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Appraising two-Dimensional Inequality: A Questionnaire-Experimental Approach

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Abstract

This paper aims to study the extent to which people's intuitions about the distribution of two attributes within a society are consistent with the different axiomatizations proposed by the economists. In particular, the objective is to compare two alternative principles, namely aversion to dispersion of attributes and aversion to correlation between attributes. By using a questionnaire approach, most people are found to be more averse to correlation rather than averse to dispersion.

JEL Classification Code : I30, D63

Keywords : Multidimensional Inequality ; Questionnaire - Experimental

1 Introduction

It has long been recognized that monetary income is not the only attribute of human well-being and that non-monetary attributes as health or education should be treated as relevant for distributive justice (see for example Sen (1985) and Sen (1993)). Inequality should be then treated as a multidimensional phenomenon.

This paper uses a questionnaire - experimental methodology to assess the various theoretical routes to address the question of the measurement of multidimensional inequality. In the context of a single attribute, the Pigou-Dalton principle of progressive

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transfer states that a social situation improves normatively when a *small* amount of attribute is transferred from an individual to a poorer one. The point that the theoretical litterature deals with is to find an unanimous extension of the Pigou-Dalton principle of progressive transfer in the context of two or more attributes to distribute among a population. Two possibilities have been explored by the economists. A first way introduced by Kolm (1977) requires that lowering *dispersion* of attributes reduces multidimensional inequality. That is, averaging allocation of the attributes across individuals reduces multidimensional inequality. According to the second route initiated by Atkinson and Bourguignon (1982), our assessment of multidimensional inequality should depend on how the well-being's attributes varies together, that is, on the correlation between distributions of the different attributes.

This paper explores whether these two theoretical structures capture the intuition of people on how bi-dimensional inequality should be normatively measured. In other words, do people present aversion to dispersion of attributes and / or aversion to correlation between attributes? We use a standard questionnaire approach introduced by Yaari and Bar-Hillel (1984) and Amiel and Cowell (1992).[1] A recent paper, namely Bleichrodt et al. (2012), has also investigated the same question. Although the two papers test the same theoretical structures, the set of axioms tested in this paper is not exactly the same and the empirical methodology differs. Then, this study might be considered complement to Bleichrodt et al. (2012).

The rest of the paper is organized as follows. Section 2 presents the theoretical framework. In section 3, the empirical method is presented. Results are presented and discussed in section 4. Finally, section 5 concludes.

2 Elementary transformations

Consider a distribution of two attributes among n individuals, denoted by $\boldsymbol{z}$, described as a $2 \times n$ matrix of non-negative numbers:

$$\boldsymbol{z} = \begin{bmatrix} z_1^1 & \dots & z_i^1 & \dots & z_n^1 \\ z_1^2 & \dots & z_i^2 & \dots & z_n^2 \end{bmatrix}$$

where, for all $i = 1, ..., n$ and $j = 1, 2$, z_i^j represents the amount of attribute j received by individual i.

The question consists in defining *elementary transformations* which capture the idea of inequality reducing. This paper tests four alternative or complementary elementary transformations that could be considered as *equalizing*. We will first present ones translating aversion to dispersion and next aversion to correlation.

[1] See Schokkaert (1999) and Konow (2003) for overviews for overviews.

2.1 Dispersion-sensitive transformations

Attribute-specific Pigou-Dalton transfer. This route known as *specific* egalitarianism (Tobin (1970) and Kolm (1977)) applies the traditional Pigou-Dalton principle *independantly* to each attribute: any transfer of attribute ℓ reduces inequality no matter the distribution of the attribute m. The recipient of the transfer may be very well endowed in other goods than the donor but it is not taken into consideration.

Definition 1 *Distribution* $\boldsymbol{y}$ *results from distribution* $\boldsymbol{x}$ *by a specific Pigou-Dalton transfer of attribute* $\ell \in \{1,2\}$ *if for two individuals* h *and* k *and a real number* $\delta > 0$, $y_h^\ell = x_h^\ell - \delta \geq y_k^\ell = x_k^\ell + \delta$ *and* $y_h^m = x_h^m$ *and* $y_k^m = x_k^m$ *for* $m \neq \ell$. *For any individual* i $(i \neq h,k)$, $y_i^j = x_i^j \ \forall j = 1,2$.

It is worth emphazing that any Pigou-Dalton transfer of attribute ℓ improves social situation no matter the distribution of the attribute m. The recipient of the transfer may be very well endowed in other goods than k but it is not taken into consideration. It translates the idea that allocation of every attribute should be equalized among individuals.

Pigou-Dalton bidimensional transformation. The Pigou-Dalton bidimensional transformation demands an equalization of each dimension among individuals *simultaneously*. This transformation is close to the *uniform* majorization studied by Kolm (1977) which consists in *averaging* each marginal distribution through the application of a bistochastic matrix (see also Tsui (1999), Fleurbaey and Trannoy (2003) or Weymark (2004)).

Definition 2 *Distribution* $\boldsymbol{y}$ *results from distribution* $\boldsymbol{x}$ *by a Pigou-Dalton bidimensional transformation if for two individuals* h *and* k *and two real numbers* $\delta^1, \delta^2 > 0$, $x_h^j + x_k^j = y_h^j + y_k^j$, $|y_h^j - x_h^j| = |y_k^j - x_k^j| = \delta^j \quad \forall j = 1,2$. *For any individual* i $(i \neq h,k)$, $y_i^j = x_i^j \ \forall j = 1,2$.

