M I S C E L L A N E A

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Multidimensional Poverty Analysis in Polish Gminas

Introduction

Until the early seventies most welfare measures were based on income as an indicator of individual well-being. This narrow focus on income has been criticized by such prominent researchers as Nobel Prize winners, Joseph Stiglitz and Amartya Sen. It is now widely accepted in the economic literature that well-being and hence, the shortfall of well-being, namely poverty deprivation, is a multidimensional concept. This idea is reflected in such renowned initiatives as Stiglitz-Sen-Fitousi commission, created in 2008 by the French government with the aim of proposing new ways of measuring economic performance and social progress and the launch of Better Life Index by OECD in 2010. Governments of countries such as France, United Kingdom, Japan and Canada have been recently increasingly attending to the topic of measuring socio-economic progress. In particular, the goal is to go beyond GDP per capita as a sole indicator of well-being.

The literature on the measurement of well-being has largely addressed income well-being of individuals or of households. Yet well-being exists along multiple dimensions of which income is just one. Characteristics such as health, education, and housing are also relevant well-being factors. Income can partially be used as a proxy for them; however, there are also sources of well-being other than income. Educational outcomes may depend on factors such as the availability of schools, legislation regarding child labor, and labor market opportunities. As the empirical literature shows [Jensen, Skyt Nielsen 1997], there does not necessarily have to be much association between these factors and individual or household income, hence income well-being indices will be to a large extent inadequate in evaluating social progress. Also, measures of well-being based only on income do not account for the possibility that in many countries services such as health care or education are provided by the state. Therefore, it does not have to be the case that, for example, income poor have also low education and indeed sometimes the real picture is more complicated. Alkire and Santos [2010] show that there is nearly 40 percent of income poor in Ethiopia but, on the other hand, as much as 90 percent poor when health and education are also considered.

For the above mentioned reasons multidimensional measures sprung up in social sciences (psychology, economics, sociology) and so did measures of poverty and inequality. Most

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notably, United Nations uses Human Poverty Index (HPI) that measures deprivation in health, education and standard of living. The criticism with HPI and with most such indices is the arbitrariness of the functional form, in particular weights applied to each dimension and aggregation procedures. In order to remove this arbitrariness, Atkinson and Bourguignon [1982] presented stochastic dominance criteria under which it is possible to determine whether one multivariate distribution is more unequal than another. In economics stochastic dominance has been used usually in the decision making under uncertainty, but nowadays it is also applied in the analysis of poverty [Panek 2011][1]. Duclos, Sahn and Younger [2006] propose how to make multidimensional comparisons of two distributions with respect to poverty that are robust to the choice of an index and a poverty line. They also extended statistical results of Davidson and Duclos [2000] to cases where deprivation is measured in at least several dimensions. In what follows we draw mostly on these results.

Important thing to note is that multidimensional poverty measurement should not be mistaken with a simple measure of poverty along different dimensions separately, since then, upon aggregation, the association between attributes will be washed out. Association is a distinctive feature of multidimensional analysis; in fact, it is association that makes the analysis truly multidimensional. It can happen (and it does happen in our dataset) that the results obtained while carrying out multidimensional analysis differ if we were only to compare dimension by dimension (separately). The reason why this occurs is exactly the association between considered variables. Imagine we study poverty in dimensions such as income and health measured by the level of hemoglobin and we compare poverty between rural and urban areas. It is possible that in one dimension marginal distribution in urban stochastically dominates the one in rural areas, that is, less formally speaking, for every level of income there is lower percentage of individuals falling behind this level in urban area than in the rural area. Yet comparing marginals is not equivalent to comparing joint distributions of income and hemoglobin level in the two areas. It may happen that in cities income and hemoglobin are strongly positively correlated, hence if a person is income poor it is a good chance he or she suffers also from poor health. In poverty measurement literature such correlation is usually considered as a sign of higher poverty, that is, between two multidimensional distributions with the same marginals the one with higher association among variables is said to have more poverty. Therefore, in our example it may occur that there is bidimensional dominance of rural over urban area despite urban-over-rural unidimensional dominance in income.

In this paper we present the results of multidimensional poverty analysis carried out in Poland. We use the data on five Polish gminas (Gostyń, Gliwice, Zgierz, Małogoszcz, Manowo) that were gathered in the COMPETE project[2]. We compare relative welfare standing of the gminas in dimension of income and education (years of education completed or highest education level attained). There are some drawbacks to the considered dataset that will be described in detail in Section 2, but for comparison purposes the data available is sufficient. First, we run pairwise comparisons in each dimension separately. Two distributions in the considered dimension (for instance, the cummulative distribution of income in Zgierz in Gliwice) can either cross, be identical or dominate each other. Next we check the results of unidimensional analysis in light of bivariate welfare comparisons.

In our dataset we observe three distinctive types of results. Type 1 occurs when we find unidimensional dominance in both dimensions and bidimensional dominance. It is the least interesting type since bidimensional analysis adds no further information to what was already

[1] The concept of stochastic dominance is described in detail in the next section.

[2] The project Civilisation Competences and Sustainable Development in Polish Regions was financed by Norwegian EEA grant and Polish Ministry of Science and Higher Education. The director of the project was Professor Barbara Liberda from University of Warsaw, Faculty of Economic Sciences.

known due to unidimensional comparisons. Type 2 occurs when neither unidimensional nor bidimensional methods find dominance. It is equally uninteresting because of inconclusiveness. Type 3 is when we find bidimensional dominance although there is no unidimensional dominance in any or both of the variables. This case is interesting because it helps to remove inconclusiveness of unidimensional comparisons. However, the most intriguing in this respect is the case when there is unidimensional dominance of one region in one dimension and of the other region in the other dimension but bidimensional dominance is present. Thus bidimensional approach resolves the conflict between univariate comparisons.

