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by

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Rasch Model and Multidimensional Poverty Measurement

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Abstract:

The topic of the multidimensionality of poverty is currently at the heart of many theoretical, empirical and institutional debates in the European Union. Despite this increasing interest, there seems to be no consensus on how to define and measure multidimensional poverty. Two aspects may be considered in measuring poverty: the number of dimensions and the nature of the underlying continuum. The question of the dimensionality of poverty, one versus many dimensions, has to be resolved in applying specific multidimensional methods, like factor analysis, where the one-dimensional solution is a special case of the multidimensional procedure. The question of the nature of the continuum concerns the relationship between the items in each dimension. Two kinds of relationship are considered here: homogeneous and hierarchical. In this paper, the interest of the Rasch model for verifying the hierarchical and cumulative nature of the relationship between the items is underlined. After presenting the main characteristics of the model, and its adjustment for testing poverty, an application confirming the multidimensional nature of poverty is performed on a Luxemburgish dataset (PSELL-3).

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Key words: multidimensional poverty, accumulation of disadvantages, Rasch model

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Introduction

The topic of the multidimensionality of poverty is currently at the heart of many theoretical, empirical and institutional debates in the European Union (Atkinson, Cantillon, Marlier, Nolan, 2002, 2006). Despite this increasing interest, there seems to be no consensus on how to define and measure multidimensional poverty. Key aspects of this debate are the questions of the dimensionality of the poverty concept and the nature of the relationship between the items measuring each dimension. In this chapter we apply the Rasch model in order to illustrate the contribution of this model in dealing with these questions.

The Rasch model is essentially a unidimensional measurement theory developed in 1960 by Georg Rasch, in order to assess school achievement of Danish soldiers. The ability is considered as an unknown latent trait of persons responding to items. The response of a person to an item represents the manifest or observed variable, and is coded in a dichotomous format: a correct answer is given the value of 1 and a wrong 0. This model states explicitly the relation between observed and latent variables. The application of this psychometric model to poverty is possible if one consider poverty as a latent construct and the positive answer to an item as a deprivation. If the set of items retained on a theoretical ground as indicators of poverty are conformed to the Rasch model, then a poverty or deprivation index can be estimated from the simple sum of the dichotomous items.

The purpose of the Rasch model, in its basic form, is unidimensional. As a consequence, it may seem surprising to include it in a handbook on quantitative methods of multidimensional poverty measurement. However, several reasons exist to consider this model as particularly interesting for the study of the multidimensional aspects of poverty.

1. Many researchers such as Townsend (1979), Mack and Lansley (1985) or Nolan and Whelan (1996) constructed a deprivation index on the basis of non monetary indicators without any measurement model. An index is computed by summing the dichotomous items of deprivation and assumes the unidimensional nature of the construct without testing the dimensionality of the score. The Rasch model allows overcoming this short-cut by confirming or rejecting the unidimensional hypothesis of the score.
2. The unidimensional hypothesis of the model is particularly interesting for the measurement of poverty. If the very nature of poverty consists of accumulating disadvantages, the relationship between items is hierarchical. The model assumes that

if a person suffers from a very severe deprivation, he/she will also suffer from other, less severe deprivations.

3. Multidimensional aspects can be operationalised through the model. Some recent developments of the original Rasch model include multidimensional extensions (see volume 20 of *Applied Psychological Measurement*, 1996). Multidimensional aspects can also be operationalised when applying the basic Rasch model iteratively on a set of items.

This last procedure will be used throughout this paper that is organised in three sections: after having presented the main features of the Rasch model (section 1), we explain in which sense this model can be applied to multidimensional poverty measurement (section 2) and illustrate its contribution by applying it to the Luxemburgish socioeconomic panel "Liewen zu Lëtzebuerg" (PSELL-3) (section 3).

Section 1: The Rasch model

The Rasch model belongs to the field of psychometrics, discipline that includes all the theories and methods of measurement in psychology. This discipline consists in the measurement of latent traits such as intelligence, sociability or self-esteem whose particularity is that they can not be observed directly and must be inferred from their external manifestations. Often, the measurement of a latent trait is based on the application to a population of a test constituted by a set of items from a survey questionnaire. The main hypothesis is that we can indirectly infer the position of a person on a latent trait through his/her answers to this test.