Remark 1 *Kolm (1977) have shown the equivalence between the attribute-specific transfer and the Generalized Lorenz criterion applied to the marginal distributions.*

Consider two distributions with the same means, $\boldsymbol{x}$ *and* $\boldsymbol{y}$. *The distributions* $\boldsymbol{y}$ *is obtained by* $\boldsymbol{x}$ *by a finite set of attribute-specific Pigou-Dalton transfers if and only if* $\boldsymbol{y} \succ_{GL} \boldsymbol{x}$, *where* $\boldsymbol{y} \succ_{GL} \boldsymbol{x} \Leftrightarrow \boldsymbol{y}^j \succeq_{GL^j} \boldsymbol{x}^j \ \forall j \in \{1,2\}$ *and* $\boldsymbol{y}^j \succ_{GL^j} \boldsymbol{x}^j$ *for one* j *with* $\succ_{GL^j}$ *the well-known Generalized Lorenz criterion introduced by Shorrocks (1983).*

2.2 Correlation-sensitive transformations

It is worth emphasizing that attribute-specific Pigou-Dalton transfer and Pigou-Dalton bidimensional transformation ignore issues pertaining to the way by which the two attributes are *jointly* allocated among individuals. It could be argued that appraising bidimensional inequality should be based on correlation between attributes (see Epstein and Tanny (1980), Atkinson and Bourguignon (1982), Tsui (1999) or Gravel and Moyes (2006)). For any correlation-averse social planner, a situation is better than another if, all other things being equal, correlation between attributes is lower.[2]

Within-type Pigou-Dalton transfer. A wiser way of taking dependance between attributes into account consists in considering as inequality reducing any transfer of attribute ℓ from a rich to a poor (with respect to ℓ) while both of them are endowed with the same amount of attribute m (with $m \neq \ell$). This transformation is referred to as a *within-type*[3] *progressive transfer.*

Definition 3 *$\boldsymbol{y}$ results from $\boldsymbol{x}$ by a Within-type Pigou-Dalton transfer of attribute $\ell \in \{1,2\}$ if for two individuals h and k such that $x_h^m = x_k^m$ (with $m \neq \ell$) and a real number $\delta > 0$, $y_h^\ell = x_h^\ell - \delta \geq y_k^\ell = x_k^\ell + \delta$. For any individual i ($i \neq h, k$), $y_i^j = x_i^j$ $\forall j = 1, 2$.*

Between-type Pigou-Dalton transfer The *between-type* progressive transfer introduced by Ebert (1997) requires to transfer a certain amount of attribute from an individual to another who is not better endowed in the *both* attributes.[4]

Definition 4 *$\boldsymbol{y}$ results from $\boldsymbol{x}$ by a Between-type Pigou-Dalton transfer of attribute ℓ if for two individuals h and k and a real number $\delta > 0$, $y_h^\ell = x_h^\ell - \delta \geq y_k^\ell = x_k^\ell + \delta$ for $\ell = 1$ or 2 and $y_k^m = x_k^m \leq y_h^m = x_h^m$ for $m \neq \ell$. For any individual i ($i \neq h, k$), $y_i^j = x_i^j$ $\forall j = 1, 2$.*

Remark 2 *Gravel and Moyes (2006) shows that the two following propositions are equivalent:*

1. *$\boldsymbol{y}$ results from $\boldsymbol{x}$ by a between-type progressive transfer of attribute ℓ*

[2] Epstein and Tanny (1980) have introduced the transformation of *favorable permutation* of attributes which captures the aversion with respect to correlation given that the marginal distributions remains the same (see also Moyes (1999)).
Formally, suppose a distribution $\mathbf{x}$ with two individuals h and k such that $x_h^j > x_k^j$. The distribution $\mathbf{y}$ is obtained from $\mathbf{x}$ by a favorable permutation if : $y_h^\ell = x_k^\ell$, $y_k^\ell = x_h^\ell$ and $y_i^m = x_i^m$ with $\ell = 1$ or 2, $m \neq \ell$, $i = h, k$.
Tsui (1999) has proposed a similar transformation, namely the *correlation increasing majorization.* This transformation is not tested in this paper but an empirical assessment can be found in Bleichrodt et al. (2012).

[3] The *type* is in fact defined relatively to the endowment of the other attribute.

[4] See also Gravel and Moyes (2012).

2. *the total amount of attribute ℓ necessary to eliminate poverty in attribute ℓ is lower in $\boldsymbol{y}$ than in $\boldsymbol{x}$ for all combinations of individual poverty lines which are decreasing with the amount of the other attribute.*[5]

2.3 An additive social welfare function

The interest of the theory of inequality measurement comes from the fact that it establishes the equivalence between elementary distributions and welfare dominance. Let's introduce an additive social welfare function which is symmetrical with respect to bundles (in other words, we assume *anonymity*):

$$W(\boldsymbol{z}) = \sum_{i=1}^{n} u(z_i^1, z_i^2)$$

A distribution $\boldsymbol{y}$ is said to dominate $\boldsymbol{x}$ with respect to a certain class of utility functions $\mathcal{U}$, denoted $\boldsymbol{y} \succ_{\mathcal{U}} \boldsymbol{x}$, if $W(\boldsymbol{y}) \geq W(\boldsymbol{x})$ for all utility functions, $u(z_i^1, z_i^2)$, in the class $\mathcal{U}$ *and* $W(\boldsymbol{y}) > W(\boldsymbol{x})$ for one at least utility function in $\mathcal{U}$. Let us consider the following classes of utility functions:
$\mathcal{U}_1 = \{u : u_j \geq 0,\ u_{jj} \leq 0 \text{ and } u_{j\ell} = 0\ \forall j, \ell = \{1,2\} \text{ and } j \neq \ell\}$
$\mathcal{U}_2 = \{u : u_j \geq 0\ \forall j \in \{1,2\} \text{ and } u(\lambda z + (1-\lambda)\widetilde{z}) > \lambda u(z) + (1-\lambda) u(\widetilde{z})\}$
$\mathcal{U}_3 = \{u : u_j \geq 0\ \forall j \in \{1,2\} \text{ and } u_{j\ell} \leq 0\ \forall j, \ell \in \{1,2\}, j \neq \ell\}$