In what follows we compare well-being status in five gminas by how well they fare in poverty deprivation. We build on the substantial statistical literature on poverty rankings [Duclos, Sahn, Younger 2006; Davidson, Duclos 2000]. We use the tests of unidimensional comparisons included in DASP which is a distributive analysis package written for STATA by Duclos and Abdelkrim [Duclos, Abdelkrim 2009] and multidimensional test of Duclos, Sahn and Younger [2006][3]. Gminas were choosen as representative of some characteristic (demographic situation, cultural and economic activity, etc.). We examine if this choice is consistent with the results of multidimensional analysis.

There are four major conclusions from the analysis. First of all, our results indicate that it is worthwile to conduct multidimensional comparisons in Polish context, since two out of ten cases we analyze fall into the most interesting category (type 3). These are situations where multidimensional analysis is more informative and helps to remove inconclusiveness that would arise had we done only unidimensional tests. Secondly, in applying stochastic dominance techniques we use information on the whole distribution, therefore the results we obtain differ from and are more thorough than, for example, simple comparisons of means only. Thirdly, bidimensional perspective reveals that gmina Gostyń fares relatively better than one would think by considering mean income only (which is second lowest). Gostyń dominates all other gminas, thanks to the low correlation of income and years of education. This low correlation means that it is less possible in Gostyń than in other gminas to be deprived in both dimensions. In other words, in Gostyń those with low education are less likely to have low income too. Finally, we found a pattern that already emerged in other multidimensional results [Duclos 2006]: multidimensional poverty can be greater in cities (Gliwice) than in rural areas (Gostyń).

With respect to unidimensional dominance, we have obtained interesting results in case of income comparisons. Zgierz which has clearly the highest mean income is dominated by most of the gminas. This is due to high income inequality in Zgierz.

In Section 1 we define stochastic dominance formally. In Section 2 we describe survey and data we use. In Section 3 we present the results. Finally, we conclude.

1. Stochastic dominance

The concept of stochastic dominance in economics was motivated by the studies in the field of decision making under uncertainty. Namely, it is well-known that with mild assumptions on the preferences, a person would choose distribution A over B if A stochastically dominates B in the first order. This is a much more powerful conclusion than the one that comes from comparing expected outcomes between two distributions, because the fact that expected outcome is higher in one distribution than in the other is not a sufficient condition

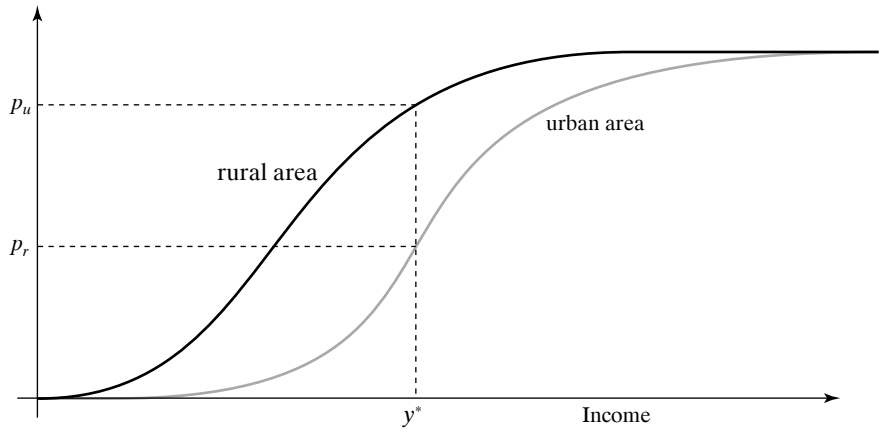
[3] The version of the test we use was originally written by Gaston Yalonetzky from Oxford Poverty and Human Development Initiatiave and later modified by us with the help of Piotr Miłoś to account for sampling design.

for stochastic dominance. Ranking distributions with regard to stochastic dominance requires more than simply comparing the means of the distributions. The determinants of stochastic dominance ranking are both differences in expected performance and the degree of risk embedded in given distributions.

First, we will motivate the concept of stochastic dominance informally, then we will provide formal definitions. In order to introduce some intuition we will start with univariate example as in this context it is easier to grasp the general idea. In Figure 1 we see cummulative density function (cdf) for income distribution in rural and urban areas, where the cdf for urban lies everywhere below cdf for rural.

Figure 1

Cummulative distribution curves for rural and urban area



Source: Own elaboration.

Let us think of the values of income as poverty lines. Then, for a given income y^* the fraction on the vertical axis will indicate the cummulative share of individuals who have less and equal income to y^*, or equivalently well-known headcount ratio. It is easy to see that no matter what poverty line is, headcount ratio is always greater in rural (p_r) than in urban area (p_u) and consequently, poverty is greater (or well-being is lower) in rural area than in urban. In such a case we say that distribution in urban area dominates distribution in rural area in terms of *first order domination*. This conclusion is robust to the choice of poverty line. However, it is also robust to the choice of poverty index [Duclos, Sahn, Younger 2006], namely, it is valid for broad class of poverty measures that are additive, non-decreasing (with respect to any person's income) and anonymous. Anonymity axiom means that the index is invariant with respect to permutation of individual incomes.