We can model the information coming from a survey as a matrix X containing the answer X_{ij} of i=1..n individuals to j=1..m items. In the case where all the items are dichotomous, the answer can be positive, i.e. indicative of a high position on the latent trait, and are given a value $X_{ij}=1$ or negative, i.e. indicative of a low position on the latent trait and are given a value $X_{ij}=0$. On the basis of this information, we can compute a score $S_i = \sum_{j=1}^{m} X_{ij}$ for each individual i = 1..n. This score test can vary from 0 to m and represents the observed score on the latent trait of individual i.

Psychometrics can be divided in two branches according to the way of conceiving the relationship between this observed score and the true score on the latent trait. On one hand, the classical test theory presupposes a linear relationship between the observed score and the true score of the individuals. The reliability of the observed score depends on an error component. The weaknesses of this approach have been widely documented (Molenaar, 1995). One of them is that there is no empirical verification of the legitimacy of summing the different items in the same scale.

In the second branch, the *Item Response Theory* (IRT) models the relationship between the observed items and the latent variable via a measurement model that allows verifying that the external manifestations really measure the same phenomenon. Indeed, as stated by Molenaar (1995:4), "IRT is build around the central idea that the probability of a certain answer when a person is confronted with an item, ideally can be described as a simple function of the person's position on the latent trait plus one or more parameters characterizing the particular item."

The Rasch model is a latent trait model, belonging to the parametric IRT, where the latent variable is continuous and the observed variables are categorical. As other IRT models, it relies on three fundamental hypotheses (Hardouin, 2005):

- the hypothesis of unidimensionality implies that the responses to each item can be explained by the same latent variable. Hence, this central hypothesis presupposes the existence of a unique latent continuum on which each individuals and each items have a position and can be scaled;
- the hypothesis of monotonicity on the latent trait states that the probability of answering correctly to an item is a non decreasing function on the latent trait, i.e. the higher is the position of an individual on the latent trait, the higher is his/her probability of answering correctly to a given item;
- the hypothesis of local independence postulates that conditionally to the latent trait, the answers of an individual i to different items j and k are independent.

The relationship between what we can observe and the latent variable is realised by the latent trait model and corresponds to the probability $P(X_{ij} = x_{ij} | \theta_i, \delta_j)$ that the individual i answer x_{ij} to item j, given the individual parameter θ_i and the item parameter(s) δ_j.[2] In the Rasch model, the probability of an individual to give a positive answer to an item can be expressed in the one parameter logistic formula:

[2] The different IRT models can be distinguished on the basis of the number of parameters characterising the items and the specification of the link between the latent continuum and the probability of answering correctly to the items, called *items response function* (IRF).

$$P(X_{ij} = 1 | \theta_i, \delta_j) = \frac{\exp(\theta_i - \delta_j)}{1 + \exp(\theta_i - \delta_j)} \qquad [1]$$

θ_i is the ability parameter of individual i on the latent trait. For a given item, the higher is θ_i, the higher is the probability to answer correctly to the item.

δ_j is the parameter of difficulty of item j. For a given individual, the higher is δ_j, the lower is the probability of a correct answer.

Individuals and items are ranked on the same scale. The parameter δ_j of an item represents the value for which an individual of ability parameter θ_i equal to δ_j would have a probability of 0.5 to answer correctly to the item j. Hence, if θ_i overcomes δ_j, individual i will have a probability higher than 0.5 to answer correctly to item j. The relationship between the items and the individuals is probabilistic. If θ_1 is higher (resp. lower) than δ_1, it doesn't necessarily imply that individual 1 will answer correctly (resp. wrongly) to item 1. The higher the score of the individual on the latent trait, the higher is the probability for a positive answer to an item, but this relation is not deterministic.

Under the three hypotheses mentioned above, the Rasch model presents two other important characteristics: the property of "sufficiency of the score on the latent trait" and the property of "specific objectivity". The property of the sufficiency of the score on the latent trait means that, the unweighted raw score S_i computed on the basis of a set of items respecting the Rasch model assumptions contains all the statistical information on the value of the unknown ability parameter of an individual, given fixed item parameters (Molenaar, 1995). The property of specific objectivity means on one side that the comparison of persons remains the same under the use of different items and, on the other side, that the use of other persons does not change the item structure obtained (Molenaar, 1990). Hence, the Rasch model allows obtaining an "objective measure" of the phenomenon under study, i.e. a measure independent of the tool of measure. The counterpart of this useful property is that the constraints underlying the application of the Rasch model are so demanding that it is sometimes difficult to find a set of items meeting them.