The first class of utility functions assumes additivity of the utility function with respect to the both attributes, that is, the marginal utility of each attribute does *not* depend on the endowment of the other attribute. Thus, any social criterion which respects this property is not sensitive to give one extra euro to an ill-health individual rather than to a well-health one - given that the two individuals have the *same* income. The class $\mathcal{U}_2$ assume the concavity of the utility function which captures the preference for *diversity*. That is, being rich and ill-health is preferred by having a *lower* income but in a *better* health since the bundle of attributes is more balanced.[6] Finally, the class $\mathcal{U}_3$ assumes the decreasingness of marginal utility of each attribute with respect to the other attribute. It is then normatively better to give one extra euro to an ill-health individual rather than to a well-health one - given that the two individuals have the *same* income.

The following proposition allows to interpret the elementary transformations presented above in the setting of additive social welfare function.

Proposition 1 *(Kolm (1977), Fleurbaey and Trannoy (2003), Gravel and Moyes (2006)). Consider two bidimensional distributions with the same means, $\boldsymbol{x}$ and $\boldsymbol{y}$.*

[5] More exactly, they have shown that a between-type progressive transfer is a combination of within-type transfer and a favorable permutation and that this combination is equivalent to (2).

[6] See Fleurbaey and Trannoy (2003) and Trannoy (2004).

1. *Distribution* $\boldsymbol{y}$ *results from distribution* $\boldsymbol{x}$ *by a finite set of attribute-specific Pigou-Dalton transfer(s) if and only if* $\boldsymbol{y} \succeq_{\mathcal{U}_1} \boldsymbol{x}$.

2. *Distribution* $\boldsymbol{y}$ *results from distribution* $\boldsymbol{x}$ *by the transformation of a bistochastic matrix if and only if* $\boldsymbol{y} \succeq_{\mathcal{U}_2} \boldsymbol{x}$.

3. *Distribution* $\boldsymbol{y}$ *results from distribution* $\boldsymbol{x}$ *by a finite set of Within-type and / or Between-type Pigou-Dalton transfer(s) if and only if* $\boldsymbol{y} \succeq_{\mathcal{U}_3} \boldsymbol{x}$.[7]

3 Empirical methodology

3.1 The questionnaire

The problem submitted to subjects is to assess distribution of crops (*crops per villager*) and health status (*proportion of people affected by the malaria*) among four villages of an hypothetical island. These villages are identical with respect to all aspects except for crops and health. Within each village, each individual receives the same amount of crops and has the same probability to be affected by malaria.

An appropriate choice of binary comparisons allows then to establish which theoretical conception is consistent with people's perception of bidimensional inequalities. The choice pairs are detailed in the table 1. Note that, for each question, distribution B results from distribution A by a certain elementary transformation as defined in section 2. That is, hereafter, a response will be called *orthodox* if B is preferred to A ($B \succ A$) and *heterodox* if A is preferred to B ($A \succ B$).

Subjects is assigned a quasi-impartial spectator (see Konow (2003), Amiel et al. (2007) or Konow (2009)). The question posed is: "Suppose that you are an **outside observer**. Please state which situation would be better from collective viewpoint."

3.2 The sample

The design is similar to a between-subjects design: four versions of the questionnaire have been drawn up and posed to different groups of subjects. Each of the four groups is asked questions relative to a particular elementary transformation.[8] As no question of incentives or strategic behaviors is studied, there is no show-up fee paid.

[7] As we said above, they have shown that $\succeq_{\mathcal{U}_3}$ is equivalent to a combination of within-type transfer and a favorable permutation.

[8] In fact, the subjects had to respond to five or six questions which aim to test dispersion-sensitive *or* correlation-sensitive transformations. For the sake of proper statistical treatment, we do not exploit all of the questions but only two questions per questionnaire. However, the results are not qualitatively changed by this choice.