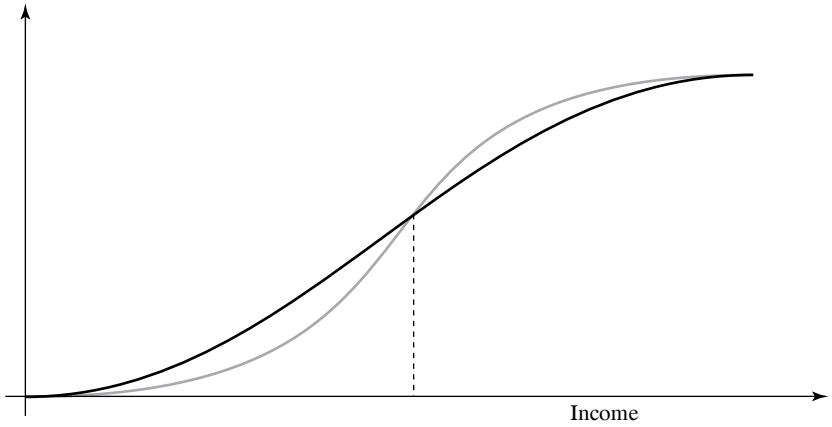
It is not always possible to establish clear poverty ranking such as the one we presented. Two curves may cross as in the Figure 2. If this happens, then we may still conclude poverty is lower in one distribution than in the other up to the value of income which is first crossing and this conclusion is still applicable to the wide class of poverty measures. On the other hand, we can resort to higher orders of dominance. We then make comparisons over smaller class of poverty measures but if additional assumptions are made areas under the crossing curves can be compared[4]. Without going into much detail, it suffices to say that in many

[4] For further information on stochastic dominance concepts see Duclos, Sahn and Younger [2006].

cases we will be able to establish *second order dominance* and find the relevant class of poverty indices. If this does not work, then we may use *third order dominance*, and so on. In practice, however, usually only orders up to the third are used as related axioms become harder to interpret.

Figure 2

Two curves crossing



Source: Own elaboration.

Bidimensional dominance is an extension of unidimensional dominance. Here, we compare surfaces rather than lines. If one surface is everywhere below the other, we obtain first order dominance. An important thing to notice is that unidimensional comparisons are the comparisons of marginal cummulative densities. It is possible that at the extreme one distribution is higher than the other (it dominates unidimensionally) but bivariate dominance is not present. This is due to the association (e.g. correlation) between two variables, in the middle of the plot one surface rises more rapidly than the other. This is why multidimensional dominance differs from multiple unidimensional comparisons; association does matter. In what follows, it is assumed that the higher correlation between variables, the more poverty we observe.

Another important thing we should mention about is the definition of poverty line. It is obvious in case of one dimension, but with many dimensions there are many possible definitions. First, there is *union* definition of poverty, which treats individual as poor if he or she is deprived in at least one dimension. On the other extreme, there is *intersection* definition of poverty, in which a person is poor if he or she is deprived in each dimension. Between these two extremes, intermediate choices are possible.

Important thing to note is that typically at the beginning of the curve, the difference is zero, i.e. two distributions intersect. This can happen either because they indeed intersect (in which case we find no dominance) or because we have not enough observations (our tests are not powerful enough). It is reasonable therefore to declare dominance over some restricted range. In our case the number of observations at the beginning of the curve was usually very low, therefore we treat it as the main cause of distributions intersecting each other.

Now we are ready to provide formal definitions. We follow Duclos, Sahn and Younger [2006]. First, we start with unidimensional dominance, then we will describe bidimensional

dominance. Let y denote the dimension of well-being (i.e. income). Let z denote the poverty line and $F(y)$ is a cummulative distribution function for y. Stochastic dominance of order y is evaluated through comparison of dominance curves

$$D_j(z) = \frac{1}{(j-1)!}\int_{y\min}^{y\max}(z-y)_+^{j-1}dF(y),$$

where $(z-y)_+ = (z-y)$ if $z > y$ and zero otherwise. Further, let us compare two distributions, A and B. Then $\Delta^j(z) = D_j^B(z) - D_j^A(z)$, we say that distribution B dominates distribution A for the order j if

$$\forall_{z\in[0,\infty]}\Delta(z) < 0.$$

This is the same as the comparison of the well-known *FGT* curves [Foster, Greer , Thorbecke 1984], namely

$$D_j(z) = \frac{1}{(j-1)!}P(\alpha, z),$$

where $P(\alpha, z)$ is an *FGT* index with parameter $\alpha = j - 1$. We will usually work with the differences of *FGT* curves.

Let x and y be two dimensions of well-being. In our case these are income and years of education. Let $z_x(y)$ and $z_x(y)$ denote the poverty lines (where poverty line in dimension x may depend on dimension y and vice versa). Let $f(x, y)$ denote joint density function. An additive poverty index is the following:

$$P(z_x(y), z_y) = \int_0^{z_y}\int_0^{z_x(y)}\pi(x, y; z_x(y), z_y(x))f(x, y)\,dxdy,$$

where z_y is an upper limit of poverty lines in the y dimension and π is the poverty line, that is:

$$\pi(x, y; z_x(y), z_y(x)) \geqslant 0 \text{ if } x \leqslant z_x(y); y \leqslant z_y(x); \pi(x, y, z_x(y), z_y(x)) = 0 \text{ otherwise.}$$

For simplicity we will put $\pi(x, y)$.

