty over time from t_1 to t_2 can be written as follows:

$$\Delta\pi_\alpha = \pi_\alpha(Y_{t_2};k) - \pi_\alpha(Y_{t_1};k) = \sum_{i=1}^{h}\left[v^i(t_2)\pi_\alpha^i(Y_{t_2};k) - v^i(t_1)\pi_\alpha^i(Y_{t_1};k)\right], \quad (6)$$

where v^i and π_α^i are, respectively, population share and poverty level of subgroup $i \in (1, ..., h)$. Accounting for the change in total poverty over time, $\Delta\pi_\alpha$ can be expressed in terms of changes in poverty within subgroups, $\Delta\pi_\alpha^i = \pi_\alpha^i(Y_{t_2};k) - \pi_\alpha^i(Y_{t_1};k)$, $i \in (1, ..., h)$, and changes in population shares of subgroups, $\Delta v^i = v^i(t_2) - v^i(t_1)$, $i \in (1, ..., h)$. Shorrocks (1999) has shown that an exact decomposition of this kind can be performed using the Shapley value concept taken from the cooperative game theory.[5] According to the Shapley value based decomposition, the equation (6) becomes:

[4] See also Zheng and Cushing (2001) for the same procedure applied to inference on inequality with dependent samples.
[5] For a textbook treatment of Shapley value based decompositions of poverty and inequality, see Duclos and Arrar (2006).

$$\Delta\pi_\alpha = \sum_{i=1}^{h}\left(W^i + P^i\right) = \sum_{i=1}^{h}\left[\frac{v^i(t_1) + v^i(t_2)}{2}\Delta\pi_\alpha^i + \frac{\pi_\alpha^i(Y_{t_1};k) + \pi_\alpha^i(Y_{t_2};k)}{2}\Delta v^i\right]. \qquad (7)$$

Within-subgroup effects, W^i, measure the contribution of poverty changes within subgroups to changes in total poverty weighted by the subgroups' population shares averaged over time. Between-subgroup population shift effects, P^i, are defined as contributions of changes in subgroups population shares to changes in total poverty weighted by the subgroup levels of poverty averaged over time. A poverty change decomposition similar to that given by (7), but with weights coming from the initial period (t_1), was initially proposed by Ravallion and Huppi (1991). However, their decomposition was inexact as it contained an interaction term between $\Delta\pi_\alpha^i$ and Δv^i. Shapley value based decomposition in (7) does not suffer from this drawback.

3. Data

We use data from waves 1-18 of the British Household Panel Survey (BHPS). The BHPS was designed as a nationally representative annual survey of adult (aged 16+) population of Great Britain (Taylor et al. 2010). It re-interviews annually the same individuals belonging to the initial sample of more than 5,000 households as well as their adult co-residents. The BHPS collects rich information about respondents' household structure, health, incomes, labour market status, housing conditions, education and socio-economic values. In this paper, we are mainly interested in cross-sectional analysis of trends in self-reported health in Britain. For this reason, we use information on all respondents giving the full interview in a given year weighted with cross-sectional weights available in the BHPS that adjust for inclusion of new entrants and for within household nonresponse. We also use information about clustering and stratification of the BHPS sample (see Taylor et al. 2010) in estimating covariance matrix Σ in (3). The total number of observations ranges from 9,790 in 1991 to 7,125 in 2008.

The self-rated health status is measured in the BHPS using an answer to the question: "Please think back over the last 12 months about how your health has been. Compared to people of your own age, would you say your health has on the whole been Excellent, Good, Fair, Poor or Very Poor?".[6] Table 1 presents the distribution of self-rated health for 1991 and 2008. For the purposes of decomposing health poverty we use also information on individual marital status, household type and labour market status. The distributions of these variables in 1991 and 2008 are given in Table 3.

Table 1. Distribution of self-rated health status for the BHPS data, percent of samples

Self-assessed health status	1991	2008
Excellent	28.1	20.3
Good	45	47.7
Fair	18.6	22.5
Poor	6.2	7.7
Very poor	2.1	1.7

Note: estimates are weighted with cross-sectional respondent weights.