	Situation A	Situation B
Attribute-specific Pigou-Dalton transfer		
Q1	$\begin{bmatrix} 5 & 11 & 16 & 20 \\ 0.14 & 0.10 & 0.12 & 0.08 \end{bmatrix}$	$\begin{bmatrix} 5 & 13 & 14 & 20 \\ 0.14 & 0.10 & 0.12 & 0.08 \end{bmatrix}$
Q2	$\begin{bmatrix} 5 & 7 & 9 & 22 \\ 0.07 & 0.10 & 0.15 & 0.25 \end{bmatrix}$	$\begin{bmatrix} 5 & 12 & 9 & 17 \\ 0.07 & 0.10 & 0.15 & 0.25 \end{bmatrix}$
Pigou-Dalton bidimensional transformation		
Q3	$\begin{bmatrix} 5 & 11 & 16 & 20 \\ 0.14 & 0.08 & 0.12 & 0.05 \end{bmatrix}$	$\begin{bmatrix} 5 & 13 & 14 & 20 \\ 0.14 & 0.09 & 0.11 & 0.05 \end{bmatrix}$
Q4	$\begin{bmatrix} 5 & 11 & 16 & 20 \\ 0.05 & 0.08 & 0.12 & 0.05 \end{bmatrix}$	$\begin{bmatrix} 5 & 13 & 14 & 20 \\ 0.05 & 0.09 & 0.11 & 0.05 \end{bmatrix}$
Q5	$\begin{bmatrix} 5 & 7 & 9 & 20 \\ 0.07 & 0.10 & 0.12 & 0.25 \end{bmatrix}$	$\begin{bmatrix} 5 & 12 & 9 & 15 \\ 0.07 & 0.14 & 0.12 & 0.21 \end{bmatrix}$
Q6	$\begin{bmatrix} 5 & 7 & 9 & 20 \\ 0.25 & 0.10 & 0.12 & 0.25 \end{bmatrix}$	$\begin{bmatrix} 5 & 12 & 9 & 15 \\ 0.25 & 0.14 & 0.12 & 0.21 \end{bmatrix}$
Within-group Pigou-Dalton transfer		
Q7	$\begin{bmatrix} 5 & 7 & 12 & 25 \\ 0.12 & 0.06 & 0.12 & 0.06 \end{bmatrix}$	$\begin{bmatrix} 5 & 10 & 12 & 22 \\ 0.12 & 0.06 & 0.12 & 0.06 \end{bmatrix}$
Q8	$\begin{bmatrix} 5 & 7 & 9 & 20 \\ 0.12 & 0.06 & 0.12 & 0.06 \end{bmatrix}$	$\begin{bmatrix} 5 & 12 & 9 & 15 \\ 0.12 & 0.06 & 0.12 & 0.06 \end{bmatrix}$
Between-group Pigou-Dalton transfer		
Q9	$\begin{bmatrix} 5 & 8 & 12 & 15 \\ 0.09 & 0.15 & 0.15 & 0.07 \end{bmatrix}$	$\begin{bmatrix} 7 & 8 & 12 & 13 \\ 0.09 & 0.15 & 0.15 & 0.07 \end{bmatrix}$
Q10	$\begin{bmatrix} 5 & 8 & 12 & 18 \\ 0.09 & 0.15 & 0.15 & 0.07 \end{bmatrix}$	$\begin{bmatrix} 10 & 8 & 12 & 13 \\ 0.09 & 0.15 & 0.15 & 0.07 \end{bmatrix}$

Table 1: The binary comparisons

During the college year 2010-2011, a total of 359 students of the University of Rennes took part in the survey. All of them are first and second year students in economics and none of them has been exposed to any lecture on the evaluation of unidimensional and multidimensional inequality. The survey includes hard-copy form questionnaires filled in during classes ($N = 300$) and on-line questionnaire ($N = 59$). Table 2 gives some descriptive statistics.

	N	Stat.
Age (mean)	339	18.85
Gender		
Female	141	40.17 %
Male	210	59.83 %
Political views		
No response	102	32.32 %
Mean value	243	3.84
Type of questionnaire		
Hardcopy form	300	83.57 %
On-line form	59	15.43 %
Version of questionnaire		
A	77	21.45 %
B	78	21.73 %
C	103	28.69 %
D	101	28.13 %

Table 2: Descriptive statistics of the main sample

	Change in social welfare			
	decreases	is the same	increases	
Questions	$A \succ B$	$A \sim B$	$B \succ A$	$N =$
Attribute-specific Pigou-Dalton transfer				
Q1	16	17	42	75
Q2	21	9	45	76
Pigou-Dalton bidimensional transformation				
Q3	17	17	44	78
Q4	15	14	49	78
Q5	29	9	36	74
Q6	19	14	41	74
Within-type Pigou-Dalton transfer				
Q7	12	20	71	103
Q8	16	11	76	103
Between-type Pigou-Dalton transfer				
Q9	19	12	70	101
Q10	16	10	75	101

Table 3: Comparisons of questions (frequencies)

4 Results

How do subjects value aversion to dispersion and aversion to correlation? Let us compare the distributions of preferences for each elementary transformations. Table 3 reports the results for each question. The chi-square test procedure is then applied in order to test the following null hypotheses:

- H_0^1: the distribution of preferences $(\succ, \sim, \prec)$ is the same for each of elementary transformations j and j'.
- H_0^2: the proportion of *orthodox* answers is the same for each of elementary transformations j and j'.
- H_0^3: the proportions of *heterodox* answers is the same for each of elementary transformations j and j'.

The values of test-statistics and p-values are summarized in the following table.[9] Each cell reports the three tests comparing transformation in row and transformation in column. The lines of each cell correspond to, respectively, H_0^1, H_0^2 and H_0^3.

		Between-type transf.	Att.-specific transf.	Bidim. transf.
Within-type transf.	H_0^1	2.28 ($p = 0.320$)	8.64 ($p = 0.013$)	14.64 ($p = 0.001$)
	H_0^2	0.01 ($p = 0.925$)	7.29 ($p = 0.007$)	12.44 ($p = 0.000$)
	H_0^3	1.09 ($p = 0.297$)	6.97 ($p = 0.008$)	11.91 ($p = 0.001$)
Between-type transf.	H_0^1		7.86 ($p = 0.020$)	13.03 ($p = 0.001$)
	H_0^2		7.70 ($p = 0.006$)	12.99 ($p = 0.000$)
	H_0^3		2.74 ($p = 0.098$)	5.58 ($p = 0.018$)
Att.-specific transf.	H_0^1			0.18 ($p = 0.913$)
	H_0^2			0.12 ($p = 0.731$)
	H_0^3			0.17 ($p = 0.677$)

Result 1: subjects are more averse to correlation than averse to dispersion.