The application of a measurement model implies in a first step to estimate the parameters of ability of the individuals and of difficulty of the items. This is done via iterative maximum likelihood methods (Fischer and Molenaar, 1995). The second step consists in assessing the goodness of fit of the set of items to the assumptions of the Rasch model. Two kinds of tests exist: (a) global tests are derived from the maximum likelihood function and allow assessing the goodness of fit of the overall set of items to a Rasch model; (b) local tests are carried out on each item separately. First, one can verify the logistic nature of the relationship between the parameters of difficulty and of ability. Further, it is also possible to test the stability of the estimation of the difficulty parameter of the items obtained with different samples. According to the property of specific objectivity of the model, these estimations have to be congruent.

As a conclusion, we can underline that two properties of the Rasch model are particularly interesting for our purpose. The property of sufficiency of the score on the latent trait justify the use of the raw unweighted score S_i when using a set of items meeting the Rasch model assumptions. The second important property is the hypothesis of unidimensionality stating that all the items selected by the Rasch model are related to the same latent trait. The immediate question is how a model based on a hypothesis of unidimensionality can be used in the framework of the analysis of the multidimensionality of poverty. This will be explained in the next section.

Section 2: Rasch model and multidimensional poverty

Alkire (2001) points out in a book on human development that when we argue that a phenomenon is multidimensional, we have to explain in what sense it is multidimensional. Three main ways of conceptualising, explicitly or implicitly, the multidimensionality of poverty can be found in the literature. The first one is the most widespread and simply consists in taking into account non monetary indicators to study poverty. Hence, every approach that takes into account non monetary information is considered, in an ad hoc way, to be multidimensional (e.g. Townsend, 1979).[3] The second approach considers that poverty is a polysemous concept and that its different definitions (e.g. lack of resources, subjective poverty, etc.) constitute the different dimensions of poverty. In this case, multidimensionality can implicitly be conceived as a reflection of this polysemy, each definition enlightening a different dimension of poverty (e.g. Bradshaw and Finch, 2003). The third conception of the multidimensionality of poverty has been introduced by Dickes (1989) and provides an original insight to the questions linked to the dimensionality of poverty. This approach is the

[3] It can be discussed whether to include or not the information on income in the analysis. This choice is highly dependant on the concept our multidimensional approach aims at operationalising. In this paper, we won't use this information.

one underlying the use of the Rasch model in the field of multidimensional poverty measurement.

The starting point of this last conception is the idea that poverty is a continuum. This notion can be easily understood when one has to compare different individuals on the basis of information from several domains, say an individual badly housed and in good health and an individual who is sick but living in a nice place. If poverty is a continuum, we will be able, on the basis of this set of heterogeneous information (*health* and *housing*), to rank individuals according to a criterion that would be homogeneous: *poverty*. This idea of a continuum of poverty is implicit in many studies dealing with direct approaches of poverty (e.g. Townsend, 1979 or Mack and Lansley, 1985) and with income poverty measures integrating a component on the depth of poverty.

The contribution of Dickes (1989) lies in his more detailed specification of the different theoretical representations of the idea of continuum of poverty leading to a thorough discussion of the dimensionality of the poverty concept. This discussion takes into account both (a) the number of dimensions measuring the construct and (b) the nature of the relationship between the items. (a) A same set of items of deprivation belonging to several domains can measure either a single or several latent characteristic. Poverty is considered as *unidimensional* if only one continuum of poverty is measured and as *multidimensional* if more than one continuum are necessary to grasp this phenomenon. Hence we have to determine if poverty is a unique phenomenon that manifests itself equally in different domains of life or if it is a concept constituted by separated continuums that manifest themselves in a differentiated way in different domains of life? (b) Moreover, two different ways of considering the relationship between the items are possible. Items in a set are considered to be *homogeneous* if their intercorrelation is high. In this case, they all measure the same latent characteristic, i.e. the variability of the items is dependent of a same latent variable. Internal consistency of these items must be high enough to constitute a reliable score for measuring the latent variable. The second option is to consider the relationship between the items as being *hierarchical*. Items forming the continuum are still homogeneous but have also another characteristic: their interrelationship is cumulative (or hierarchical). This means that if an individual presents the more severe disadvantages, he is likely to present also the less severe: not having a house can make it difficult to dress properly or to participate fully in society.