3. Poverty of self-reported health in Britain, 1991–2008

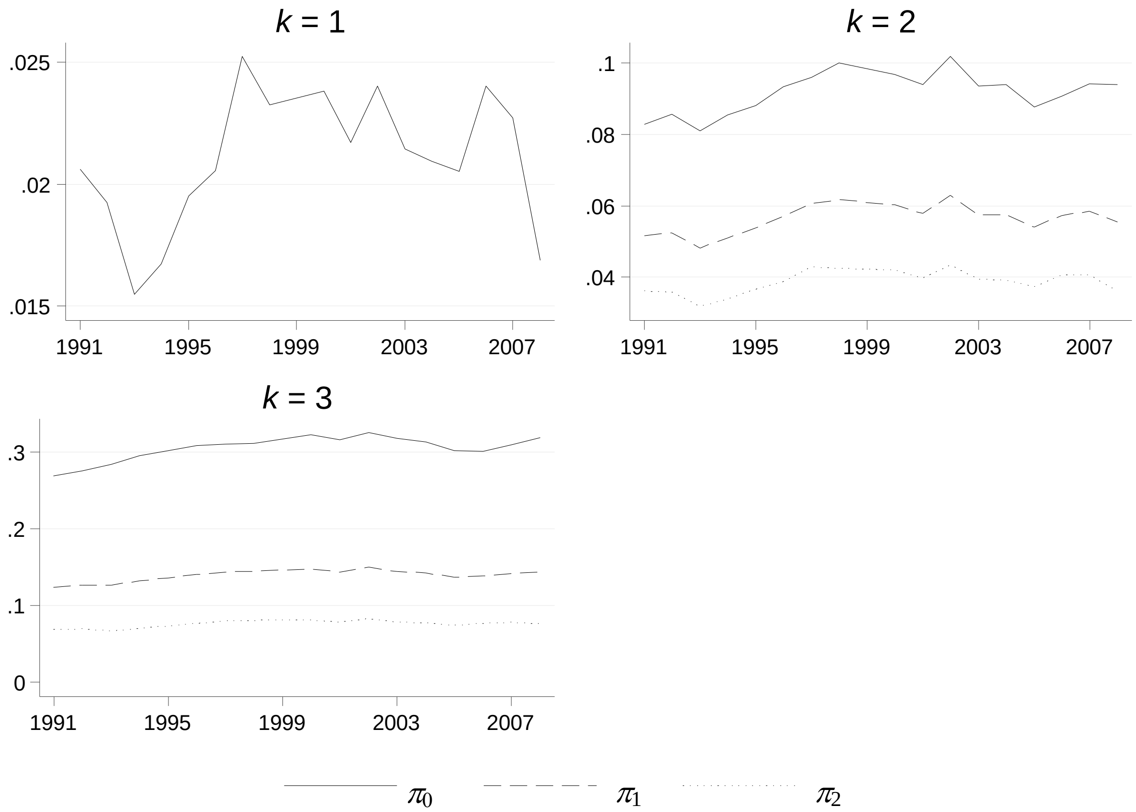
3.1. Trends in self-rated health poverty

Figure 1 shows trends in poverty of self-rated health using ordinal FGT indices with different values of α and different poverty thresholds k. The lowest possible poverty threshold k = 1 is certainly unreasonable as people reporting higher self-rated health status still consider it to be "poor". For more reasonable poverty thresholds, we observe that health poverty as measured by poverty rate (π_0) increased between 1991 and 2008 by 13.7% and 18.9% for k = 2 ("poor"

[6] We do not include wave 9 of the BHPS in our analysis as there was a change in wording of the self-rated health question at this wave.

self-rated health status) and k = 3 (“fair” self-rated health status), respectively. The growth of health poverty was smaller in the case of π_1 – 7.2% (k = 2) and 15.6% (k = 3). Finally, self-reported health poverty as measured by π_2 did not change when k = 2 and increased by 10.6% when k = 3. Table 2 presents estimates of health poverty indices for k = 2, 3 together with their standard errors and 95% confidence intervals.[7] It also gives results of significance tests on pairwise health poverty comparisons between 1991 and 2008.

Figure 1. Trends in ordinal FGT poverty indices for the BHPS data with different health poverty thresholds (k = 1, 2, 3)



The results suggest that for k = 2 a change in self-rated health poverty rate is significant at the conventional 5% significance level. However, if measures sensitive to depth (π_1) and depth

[7] The health poverty change between 1991 and 2008 for k = 1 is 0.0037, which is not statistically significant with p-value of 0.116.

and distribution of poverty (π_2) are applied, the results for *k* = 2 become statistically insignificant. When an even higher poverty threshold is used (*k* = 3), poverty increases displayed by all poverty indices used are statistically significant.

Table 2. Ordinal FGT indices for self-assessed health status (*k* = 2, 3)

	π_0	π_1	π_2
k = 2			
1991	0.0827	0.0517	0.0361
	(0.0030)	(0.0020)	(0.0016)
	[0.0769, 0.0885]	[0.0478, 0.0556]	[0.0329, 0.0394]
2008	0.0940	0.0554	0.0362
	(0.0043)	(0.0027)	(0.0021)
	[0.0855, 0.1025]	[0.0501, 0.0608]	[0.0320, 0.0403]
2008 vs. 1991	0.0113	0.0038	0.0000
	(0.0050)	(0.0032)	(0.0026)
	0.026	0.245	0.989
k = 3			
1991	0.2686	0.1240	0.0689
	(0.0053)	(0.0026)	(0.0019)
	[0.2582, 0.2790]	[0.1188, 0.1292]	[0.0651, 0.0726]
2008	0.3193	0.1434	0.0762
	(0.0071)	(0.0037)	(0.0027)
	[0.3055, 0.3331]	[0.1361, 0.1507]	[0.0710, 0.0814]
2008 vs. 1991	0.0507	0.0194	0.0073
	(0.0085)	(0.0044)	(0.0031)
	0.000	0.000	0.021

Note: standard errors appear in parentheses, 95% normal-based confidence intervals are given in square brackets. Rows for pairwise comparisons give a difference in poverty indices as well as its standard error and associated *p*-value corrected for sample dependency.