We can reject the hypothesis that the preferences follow the same distribution for all of the elementary transformations. In average, the proportion of subjects who exhibit aversion to dispersion is significantly lower than the proportion of subjects who align themselves with aversion to correlation. Moreover, we can accept the hypothesis that there are more heterodox answers in questionnaires testing aversion to dispersion than in questionnaires testing aversion to correlation.

Finally, it should be noted that the preferences for the attribute-specific transfer follow the same distribution as the preferences for the bidimensional transformation. The same observation could be made for correlation-sensitive transformations.

[9] We assume implicitly the homogeneity of answers in the questions testing the same transformation.

Table 5 in appendix gives the p-values of the Chi-Square test for the comparison of the questions on the basis of the preferences' distributions. these results are finer but does not refute the qualitative conclusions drawn above.

Are subjects' judgments robust? It is now interesting to study the robustness of perceptions of the subjects. That is to say, we want to check whether the subjects change or not their judgment about the elementary transformations according to the question. The Stuart-Maxwell test is then applied to test the following null hypothesis:

- H_0^4: the distribution of preferences for any elementary transformation j does not depend on the question.

Result 2: the homogeneity in preferences' distribution is verified only for between-type transfer.

Concerning the within-type transfer, the hypothesis that the preferences follows the same distribution is rejected ($\chi^2 = 7.83$, $p = 0.020$). However, the McNemar test is used to compare the distributions of answers between orthodox and non-orthodox. Then, we do not reject the hypothesis that the proportion of orthodox answers is the same in the two questions ($\chi^2 = 1.09$, $p = 0.297$). The hypothesis that the between-type transfer is appraised in the same way in the two questions is not rejected: $\chi^2 = 1.20$ ($p = 0.548$).

We might consider that the judgements about the attribute-specific transfer do not follow the same distribution in the two questions: the value of the test-statistic is 4.62 and the p-value is 0.099. We should note that the proportion of orthodox answers is yet the same in the two questions ($\chi^2 = 0.36$, $p = 0.549$).

Let us now study how subjects appraise the bidimensional transformation. We cannot reject the homogeneity of the distributions of answers in the questions 3, 4 and 6. To the contrary, the preferences are distributed differently in question 5. The Stuart-Maxwell tests are summarized in the following table (test-statistics and p-values):

	Q4	Q5	Q6
Q3	1.27 ($p = 0.530$)	7.84 ($p = 0.020$)	0.93 ($p = 0.627$)
Q4		7.08 ($p = 0.029$)	1.29 ($p = 0.524$)
Q5			5.28 ($p = 0.072$)

The McNemar test allows us to conclude that the proportion of orthodox answers are the same in questions 3 and 5 ($\chi^2 = 0.95$, $p = 0.330$) and in questions 5 and 6 ($\chi^2 = 0.93$, $p = 0.336$). To the contrary, we might say that the proportion of orthodox answers is higher in question 4 than in question 5 ($\chi^2 = 3.46$, $p = 0.063$).

Finally, we compare the elementary transformations on the basis of the number of subjects who change their preference from a question to another one. A respondent is in (resp. out of) the line with a certain axiom if he gives the appropriate answer whatever the question. Similarly, one can think that a certain axiom is *robustly* reasonable (resp., inadequate) if it is well accepted (resp. rejected) by people whatever the context where it is implemented. It is then interesting to study the robustness of properties by focusing on the answers given to a combination of two questions.

We want then to determine whether the proportion of (in)consistent patterns of answers is similar whatever the elementary transformation considered. We say that a subject is *consistent* if she prefers A rather B or B rather A in all questions. A transformation may be then considered *more robust* than another one if the share of consistent pattern of answers is larger for the former than the latter. In the same time, any property may be judged not robust if the share of non-consistent pattern of answers is large, seeing that the context or question seem to play a role in the assessment of the transformation by an individual.

Pair of	Pattern of answers (B versus A)					
questions	$(\succ;\succ)$	$(\succ;\sim)$	$(\sim;\sim)$	$(\prec;\sim)$	$(\prec;\prec)$	$(\succ;\prec)$
Attribute-specific Pigou-Dalton transfer						
Q1 / Q2	31	7	6	7	6	18
Pigou-Dalton bidimensional transformation						
Q3 / Q4	36	9	9	4	8	12
Q3 / Q5	20	12	4	6	6	26
Q3 / Q6	27	9	8	6	4	20
Q4 / Q5	24	7	5	5	5	28
Q4 / Q6	30	6	8	5	3	22
Q5 / Q6	25	5	7	4	11	22
Within-type Pigou-Dalton transfer						
Q7 / Q8	62	13	9	0	9	10
Between-type Pigou-Dalton transfer						
Q9 / Q10	62	7	5	5	8	14

Note:
$(\succ;\succ)$: two orthodox answers ; $(\succ;\sim)$: one orthodox answer and an indifferent one ; $(\sim;\sim)$: two indifferent answers ; $(\prec;\sim)$: one heterodox answer and an indifferent one ; $(\prec;\prec)$: two heterodox answers ; $(\succ;\prec)$: one orthodox answer and one heterodox answer.