When we cross these two criteria we obtain four theoretical representations of the idea of continuum. In the *unidimensional homogenous model*, poverty can be considered to be a single phenomenon that manifests itself homogeneously in different domains of life. As a consequence, a single continuum is enough to describe it: deprivation can occur in different domains but they are considered to refer to the same latent trait. This model is coherent with the concept of irreducible and absolute core of poverty advocated by Sen (1983). It implicitly underlies the methodologies that end up in computing a composite index of multidimensional poverty on the basis of non monetary indicators of poverty (e.g. Townsend, 1979 or Mack and Lansley, 1985) or on the application of factor analysis displaying a one-axis solution.

The second possibility is the *unidimensional homogeneous and hierarchical model*. This model corresponds to the one that can be tested by the Rasch model. In this case, we suppose again that there is only one continuum on which we can classify the individuals but also that there is a hierarchy among the items (Gailly and Hausman, 1984).

The *multidimensional homogenous model* is common in social research. It supposes that the concept of poverty is not global but affects the different domains of life in differentiated ways. The implicit hypothesis to this model is that there are several types of poverty and that an individual can be considered to be poor on one dimension and not on another. In this case, poverty is a homogeneous phenomenon for each of its constitutive dimension but the dimensions are heterogeneous among each other. The idea of a continuum is preserved but we suppose that there are several of them related to different dimensions.[4] A direct implication of this conception is that there is no common metrics among the relevant dimensions. Hence, every dimension should be treated separately. This conception corresponds to the theoretical representation used by Bourguignon and Chakravarty (2003: 27-8) who state, in the framework of the axiomatic approach to multidimensional poverty measurement, that "the issue of the multidimensionality of poverty arises because individuals, social observers or policy makers want to define a poverty limit on each individual attribute: income, health, education, etc..." This multidimensional conception also underlies the application of exploratory or confirmatory factor analysis that present solutions with several factors (Schokkaert and van Ootegem, 1990).

Finally, the *multidimensional homogeneous and hierarchical model* of poverty implies the identification of several dimensions where the relationships between the items would be hierarchical. This case correspond to the application of a multidimensional extension of the Rasch model or of the iterative application of the base version of this model.

[4] In this case, a dimension can be considered to be a component of a phenomenon that coexists with other components (Alkire, 2001). The relations between these dimensions are difficult to handle so that the multidimensionality of poverty is, by nature, complex.

All these models are specifications of the theoretical representation of the idea of a continuum. How do we choose for one or the other? According to Dickes (1989), the choice of one of the models is not a logic operation but must be the result of an empirical procedure. Indeed, the answer as to whether the latent phenomenon of poverty is a unidimensional concept or if it is a multidimensional one can not be postulated in an ad hoc way but must be the result of an analysis of the data. Unidimensionality or multidimensionality of poverty has to be demonstrated through the use of a confirmatory approach, so as the homogenous or hierarchical nature of the items of the continuum. This is precisely what the Rasch model aims at doing.

The Rasch model has been previously applied to poverty by Gailly and Hausman (1984) and Dickes *et alii* (1984). The goals of their research involved (1) the construction of an objective measure of poverty, (2) the operationalisation of a definition of poverty in terms of accumulation of disadvantages and (3) the verification of the hypothesis related to the multidimensionality of poverty. Under the hypothesis that poverty is a latent phenomenon, the use of the Rasch model makes it possible to reach these three goals at the same time. Indeed, the property of specific objectivity allows obtaining an objective measure of poverty and altogether the hypothesis of unidimensionality, the fact that all the items behave similarly, and the hierarchic property of this model allow operationalising the definition of poverty as accumulation of disadvantages.[5]

This paper focuses on the third goal: the use of the Rasch model to verify the hypothesis of unidimensionality or multidimensionality of poverty. Some recent developments of the original Rasch model include multidimensional extensions (e.g. Hardouin, 2005). However, multidimensional aspects can also be operationalised when applying iteratively the version of the Rasch model presented in the first section. Before to explain how this is done, we first need to adapt the presentation of the Rasch model to the study of poverty.