3.2. Decomposition of health poverty changes

Table 3 presents results of subgroup decompositions of changes in self-rated health poverty in Britain between 1991 and 2008 when health poverty is measured by π_2 with *k* = 3.[8] The total change in health poverty, denoted by δ, is 0.0073 or 10.6% in relative terms. We perform de-

[8] Results for π_0 and π_1 with *k* = 3 are in general qualitatively similar to those for π_2 (*k* = 3).

compositions for subgroups defined by marital status, household type and labour market status.[9]

Table 3. Subgroup decompositions of changes in π_2 for self-reported health (k = 3)

Group	1991		2008		1991-2008	
	v	π_2	v	π_2	W	P
Marital status						
Married	58.4	0.064	52.8	0.070	45.7	-51.8
Cohabiting	6.3	0.049	10.4	0.069	22.6	33.1
Widowed	9.1	0.128	8.2	0.147	22.7	-15.9
Divorced/separated	5.7	0.120	7.3	0.126	5.2	26.3
Single never married	20.5	0.049	21.3	0.051	6.3	5.7
Total population	100	0.069	100	0.076	102.5	-2.5
Household type						
Single non-elderly (age less than 65)	5.9	0.101	7.8	0.092	-8.6	25.9
Single elderly (age 65+)	7.6	0.123	8.6	0.137	15.5	18.3
Couple with no children	39.8	0.073	42.5	0.079	35.1	27.4
Couple with children	24.8	0.046	20.6	0.050	14.1	-27.8
Lone parent	2.0	0.074	1.9	0.130	14.7	-0.6
Other households	19.9	0.059	18.6	0.058	-3.1	-10.6
Total population	100	0.069	100	0.076	67.7	32.3
Labour market status						
Full-time employee	38.7	0.038	38.0	0.042	20.8	-3.6
Part-time employee	9.9	0.040	10.8	0.044	5.8	5.2
Self-employed	7.7	0.028	7.2	0.041	13.7	-2.6
Unemployed	5.5	0.058	3.0	0.078	11.2	-23.5
Retired	19.5	0.111	25.9	0.113	7.7	97.5
Inactive	18.7	0.124	15.1	0.138	30.8	-63.0
Total population	100	100	0.069	0.076	90.0	10.0

Note: *W* and *P* are expressed as percentages of a change in total poverty.

The decomposition based on marital status suggests that between-subgroup population shifts had in overall an offsetting effect on changes in total poverty. The largest ovarall poverty-increasing effect among subgroups is due to increasing health poverty and population share of persons cohabiting. Turning to decompositions using subgroups defined by household type, we can observe that in this case the within-subgroup population shifts have accounted for as much as about 32% of δ. Increases in the populations of single non-elderly persons and cou-

[9] Decompositions for sub-groups defined by the number of children, education and income group are available upon request.

ples with no children have each contributed to more than 25% of δ. Health poverty increase among couples with no children accounted for about 35% of the overall health poverty change, while a fall of health poverty among single non-elderly persons had a rather small poverty-decreasing effect. Finally, in case of decomposition for subgroups defined by labour market status 90% of δ can be accounted for by within-subgroups poverty effects. However, detailed analysis of population shift effects reveals interesting facts. The population of retired persons in the BHPS increased between 1991 and 2008 from 19.5% to 25.9%, which accounts for as much as 97.5% of the total health poverty increase. This large effect is, however, almost offset by significant decreases in the populations of inactive and unemployed persons. The biggest contributions to δ among the within-subgroup poverty effects can be assigned to deterioration in health among inactive persons (30.8%) and full-time employees (20.8%).

4. Conclusions

This paper used data from the BHPS to provide an analysis of trends in self-rated health poverty in Britain over 1991-2008. We used ordinal FGT poverty indices proposed recently by Bennett and Hatzimasoura (2011), which are appropriate for the ordinal nature of self-rated health data. We have also extended the approach of Bennett and Hatzimasoura (2011) by providing statistical inference for their ordinal FGT indices. Moreover, we have used the subgroup decompositions of health poverty changes borrowed from the literature of measuring income poverty.

Our results suggest that empirically there are additional insights from analysing health poverty with a family of ordinal FGT indices, rather than using health poverty rate only. The BHPS data show that when “fair” self-reported health status is chosen as a health poverty threshold all ordinal FGT indices indicate the growth of health poverty in Britain. However, when health poverty threshold is lower ("poor" self-reported health status) only poverty rate increases in a statistically significant way.

More generally, we may expect that the ordinal FGT poverty indices may be also useful in analysing data with more levels of self-reported health statuses. For example, it would be interesting to check if trends in poverty of *satisfaction with health*, which is measured in practice even on a 11-point ordinal scale (see, e.g., Frijters et al. 2005), are robust to the choice of a poverty threshold.

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Faculty of Economic Sciences
University of Warsaw
44/50 Długa St.
00-241 Warsaw
www.wne.uw.edu.pl