We define *bidimensional stochastic dominance* surfaces by

$$D^{S_xS_y}(z_x, z_y) = c\int_0^{z_y}\int_0^{z_x}(z_x - x)^{s_x}(z_y - y)^{s_y}f(x,y)\,dxdy,$$

where $c = ((s_x - 1)!(\text{sy} - 1)!)^{-1}$ is a constant and s_x, s_y are parameters. Denote by π^x the first derivative of $\pi(x, y)$ with respect to x and by π^y with respect to y; next π^{xy} is the cross derivative. Let us now define the class of poverty indices $\Pi^{1,1}$ such that:

$$z_x \leqslant 0; \quad \pi(x, y) = 0\ \forall y; \quad \pi^x \leqslant 0, \pi^y \leqslant 0, \pi^{xy} \geqslant 0\ \forall x, y.$$

We will now quote the main result that establishes the poverty dominance.

Theorem 1. *Poverty dominance* [Duclos, Sahn, Younger 2006]
Let ΔP, ΔD denote, respectively, the difference of the values of P, D in two considered distributions. Then, for all $P \in \Pi^{1,1}$ and for all $\zeta_y \in [0, z_y]$ and for all $\zeta_z \in [0, z_x]$

$$\Delta P(\zeta_z, \zeta_y) > 0 \text{ if } \Delta D^{1,1}(x, y) > 0, \quad \forall y \in [0, z_y], \forall x \in [0, z_x]$$

If the condition in Theorem 1 is met, then poverty is unambigously higher in one distribution than in the other for all poverty indices that belong to class $\Pi^{1,1}$ and all poverty

lines $\zeta_y \in [0, z_y]$, $\zeta_x \in [0, z_x]$. The condition requires that bidimensional surface is higher in one distribution than in the other for all poverty lines. Hence, statements about poverty can be made without arbitrariness embedded in specific poverty indices or in the choice of poverty frontier. Without explaining this in detail, let us note that higher dominance tests proceed analogously. We define classes of indices for which dominance conditions allow to declare higher poverty in one sample over the other. However, if one distribution as to the first order dominates the other, then it does so for higher orders of dominance too.

Statistical tests for dominance analysis were developed by Davidson and Duclos [2000] and Duclos, Sahn and Younger [2006].

2. Survey and data

We apply the approach presented in previous section to compare welfare among five Polish communities that have been chosen within the framework of the COMPETE research project[5]. Factor analysis based on 67 variables provided by Wójcik [2011] assures that these five units represent the most typical communities of five Polish regions from the Central-West part of Poland and at the same time they differ markedly. The city of Gliwice contains almost 200 000 people (the seventieth most populated city in Poland) and is located in the most urbanized region (Śląskie). Gostyń represents one of the most popular units in Wielkopolskie – 'active and efficient'. They are characterized by high school enrolment and efficient local self-government that gains subsidies from EU financing programs for investments. Małogoszcz is a middle-type community located in Świętokrzyskie, which is described by Wojcik as 'non-specific' one with relatively low factor loadings for all of the selected components (infrastructure, bad demography, education, culture, efficiency of local self-government). Manowo, the least populated community in Zachodniopomorskie, has been called 'a centre of local culture', whereas Zgierz is an example of the community with high level of demography dependency ratio. Random samples for each community were independent and data were weighed according to sampling design and the response rate. Originally there were about 500 observations from each community. However, due to lack of data some of them were excluded from the analysis (see Table 1).

Table 1

Basic characteristics of samples

Community	Original size	Final size	Percent of dropouts	Mean income	Mean years of education
Gliwice	500	392	21.6	2 018	13.88
Gostyń	500	392	21.6	1 662	13.29
Małogoszcz	500	431	13.8	1 651	12.61
Manowo	486	421	13.4	1 966	13.61
Zgierz	486	414	14.8	2 438	12.88

Source: Own elaboration based on COMPETE database.

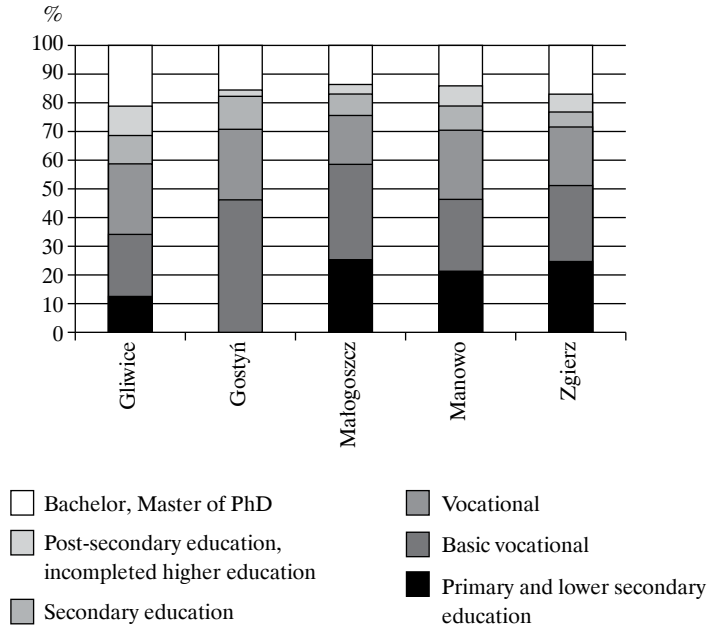
[5] For further information please refer to www.compete.pl.