All the items are dichotomous and correspond to a characteristic revealing a deprivation. The positive modality of the item is given to the modality *revealing a*

[5] Indeed, when we manage to determine a set of items that respect the Rasch model, we can rank the different items according to their difficulty. The global score is an index of cumulative disadvantage as far as a household with a high score has a high probability to accumulate the disadvantages related to items whose difficulty parameter is lower than that score. Households tend to accumulate disadvantages whose parameters are lower than their ability parameter. Hence, the presence of the most severe disadvantage is a reliable sign that the probability of an individual to accumulate diverse disadvantages present in the list of items is high. Hence, identification of the more severe items has got important political implications because if a household presents the disadvantage related to it, his/her probability to fall into a spiral of precariousness and to accumulate the others disadvantages is higher.

disadvantage. The negative modality is attributed to the modality showing the *absence of disadvantage*. The parameter of difficulty of an item corresponds to the disadvantage. It can be called the *parameter of severity*. If the Rasch model is verified, we are in the case of a relative definition of poverty. The higher is the parameter of severity, the less the disadvantage is spread in the population and the more severe is the disadvantage. The parameter of ability refers to poverty. It can be called the *parameter of position*. The higher is this parameter, the more likely is a household to suffer several deprivations and to be in a situation of poverty. Hence, applied to poverty, the formula [1] means that if we know the degree of poverty of an individual (parameter of position), and if we know the degree of severity of a given disadvantage (parameter of severity), we can compute the probability of an individual to be deprived on a given item.

The algorithm of selection of the items is the following. In a first step, we apply the Rasch model to the matrix X. By so doing, we accept the hypothesis of unidimensionality of poverty. We estimate the parameters of severity of the items and of position of the individuals. The application is blind in the sense that we obtain parameters for all the items, whether they respect or not the properties of the Rasch model. In a second step, we test the fit of these results to the model. Items displaying a high misfit with the assumptions of the Rasch model are dropped. This procedure is reproduced until we obtain a set of items that fit the properties of the Rasch model. In this case, we can conclude that all the selected items refer to the same unique latent continuum.

This latent continuum can be better interpreted ex-post by analysing the selected items. If they belong to different domains such as housing, social participation or education then we can talk about poverty. In this case, we can say that poverty is *unidimensional and multidomains*. If all the selected items belong to the same domain, e.g. housing, then we should talk about *specific poverty*. In both cases, we are in the framework of the *unidimensional homogeneous and hierarchical model* and the property of sufficiency of the score allows using the unweighted score test as a good measure of the poverty of the individual.

This procedure can be used to test the multidimensionality of poverty. The application in a first step of the model to a set of initial items covering different domains of life allows the identification of a first dimension of poverty. At this stage, poverty is a unidimensional phenomenon and can be either multidomains or specific. By applying again the unidimensional Rasch model to the items not selected at the first stage, we are in the position of obtaining an answer to the question as to whether poverty is multidimensional or not.

Indeed, if a second scale is identified, poverty is multidimensional and the model identified is the *multidimensional homogeneous and hierarchical model*.

Hence, the base version of the Rasch model enables us to demonstrate the multidimensionality or not of poverty and not to accept it as a postulate. In the next section we apply this procedure to the Luxemburgish data from PSELL-3.

Section 3: Empirical illustration on the PSELL-3 data

In this section, we illustrate our previous theoretical framework by applying the Rasch model to real data. Our aim is to apply the iterative procedure presented above in order to test the hypothesis of unidimensionality or multidimensionality of poverty. The empirical application has been carried out on the data of PSELL-3 (*Panel Socio-Economique "Liewen zu Lëtzebuerg"*), which is the Luxemburgish part of the new EU programme on *Community Statistics on Income and Living Conditions* (EU-SILC). EU-SILC, which has replaced the *European Community Household Panel*, is the official longitudinal EU data source on income distribution, poverty and social exclusion. A key aim of EU-SILC is to provide reliable and timely indicators for use in the context of the EU Social Protection and Social Inclusion Process. EU-SILC was launched in 2003 on a gentleman's agreement basis in six EU Member States (Belgium, Denmark, Greece, Ireland, Luxembourg and Austria) as well as Norway. Since 2006, EU-SILC covers all EU-25 countries as well as Bulgaria, Romania, Turkey, Iceland and Norway (Atkinson, Cantillon, Marlier and Nolan, 2006).