Table 4: Responses for Pairs of Questions.

Table 4 presents patterns of answers for all possible combinations of two questions which test the same transformation.[10] Around 60% of the subjects have a strong aversion to correlation ($B \succ A$ for the two questions) while 40 % of them are consistently in the line with the dispersion to correlation.[11] Moreover, the proportion of people who have not, in two questions, the same opinion about the transformations capturing aversion to dispersion is close to 25%. The corresponding share for correlation-sensitive transformation is close to 10%. Let us now check whether such observation are statistically significant.

Thanks to a Chi-Square test, the following hypothesis is tested:

- H_0^5: the distribution of patterns of answers is the same for elementary transformation j and j'.
- H_0^6: the proportion of subjects who are *always* orthodox is the same for elementary transformation j and j'.
- H_0^7: the proportion of subjects who change their preference is the same for elementary transformation j and j'.

Result 3: the evaluation of the correlation-averse transformations seems more robust than the evaluation of the dispersion-averse transformations.

Let us start to study the homogeneity of the distribution of all possible pairs of answers according to the pair of questions, that is, we test H_0^5. The following table summarizes the results of the Chi-Square tests (values of the test-statistic and the p-values).

[10]Note that there are six pairs of questions which test the empirical support for the bidimensional transformation. The distributions of patterns of answers are compared thanks to McNemar and Stuart-Maxell tests - see table 6 in the appendix.

[11]Concerning the bidimensional transformation, the proportion of inconsistent pairs of answers varies from 15% (Q3/Q4) to 37% (Q4/Q5). The subjects who are in the line of such a property in all of the two questions varies 27% (Q3/Q5) to 46% (Q3/Q4). These differences are statistically significant (see table 6).

	Within-type transf.	Between-type transf.	Att-specific transf. (Q1/Q2)
Within-type (Q7/Q8)		8.65 ($p = 0.124$)	18.68 ($p = 0.002$)
Between-type (Q9/Q10)			7.87 ($p = 0.163$)
Bidimensional transf			
Q3/Q4	8.58 ($p = 0.127$)	5.69 ($p = 0.337$)	3.47 ($p = 0.628$)
Q3/Q5	33.33 ($p = 0.000$)	23.30 ($p = 0.000$)	5.61 ($p = 0.346$)
Q3/Q6	21.64 ($p = 0.001$)	13.34 ($p = 0.020$)	1.39 ($p = 0.926$)
Q4/Q5	30.47 ($p = 0.000$)	18.42 ($p = 0.002$)	3.57 ($p = 0.612$)
Q4/Q6	22.11 ($p = 0.000$)	12.07 ($p = 0.034$)	2.11 ($p = 0.834$)
Q5/Q6	24.14 ($p = 0.000$)	14.96 ($p = 0.011$)	3.74 ($p = 0.588$)

The main conclusion is that we can accept the hypothesis that the distribution of pairs of answers is not distributed in the same for correlation-sensitive transformations than for dispersion-sensitive ones.

We test now the hypothesis that the proportion of subjects who are always orthodox is equal for correlation-averse transformations and dispersion-averse ones. The results of the Chi-Square tests of H_0^6 are summarized in the following table.

	Within-type transf.	Between-type transf.	Att-specific transf. (Q1/Q2)
Within-type (Q7/Q8)		0.03 ($p = 0.862$)	6.19 ($p = 0.013$)
Between-type (Q9/Q10)			6.95 ($p = 0.008$)
Bidimensional transf			
Q3/Q4	3.52 ($p = 0.060$)	4.12 ($p = 0.042$)	0.36 ($p = 0.548$)
Q3/Q5	19.05 ($p = 0.000$)	20.25 ($p = 0.000$)	3.39 ($p = 0.066$)
Q3/Q6	9.68 ($p = 0.002$)	10.59 ($p = 0.001$)	0.37 ($p = 0.544$)
Q4/Q5	13.29 ($p = 0.000$)	14.33 ($p = 0.000$)	1.27 ($p = 0.260$)
Q4/Q6	6.66 ($p = 0.010$)	7.44 ($p = 0.006$)	0.01 ($p = 0.922$)
Q5/Q6	12.02 ($p = 0.001$)	13.02 ($p = 0.000$)	0.91 ($p = 0.341$)

It is obvious that we can accept the hypothesis that the proportion of consistent correlation-averse subjects is higher than the proportion of consistent dispersion-averse subjects.

Finally, we study the proportion of inconsistent subjects, that is, we test H_0^7.

	Within-type transf.	Between-type transf.	Att-specific transf. (Q1/Q2)
Within-type		0.85 ($p = 0.357$)	6.27 ($p = 0.012$)
Between-type			2.68 ($p = 0.101$)
Bidimensional transf			
Q3/Q4	1.34 ($p = 0.247$)	0.08 ($p = 0.774$)	1.80 ($p = 0.180$)
Q3/Q5	17.18 ($p = 0.000$)	10.96 ($p = 0.001$)	2.22 ($p = 0.136$)
Q3/Q6	9.18 ($p = 0.002$)	4.73 ($p = 0.030$)	0.18 ($p = 0.672$)
Q4/Q5	20.21 ($p = 0.000$)	13.46 ($p = 0.000$)	3.34 ($p = 0.068$)
Q4/Q6	11.65 ($p = 0.001$)	6.58 ($p = 0.010$)	0.62 ($p = 0.430$)
Q5/Q6	11.65 ($p = 0.001$)	6.58 ($p = 0.010$)	0.62 ($p = 0.430$)

Generally, we can reject the hypothesis that there is the same proportion of inconsistent subjects in the four questionnaires. Hence, we can conclude that the aversion to dispersion is less robust than the aversion to correlation.