Percent of dropouts in two of five communities is much higher than in three others. We report this outcome as one may suspect that it affects our analysis to some extent. Income nonresponse is an old and widely known problem in survey research [cp. Schräpler 2006]. Fortunately, in our case non-response rate for income questions does not seem to be correlated with the mean income in the community. Thus, for the purpose of this paper it is reasonable to neglect the problem and still treat the final samples as random ones.

Let us further notice that the Gini coefficient of income distribution for Gostyn is the lowest one (29.8%) whereas for Zgierz it is much higher (54.0%). This implies higher inequality in case of the city Zgierz than in any other community. From this point of view we decide to define well-being as a combination of two components. It is rather obvious that we use household income as a first proxy of well-being. However, as we pointed out in the Introduction, more than one dimension should be considered. Thus, we use the level of education attained (alternatively years of schooling) as another variable that enables us to measure welfare in each community. It follows a common pattern in Poland that relatively better educated people live in urban areas, e.g. the share of those who obtained an university diploma is in the city of Zgierz almost 50% higher than in case of the village Małogoszcz (see Figure 3).

Figure 3

Structure of educational attainment among analysed communities



Source: Own elaboration based on COMPETE database.

The main drawback of the COMPETE dataset is that there is information on household income and educational attainment of one of household members, thus the data cover different units. However, one may assume that the process of choosing a person to complete the questionnaire is more or less the same in all surveyed communities (even if it is not random). This seems to be enough for the purpose of comparisons.

3. Results

In this section we present results of unidimensional and bidimensional tests of stochastic dominance for comparing the distributions of income and education in five Polish gminas. Let us first concentrate on income comparisons. The results are included in Table 2.

Table 2

Stochastic dominance in income

Community A	Community B	Davidson&Duclos test outcome interpretation	Dominance order tested
Gliwice	Gostyń	no dominance	Up to III
Gliwice	Małogoszcz	Gliwice dominates	I
Gliwice	Manowo	no dominance	Up to III
Gliwice	Zgierz	Gliwice dominates	II
Gostyń	Małogoszcz	Gostyń dominates	II
Gostyń	Manowo	no dominance	Up to III
Gostyń	Zgierz	Gostyń dominates	I
Małogoszcz	Manowo	Manowo dominates	I
Małogoszcz	Zgierz	no dominance	Up to III
Manowo	Zgierz	Manowo dominates	II

Source: Own elaboration based on COMPETE database.

No clear ranking emerges. Gliwice dominates most of the gminas and both Manowo and Gostyń dominate Zgierz and Małogoszcz. This means that, for instance, for every income level lower than 1200 PLN the percentage of individuals falling behind this particular level of income is higher in Zgierz than in Gostyń. Figure 4 presents the difference of cummulative distributions (with 95% confidence intervals) of Gostyń and Zgierz. Except for the very beginning this difference is below zero until level 1200 PLN, which means that in this range (0, 1200 PLN) income distribution in Gostyń (first order) stochastically dominates income distribution in Zgierz.

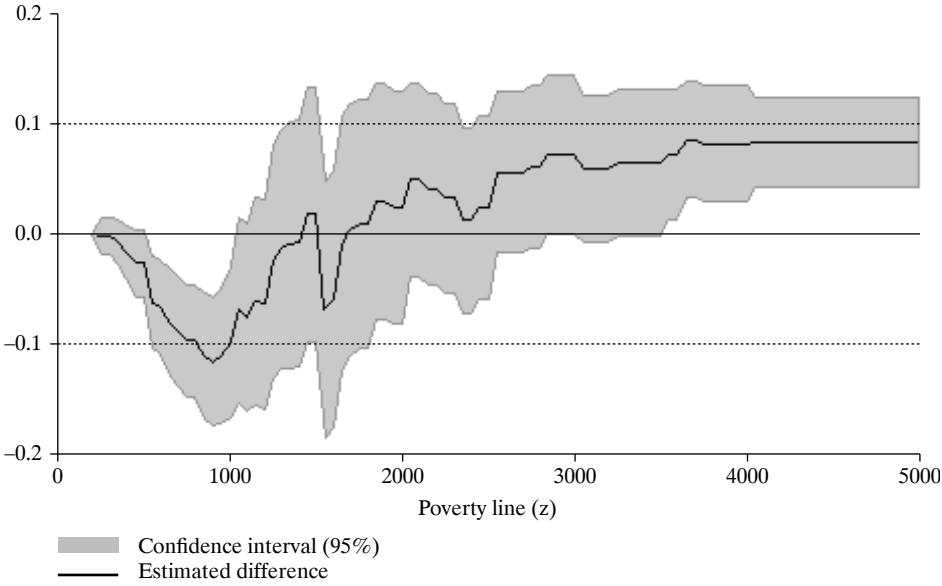
These results might seem highly surprising if one again looks into the mean income values. Mean income in Zgierz is clearly the highest among all the gminas, whereas mean income in Gostyń is close to be the lowest. In general there are two roots of dominance: the difference in expected outcomes (here mean income) and the degree of risk embedded in the distribution. If mean income is higher in Zgierz but we still obtain that Gostyń dominates Zgierz it means there must be much more inequality in incomes (or in other words, more risk) in income distribution in Zgierz. We can check it using Lorenz dominance curves (Figure 5)[6].