As mentioned above, Luxembourg was part of the countries that launched their survey in 2003. The initial sample of PSELL-3 consisted of 3500 households (9500 individuals) representative of the population living in private households in Luxembourg. As this dataset is designed as a full panel, the original sample will be followed over time. In our paper, we made use of the data relative to the second wave of PSELL-3, conducted in 2004.

PSELL-3 allows computing an index of material deprivation thanks to its multidimensional coverage of a range of topics pertaining to the same households. Following the example of Whelan *et alii* (2001), we initially selected a set of items belonging to the domains of absence of housing facilities, problems with the accommodation, problems with the environment or neighbourhood, inability to afford most basic requirements, inability to meet payment schedules and lack of durable goods. Hence our approach is multidomains. The items can be either objective or subjective and aim at revealing the presence or absence of a deprivation. Finally, the unit of observation is the household.

A list of 29 dichotomous items has been selected (see table 1). The negative modality (x_{ij}=0) corresponds to the absence of deprivation for the corresponding item and the positive modality (x_{ij}=1) to its presence. Taking into account the procedure of demonstration of multidimensionality described above, we apply the Rasch model to this set of items in order to assess if they all refer to the same latent trait. The analysis was carried out with the software PML introduced by Gustafsson (1977) and adapted to PC-Computers by Molenaar (1990). For every item, we obtained an estimation of the parameter of severity (see table 1).

To test the goodness of fit of our set of items to the assumptions of the Rasch model, we carried two global tests. The Martin-Löf fit test for score group is based on difference between the observed proportion of positive answers per item per score group and the expected proportion. If the Rasch model holds, the observed number per score group scoring positive on a particular item has a binomial distribution with this expected proportion as success probability (Molenaar, 1990). The total chi-square value is of 1472.23 (degrees of freedom: 532; p = 0.000) indicating a misfit with the Rasch model assumptions.

The Andersen likelihood ratio test aims at testing the stability of the household parameter when the sample is partitioned in two groups according to the raw scores. In our case, we obtained a chi square of 391 (degrees of freedom: 28; p = 0.000), similarly showing a misfit with the Rasch model assumptions.

Hence, the two global tests show that the set of 29 items don't fit the properties of the Rasch model. We computed some local tests in order to decide which items from the initial list can be dropped (table 1).

The U test of Molenaar consists in assessing for each item whether for each score group the observed proportion correspond to the expected one according to the Rasch model. Hence, what is tested is the logistic nature of the relationship between the parameters of position and of severity. Large positive or negative values (greater than 3 in absolute value) indicate important deviations. This test leads us to drop items 11, 12, 13, 16, 18, 21, 22, 23, 27, 28 and 29.

Table 1: Analysis of the 29 items

Item	Parameter of severity	Molenaar's U	t – diff (global score)
1. heating	2.21	-1.703	2.610
2. bathroom	2.69	-1.233	2.770
3. indoor flushing toilet	3.36	-1.353	2.410
4. hot running water	1.80	-0.440	0.680
5. double glazing	-0.59	2.239	-4.050
6. place to eat outside	-0.83	-0.792	0.090
7. leaky roof	0.15	0.339	-1.100
8. damp walls or floors	-0.56	2.029	-3.260
9. rot in walls, etc.	-0.16	-1.252	0.910
10. too dark	0.07	-0.436	-0.830
11. noise	-1.54	6.012	-7.330
12. pollution	-1.06	6.874	-8.330
13. crime	-0.88	8.859	-9.170
14. telephone	2.65	-1.795	1.830
15. colour TV	1.79	0.398	-2.430
16. computer	-2.07	-3.741	-0.820
17. washing machine	0.77	0.698	-0.290
18. private car	-0.35	-5.061	3.520
19. camera	-0.80	-2.890	-0.420
20. video player	-1.38	-0.003	-2.670
21. CD player	-1.06	-3.742	0.360
22. DVD player	-2.51	5.950	-7.410
23. audio tape player	-1.93	4.756	-6.570
24. rent or mortgage payment	1.17	-2.415	2.070
25. bills	0.83	-1.751	0.450
26. savings	-1.72	1.860	-2.910
27. unscheduled payments	-0.54	-4.794	3.950
28. Holydays	-0.66	-5.216	3.320
29. meat or fish	1.17	-3.795	4.290

Source: PSELL3/2004, CEPS/INSTEAD, STATEC

The t-test (t - diff global score) allows determining if the differences between the estimated parameters of the items for the group whose score belong to the interval [1-8] (2888 households) and the group whose score belongs to the interval [9-28] (321 households) are important.[6] If the items respect the Rasch model hypothesis, these estimates should be similar. A difference greater than 3, in absolute value, leads to reject this hypothesis. Hence, we rejected also items 5 and 8.