5 Conclusion

This paper investigates the extent to which people's intuitions about bidimensional inequality are in accordance with the theoretical structures proposed by the economists. Properties translating aversion with respect to correlation (*within-type* transfer and between-type transfer) seem to be well accepted by the subjects and more "popular" than properties which capture sensitiveness to dispersion of attributes (attribute-specific transfer and transfer of bundle). Moreover, the subjects' appraisal of correlation-sensitive transformations seems rather robust while subjects' evaluation of dispersion-sensitive transfers seem less consistent.

Even though the support to the uniform majorization or the Pigou-Dalton bidimensional transformation found in this paper is fairly similar than in Bleichrodt et al. (2012), the conclusion emerged from the two studies are different. Indeed, Bleichrodt et al. (2012) have found that the income-related health transfer and the correlation-increasing majorization are not supported by the subjects. Yet it does not mean that the aversion with respect to correlation is not supported since axioms tested are not exactly the same. It could be argued that the implementation of a given rule matters for people. For instance, people could think that the correlation-increasing majorization is not a good manner to implement the idea of aversion to correlation.

References

Amiel, Y. and Cowell, F. (1992). Measurement of income inequality: experimental test by questionnaire. *Journal of Public Economics*, 47:3–26.

Amiel, Y., Cowell, F., and Gaertner, W. (2007). Distributional orderings: an approach with seven flavours. Distributional Analysis research paper 93, STICERD, LSE, London.

Atkinson, A. B. and Bourguignon, F. (1982). The comparison of multi-dimensioned distribution of economic status. *Review of Economic Studies*, 49:183–201.

Bleichrodt, H., Rohde, K. I., and Van Ourti, T. (2012). An Experimental Test of the Concentration Index. *Journal of Health Economics*, 31(31):86–98.

Ebert, U. (1997). Social welfare when needs differ: an axiomatic approach. *Economica*, 64:233–244.

Epstein, L. and Tanny, S. M. (1980). Increasing generalized correlation: A definition and some economic consequences. *Canadian Journal of Economics*, 13:16–34.

Fleurbaey, M. and Trannoy, A. (2003). The impossibility of a Paretian egalitarian. *Social Choice and Welfare*, 21:243–263.

Gravel, N. and Moyes, P. (2006). Ethically robust comparisons of distributions of two attributes. IDEP working paper, no 06-04.

Gravel, N. and Moyes, P. (2012). Ethically robust comparisons of distributions of two attributes. *Journal of Economic Theory*, Forthcoming.

Kolm, S. C. (1977). Mulidimensional egalitarianisms. *Quarterly Journal of Economics*, 91:1–13.

Konow, J. (2003). Which is the fairest one of all? A positive analysis of Justice theories. *Journal of Economic Litterature*, 41:1186–1237.

Konow, J. (2009). Is fairness in the eye of the beholder? an impartial spectator analysis of justice. *Social Choice and Welfare*, 33:101–127.

Moyes, P. (1999). Comparaisons de distributions hétérogènes et critères de dominance. *Economie et Prévision*, pages 125–146.

Schokkaert, E. (1999). M. Tout-le-monde est "post-welfariste": opinions sur la justice distributive. *Revue Economique*, 50:811–831.

Sen, A. K. (1985). *Commodities and Capabilities*. North Holland, Amsterdam.

Sen, A. K. (1993). Capability and well-being. In Nassbaum, M. and Sen, A. K., editors, *The Quality of Life*, pages 30–52. Clarendon Press.

Shorrocks, A. (1983). Ranking income distributions. *Economica*, 50:3–17.

Tobin, J. (1970). On limiting the domain of inequality. *Journal of Law and Economics*, 13:263–277.

Trannoy, A. (2004). Multidimensional egalitarianism and the dominance approach. In Farina, F. and Savaglio, E., editors, *Inequality and Economic Integration*. Routeledge, London and New-York.

Tsui, K. (1999). Multidimensional inequality and multidimensional generalised entropy measures: an axiomatic derivation. *Social Choice and Welfare*, 16:145–157.

Weymark, J. (2004). The normative approach to the measurement of multidimensional inequalities. In Farina, F. and Savaglio, E., editors, *Inequality and Economic Integration*. Routledge.

Yaari, M. and Bar-Hillel, M. (1984). On Dividing justly. *Social Choice and Welfare*, 1:1–24.

A The wording of the questionnaire (translated from french)

Important note

The aim of this research is to study the attitudes of people about the social inequalities in a society. For that, we will consider a simple society. We propose you different situations and we will ask you to compare some of these situations.

As it's about **your opinions**, **there is not right answers to the following questions**.

This questionnaire has [4,5] questions plus questions concerning some personal characteristics.

This questionnaire is **anonymous**.

Situation of Alpha Island

We are interested by an island, namely Alpha Island, with 4 villages of the same size. The villages differs from each other on the basis of the following aspects :

1. the crops (fruits and vegetables)
2. the proportion of villagers infected by the malaria

In each village, the crops are equally distributed among the villagers and each villager have the same chance of been infected by malaria.

In each of the following questions, two situations will be proposed. Given that you are an **outside observer**, we will ask you to state the situation that you consider better from collective viewpoint.