Indeed, the difference between two Lorenz curves is positive which here means that Gostyń clearly dominates Zgierz in inequality; there is much less income inequality in Gostyń than in Zgierz and this is the reason why first order dominance holds. In fact, Zgierz is dominated by all gminas except of Małogoszcz and the main reason is also high income inequality. In case of Małogoszcz the difference in inequality (which we can see in Figure 6) is not enough to compensate for the difference in means (let us recall that Małogoszcz has the lowest mean income) and hence no dominance occurs.

[6] Alternatively, we can use Gini coefficient as we did it in the previous section, however Lorenz dominance is a more general notion.

Figure 4

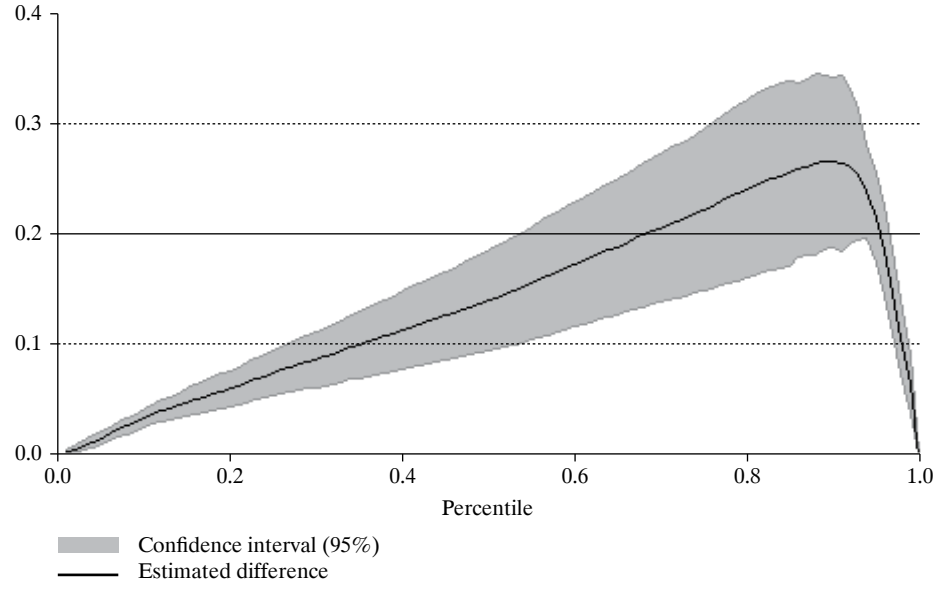
Stochastic dominance (1st order) in income – Zgierz vs. Gostyń



Source: Own elaboration based on COMPETE database.

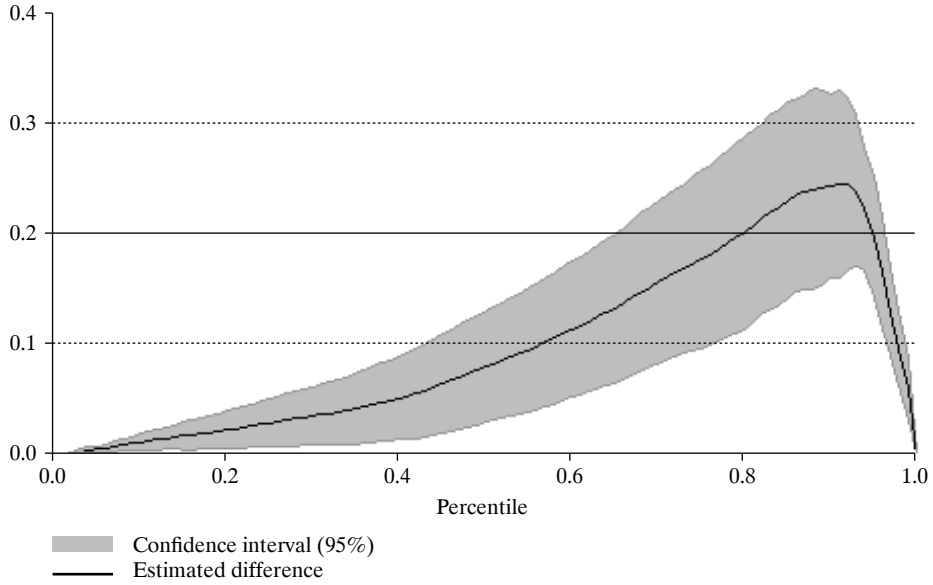
Figure 5

Lorenz dominance in income – Zgierz vs. Gostyń



Source: Own elaboration based on COMPETE database.