This procedure was reproduced until we found a subgroup of the initial set of items fitting the Rasch model properties. Nine items were finally selected and are presented in table 2. The application of the Rasch model to these 9 items leads to the following global test. The Martin Löf test gives a chi square of 66.84 (degrees of freedom: 40; p = 0.005) and the Andersen likelihood ratio test a chi square of 15.92 (degrees of freedom: 8; p = 0.043). These global tests confirm the fit of this set of items to the Rasch model assumptions.

Table 2: Analysis of the 9 items

Item	parameter of severity	Molenaar's U	t diff global score
9. rot in walls, etc.	-1.74	0.209	0.64
10. too dark	-1.47	1.210	0.72
7. leaky roof	-1.37	-1.496	2.06
25. bills	-0.61	-0.465	-2.26
24. rent or mortgage payment	-0.25	-1.806	-0.15
1. heating	0.83	0.854	-1.38
14. telephone	1.28	1.073	-0.83
2. bathroom	1.32	-0.350	-0.21
3. indoor flushing toilet	1.99	-0.293	1.19

Source: PSELL3/2004, CEPS/INSTEAD, STATEC

Similarly, the local tests presented in table 2 show a good fit of each item to the Rasch model. Hence, we can conclude that these 9 items all refer to the same latent construct. The 9 items of this scale belong to different domains of the living conditions: problems with accommodation (items 1, 2, 3, 7, 9 and 10), possession of durable goods (14) and inability to meet payment schedules (25, 26). These items are part of the items usually used to discriminate between deprived or non deprived people. Hence, we can conclude that our scale can be considered to be a scale of poverty.

[6] The estimation of the parameters is done using a method of conditional maximum likelihood. In this method, the perfect score (s=m) and the zero score (s=0) don't add any information and are discarded from the estimation.

Moreover, as mentioned previously, the Rasch model allows operationalising a definition of poverty as an accumulation of disadvantage. In this application, the items related to problems with the accommodation are the most severe. Indeed, the most severe items turn out to be the absence of an indoor flushing toilet ($\delta_3 = 1.99$) and of a bathroom ($\delta_2 = 1.32$). At the other side of the scale, the less severe items of deprivation are the presence of "rot in walls, window frames or floors" ($\delta_9 = -1.74$) and "accommodation is too dark/not enough light" ($\delta_{10} = -1.47$). This means that in Luxembourg, in 2004, households living in a house without bathroom or indoor flushing toilet have a high probability to face problems of rot in walls or to consider their accommodation too dark. On the other hand, problems of rot in windows or of dark accommodation don't imply to live without bathroom or indoor flushing toilet. Hence, the absence of bathroom or indoor flushing toilet can be considered to be a reliable sign of the presence of other less important deprivations.

The scale of poverty constituted by the 9 items is presented in table 3.

Table 3: Scale of poverty

Raw score	Number of observations	Parameter of position (log)	Standard error
1	503	-2.67	1.12
2	164	-1.70	0.89
3	99	-0.98	0.82
4	19	-0.33	0.80
5	7	0.31	0.80
6	1	0.97	0.83
7	0	1.70	0.90
8	0	2.69	1.13

Source: PSELL3/2004, CEPS/INSTEAD, STATEC

This scale can be used in subsequent analysis by using the raw score as it is a sufficient statistics of the parameter of position estimated through the use of the Rasch model. At this point of the analysis, we have identified a unidimensional hierarchical scale of poverty constituted of items belonging to three domains. Poverty is unidimensional and multidomains. In order to test if poverty is multidimensional, we applied the Rasch model to different subset of the items that didn't meet the Rasch model assumptions at the first iteration.