Question 1 : Situation A versus Situation B

The following table describes the two situations :

Villages	**Situation A**		**Situation B**	
	Crops per villager	Proportion of people affected by malaria	Crops per villager	Proportion of people affected by malaria
Village 1	5	14%	5	14%
Village 2	11	10%	13	10%
Village 3	16	12%	14	12%
Village 4	20	8%	20	8%

Imagine that you are an outside observer. State, please, which situation that you consider better from collective viewpoint. Tick "Situation A" or "Situation B" according to your preference. Tick "Situation A" and "Situation B" if your are indifferent between these two situations.

□ Situation A

□ Situation B

B Tables

Distribution of preferences

H_0: equality of the distributions of preferences for questions j and j'.

	Q1	Q2	Q7	Q8	Q9	Q10
Q1			0.139	0.033	0.112	0.024
Q2			0.021	0.095	0.328	0.094
Q3	0.991	0.329	0.131	0.038	0.134	0.029
Q4	0.669	0.404	0.366	0.244	0.497	0.197
Q5	0.036	0.316	0.000	0.001	0.009	0.001
Q6	0.758	0.629	0.048	0.039	0.161	0.032
Q7					0.168	0.136
Q8					0.768	0.983

Proportion of orthodox answers

H_0: equality of the distributions of orthodox/non-orthodox preferences for questions j and j'.

	Q1	Q2	Q7	Q8	Q9	Q10
Q1			0.077	0.013	0.070	0.011
Q2			0.178	0.039	0.163	0.034
Q3	0.959	0.725	0.083	0.014	0.075	0.012
Q4	0.390	0.646	0.389	0.114	0.362	0.100
Q5	0.369	0.194	0.006	0.001	0.006	0.001
Q6	0.942	0.638	0.066	0.011	0.059	0.009
Q7					0.954	0.399
Q8					0.478	0.939

Proportion of heterodox answers

H_0: equality of the distributions of heterodox/non-heterodox preferences for questions j and j'.

	Q1	Q2	Q7	Q8	Q9	Q10
Q1			0.080	0.320	0.679	0.350
Q2			0.006	0.048	0.165	0.056
Q3	0.945	0.401	0.065	0.280	0.622	0.308
Q4	0.746	0.218	0.156	0.513	0.944	0.552
Q5	0.018	0.133	0.000	0.000	0.003	0.000
Q6	0.532	0.787	0.015	0.095	0.277	0.108
Q7					0.154	0.384
Q8					0.535	0.952

Table 5: Comparisons between questions: Chi-Square tests (p-value).

	Q3/Q5	Q3/Q6	Q4/Q5	Q4/Q6	Q5/Q6
	Distribution of preferences for pairs of questions				
	H_0: equality of the distributions of preferences for pairs j and j'.				
Q3/Q4	14.54 ($p = 0.0125$)	5.85 ($p = 0.3211$)	12.03 ($p = 0.0343$)	6.23 ($p = 0.2846$)	7.47 ($p = 0.1878$)
Q3/Q5		9.53 ($p = 0.0898$)	4.00 ($p = 0.5491$)	11.13 ($p = 0.0488$)	7.59 ($p = 0.1801$)
Q3/Q6			5.12 ($p = 0.4017$)	3.06 ($p = 0.6906$)	9.27 ($p = 0.0986$)
Q4/Q5				7.09 ($p = 0.2138$)	5.45 ($p = 0.3638$)
Q4/Q6					8.01 ($p = 0.1558$)
	Proportion of pairs of orthodox answers				
	H_0: equality of the distributions of orthodox/non-orthodox preferences for pairs j and j'.				
	Q3/Q5	Q3/Q6	Q4/Q5	Q4/Q6	Q5/Q6
Q3/Q4	10.67 ($p = 0.0011$)	5.40 ($p = 0.0201$)	5.14 ($p = 0.0233$)	2.00 ($p = 0.1573$)	3.67 ($p = 0.0555$)
Q3/Q5		3.27 ($p = 0.0707$)	1.33 ($p = 0.2482$)	4.55 ($p = 0.0330$)	1.92 ($p = 0.1655$)
Q3/Q6			0.39 ($p = 0.5316$)	1.00 ($p = 0.3173$)	0.20 ($p = 0.6547$)
Q4/Q5				2.25 ($p = 0.1336$)	0.09 ($p = 0.7630$)
Q4/Q6					1.47 ($p = 0.2253$)
	Proportion of inconsistent pairs of answers				
	H_0: equality of the distributions of inconsistent/non-inconsistent preferences for pairs j and j'.				
	Q3/Q5	Q3/Q6	Q4/Q5	Q4/Q6	Q5/Q6
Q3/Q4	7.54 ($p = 0.0060$)	2.91 ($p = 0.0881$)	8.53 ($p = 0.0035$)	4.55 ($p = 0.0330$)	4.17 ($p = 0.0412$)
Q3/Q5		1.80 ($p = 0.1797$)	0.25 ($p = 0.6171$)	0.73 ($p = 0.3938$)	0.67 ($p = 0.4142$)
Q3/Q6			2.67 ($p = 0.1025$)	0.29 ($p = 0.5930$)	0.14 ($p = 0.7055$)
Q4/Q5				1.64 ($p = 0.2008$)	1.29 ($p = 0.2568$)
Q4/Q6					0.00 ($p = 1.0000$)

Table 6: Bidimensional transformation, Stuart-Maxwell and McNemar tests for distributions of preferences for all possible pairs of questions.