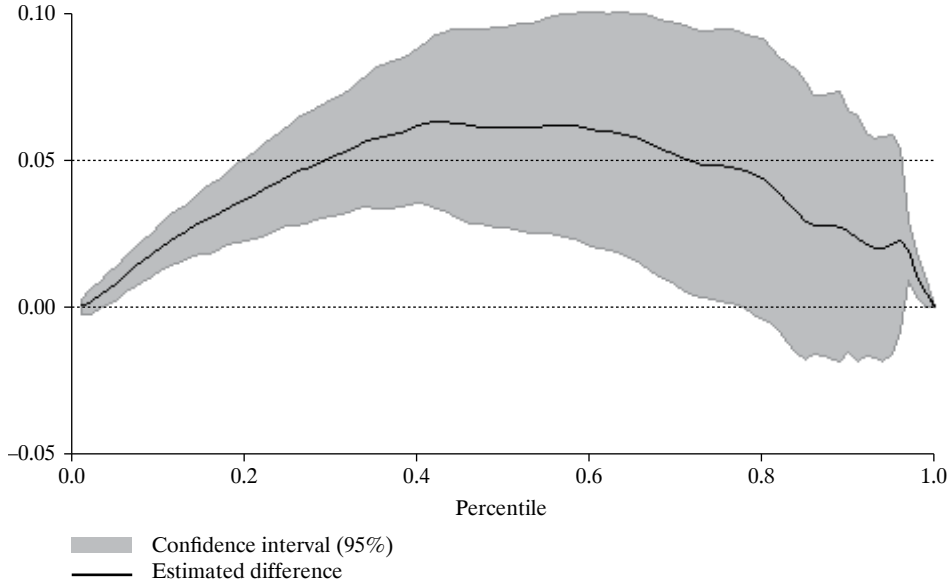
Figure 6
Lorenz dominance in income – Zgierz vs. Małogoszcz



Source: Own elaboration based on COMPETE database.

In the same vein we can make other comparisons. Let us consider Gostyń and Małogoszcz. Mean incomes are similar (respectively, 1662 PLN and 1651 PLN) and Gostyń dominates Małogoszcz. Therefore we expect there is more inequality in Małogoszcz than in Gostyń and this is confirmed by the Figure 7.

Figure 7
Lorenz dominance in income – Małogoszcz vs. Gostyń

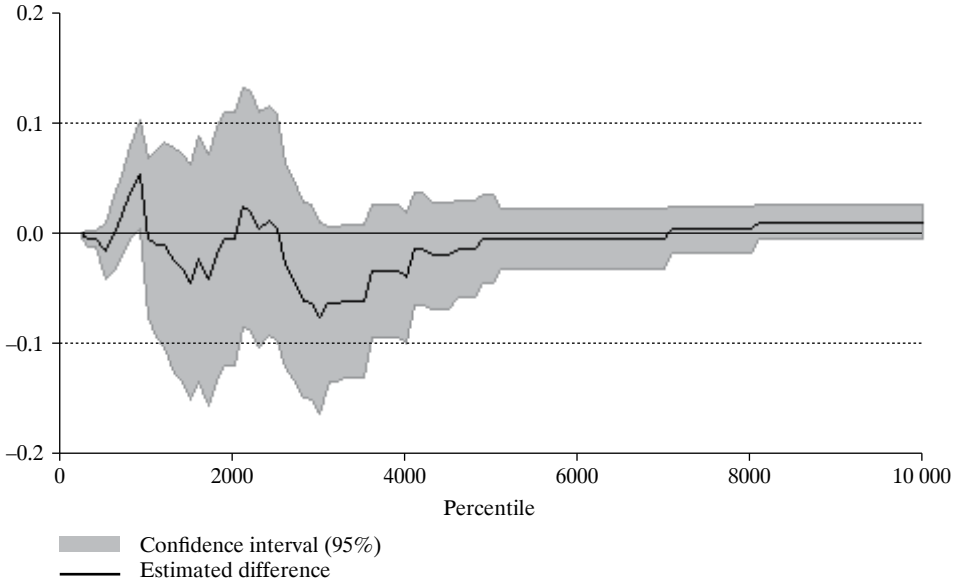


Source: Own elaboration based on COMPETE database.

In case of Gliwice and Manowo we get an inconclusive ranking (Figure 8). The means are close to each other (2018 PLN in Gliwice and 1966 PLN in Manowo), and the degree of inequality is similar, too.

Figure 8

Stochastic dominance (1st order) in income – Manowo vs. Gliwice



Source: Own elaboration based on COMPETE database.

Let us now consider education. Differences in welfare measured on the educational attainment scale between two communities mentioned above seem to be rather obvious. Table 3 summarizes the results of dominance tests.

Table 3

Stochastic dominance in years of education

Community A	Community B	Davidson&Duclos test outcome interpretation	Dominance order tested
Gliwice	Gostyń	Gliwice dominates	I
Gliwice	Małogoszcz	Gliwice dominates	I
Gliwice	Manowo	Gliwice dominates	I
Gliwice	Zgierz	Gliwice dominates	I
Gostyń	Małogoszcz	Gostyń dominates	I
Gostyń	Manowo	no dominance	Up to III
Gostyń	Zgierz	Gostyń dominates	II
Małogoszcz	Manowo	Manowo dominates	I
Małogoszcz	Zgierz	no dominance	Up to III
Manowo	Zgierz	Manowo dominates	II