Analysis of 5 durable goods

Nine items are related to the possession of durable goods: colour TV, computer, washing machine, private car, camera, video player, CD player, DVD player and audio tape player. We want to determine if the Rasch model applies to these nine items or to a subgroup of this set of items. If this is the case, poverty will be considered as multidimensional. According to our analysis, the items relative to the possession of a video player, a camera, a private car, a washing machine and a colour TV fit the Rasch model assumptions.

Indeed, the global tests related to this set of 5 items show a good fit with the Rasch model. The Martin Löf test displays a Chi square of 28.08 (degrees of freedom: 12; p = 0.005) and the Andersen test a chi square of 517 (degrees of freedom: 4; p = 0.270). The local tests presented in table 4 are also satisfying for these 5 items.

Table 4: Analysis of the 5 items of "durable goods"

Number of the item	Estimation of the parameter	U of Molenaar	t diff score global
20. Video player	-1.62	0.174	1.60
19. Camera	-0.90	-0.425	0.24
18. Private car	-0.36	0.305	-0.39
17. Washing machine	0.90	0.144	-1.60
15. Colour TV	1.98	-1.160	-1.01

Source: PSELL3/2004, CEPS/INSTEAD, STATEC

As all the items belong to the same domain, we can talk of specific poverty related to the dimension of "durable goods". Again a scale can be computed with the items belonging to this dimension.

Table 5. Scale of durable goods

Raw score	Number of observations	Parameter of position (log)	Standard error
1	751	-1.83	1.21
2	341	-0.60	1.05
3	133	0.52	1.08
4	39	1.85	1.26

Source: PSELL3/2004, CEPS/INSTEAD, STATEC

At this point of the analysis we have identified two scales to represent the concept of poverty. One is a scale of poverty and the second a scale of specific poverty related to the dimension of "durable goods". Hence poverty can now be considered to be multidimensional and we can insist on the cumulative nature of the disadvantages into the dimensions conceptualising this phenomenon.

We took further our logic by analysing two other set of items related to the domain of "financial difficulties" and of "environmental problems". Because of our limited space we just give the main conclusions here. On the basis of the five items related to the financial difficulties (25, 26, 27, 28, 29), we were able to identify a third dimension of deprivation composed by the items inability to afford one week's annual holyday away from home (27), to face unscheduled payment (28) and to eat meat or fish every second day, if wanted (29). On the other hand, the application of the Rasch model to the three 3 items related to the environment (items 11, 12 and 13) didn't allow showing they were referring to the same latent continuum.

At the end of our application, we have shed light on the fact that poverty is a multidimensional phenomenon. Three hierarchical dimensions have been identified, namely a base dimension of "poverty" and two dimensions related to the specific domains of "possession of durable goods" and "financial difficulties". To give more robustness to our results, we need to assess if the three dimensions identified are actually heterogeneous one from the other as requested. In order to do so, we have tested the homogeneity of the three scales, taken 2 by 2.

This test of homogeneity based on a chi square test has been carried by PML. The hypothesis of homogeneity of the "scales of poverty" and of "durable goods" has been rejected (Chi^2=463.09, dl=44, p=0.000). The correlation between these two scales is 0.218. We reach the same conclusion when testing the homogeneity of the "scales of poverty" and of "financial difficulties" (Chi^2=46341.02, dl=26, p=0.000, correlation of 0.38) and of the scales of "durable goods" and of "financial difficulties" (Chi^2=510.25, dl=14, p=0.000, correlation of 0.29).

These results give further evidence that we need a representation of different hierarchical poverty scales when trying to assess poverty on the basis of our starting list of 29 items. This confirms our conclusion that poverty is a multidimensional phenomenon in the sense used in this paper.

Conclusion

In this chapter, we made use of the logistic model for dichotomous items introduced by Rasch (1960) in order to assess the dimensionality and the cumulative nature of the dimensions of the concept of poverty. The application of this model to Luxemburgish data allowed us to demonstrate ex-post that poverty is multidimensional and not to postulate it ex-ante as it is sometimes done.

The use of the Rasch model implies that the dimensions are defined *a posteriori* on the basis of the analysis of the data. In this case, dimensions can be constituted by items belonging to the same domains (specific poverty) or to different ones (poverty). Moreover, the properties of the Rasch model allow operationalising a definition of poverty as an accumulation of disadvantages and to obtain an objective measure. Hence, there is ground to consider that the Rasch model can be very useful in the study of poverty and its multidimensional aspects.

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