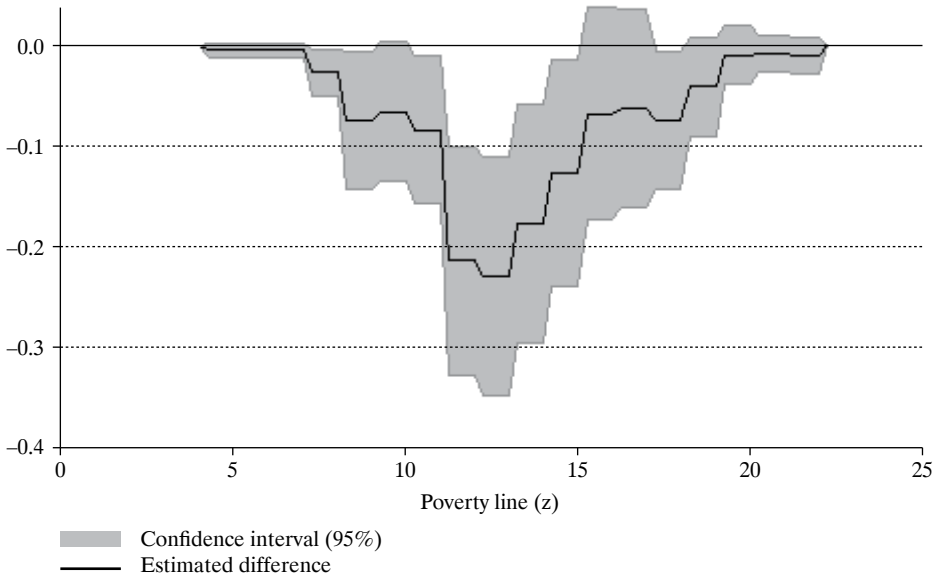
Source: Own elaboration based on COMPETE database.

These results follow more or less the distribution of mean level of years of education completed. We do not observe dominance between gminas for which means are close to each other such as Małogoszcz and Zgierz (respectively, 12.61 and 12.88 years) and Gostyń and Manowo (respectively, 13.29 and 13.61 years). Except for Małogoszcz, Zgierz is dominated by all other gminas. The position of Zgierz may be explained by the fact that it is the community with relatively high dependency ratio (a relation between the number of people who are typically out of the labour force due to their age and those aged 15–60/65). As educational attainment is strongly determined by the age (older cohorts are relatively worse educated), in communities with high share of the elderly one may observe high share of those who completed only primary school.

Gliwice clearly dominates all other gminas in terms of educational attainment of its citizens (Figure 9). This is hardly surprising since it is the biggest urban area in this study.

Figure 9

Stochastic dominance in years of education – Małogoszcz vs. Gliwice



Source: Own elaboration based on COMPETE database.

Finally, we would like to present the results of bidimensional comparisons with taking into account both dimensions – income and education. Wanting to apply the test of Duclos-Sahn-Young for one discrete and one continuous variable we changed education variable from years of schooling into the highest level of education completed (the correlation between the two is 0.91). Having applied Duclos-Sahn-Young test with correction for weighed survey data we obtained the results presented in Table 4.

Each pair of communities has been classified as 'type 1' or 'type 2' when the direction of bidimensional stochastic dominance is the same as the univariate ones or if we observe no dominance or intersections. 'Type 3' is a category for those pairs of communities where bidimensional dominance is of reversed direction in comparison to at least one of the univariate ones or when there are two unidimensional no dominance results. Particularly interesting is the case of Gostyń and Gliwice. Gliwice dominated Gostyń with respect to educational attainment and the ranking was inconclusive in terms of income comparison.

Table 4

Bidimensional stochastic dominance for income and educational attainment

Community A	Community B	Davidson&Duclos test outcome interpretation	Dominance order tested	Type of the result
Gliwice	Gostyń	Gostyń dominates	II	3
Gliwice	Małogoszcz	Gliwice dominates	II	1
Gliwice	Manowo	Intersection	–	2
Gliwice	Zgierz	Gliwice dominates	I	1
Gostyń	Małogoszcz	Gostyń dominates	II	1
Gostyń	Manowo	Gostyń dominates	II	3
Gostyń	Zgierz	Gostyń dominates	II	1
Małogoszcz	Manowo	Manowo dominates	I	1
Małogoszcz	Zgierz	Intersection	–	2
Manowo	Zgierz	Manowo dominates	II	1

Source: Own elaboration based on COMPETE database.

Now Gostyń dominates Gliwice bidimensionally. This is, as we mentioned previously, because of the low correlation of both variables; indeed, *R*-Pearson coefficient between income and years of education for Gostyń is equal to 0.28 whereas in case of Gliwice it is as high as 0.36. In other words, there is greater chance in Gliwice of being both educationally and income poor than in Gostyń. This means that there is less poverty in rural area such as Gostyń than in big urban area such as Gliwice. If we were to judge each dimension separately, we would probably come out with a different and a misleading conclusion. This is exactly the situation when the knowledge about the whole distribution is necessary for the analysis.

Conclusions

In this paper we compared five Polish communities with respect to poverty status. The comparison method employed in the article is truly multidimensional in a sense that it uses information about the whole distribution of attributes. We chose income and educational background as dimensions of welfare. Since the analysis is one of the first applications (to the best of our knowledge) of multidimensional dominance approach to Polish data, we concentrated more on presenting the benefits of the approach in analyzing poverty in Poland than on the results itself. Therefore, the choice of welfare attributes follows the common practice in social welfare and poverty literature. The general conclusion from the study is that multidimensional approach sheds light on new aspects and characteristics of poverty in Poland. For instance, in two out of ten cases we found situation in which bidimensional dominance resolves the conflict or inconclusiveness between unidimensional measures. This means that in one fifth of the cases analyzed in the study multidimensional methods provide

new information that changes the general picture of the poverty comparisons. Furthermore, such situation was most evident in comparisons with Gostyń community which is due to low correlation of dimensions there. In consequence, Gostyń fares very well against other communities, at least better than it follows from unidimensional analyses. As we argued at the beginning of the article, current economic literature treats welfare and poverty as inherently multidimensional concepts. Our analysis shows that clear multidimensional phenomena emerge in data on Polish regions too. Therefore, welfare, inequality and poverty analysis in Poland should be based on multidimensional techniques.

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