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THE RASCH MODEL FOR VICTIMIZATION ANALYSIS: A PROPOSAL OF AN INSECURITY PERCEPTION INDEX

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Abstract: *This work focuses on the application of the Rasch Model for the Victimization Analysis. The aim of this paper is to propose a new Citizen Insecurity Perception Index referring to the Italian Country as well as to its Regions or Geographical areas. The Index is defined by means of the person location parameters estimated by a Rasch Model. This procedure is particularly suitable since the synthetic value of the latent variable "Insecurity Perception" is first evaluated at individual level; its estimated scores are then naturally aggregated to higher levels.*

Keywords: *Rasch model, partial credit model, statistical measures of security, fear of crime measures.*

1. Introduction

In this paper we consider the Partial Credit Model (PCM), a Rasch Model (RM) for ordered response categories, for investigating the insecurity perception of Italian citizens. The aim of the work is to measure the individual insecurity perception by means of a quantitative synthetic index. In the literature, the insecurity perception concept is not univocally specified. Henceforward, we adopt the definition referring to the risk perception of suffering from an offence and/or to the fear of being victim of a crime. In psychology and sociology this concept is generally called "fear of crime". The dualism in the definition is clear: the insecurity perception is both the risk of being object of an offence (that is an individual rational evaluation of the dangerousness of the context) and the fear to be a potential victim (related to the emotional aspects). For the psychological definition of "fear" see Hale [5] and Jackson [8].

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On the other hand, we may notice a lack of quantitative indicators measuring the concept of insecurity perception. In the Italian literature several studies have focused on a single aspect of the insecurity perception (e.g. home safety or feeling safe in neighborhood) usually measured by means of a unique question item in a survey; moreover, these studies consider data coming from local surveys. Other studies have investigated some particular aspects of the insecurity perception, by using an indicator based on the answers to questions referring to various aspects of a unique latent trait of interest (see [15] and [17]).
However, most studies do not employ a statistical or psychometrical approach, although their aim is to foresee the level of crime fear on the basis of proper explicative variables, like the rate of crime or measures of environmental, behavioral or socio-economic status (see, for example, [5] and [17]). Osgood *et al*. [12] measure the fear of crime and the concept of deviance using the Item Response Theory (IRT) models. Our paper, aiming at filling the lack of a psychometrical approach , gives a measure of the latent construct expressed on a metric scale.
A synthetic index is obtained, in general, as a function of the observed variables (proxies), linked to a latent construct, not directly observable, supposed to be unique and measurable by a proper weighted linear combination of those proxies. One of the most popular statistical procedures is the Factor Analysis, used in a confirmatory way: the estimated scores of the possibly unique latent factor make then it possible to classify the statistical units. The uni-dimensionality of the latent construct is the basic assumption for the insecurity perception index that we are going to introduce. With reference to the confirmatory factor analysis, the index may be constructed as a linear combination of the responses given by the interviews in order to obtain the so-called standardized "factor scores". Their levels allow to properly classify the statistical units.
We propose to use a slightly different approach, based on the PCM, in order to define a Citizen Insecurity Perception Index. To this aim we consider the data from the "Italian survey of citizens' safety" within the ISTAT Multi-scope Survey (2002), see [6] and [7], submitted to a representative sample of 60000 Italian citizens, aged 14+. We will use a subset of the items; belonging to the Section 3 of the questionnaire, related to environmental safety perception, the security measures and the analysis of the behavior assumed in order to protect oneself against crime or to face the fear of being victim of a crime (see Appendix).
The paper is organized as follows. The next section explains the characteristics of the PCM used in the analysis. In Section 3 we apply the model to empirical data, with the aim of obtaining a Section 3.1 we estimate the model and we calculate the fit statistics. We show the different tendency of the items of the survey in arousing the insecurity. In Section 3.2 we construct the Insecurity Perception Index, referring to the Italian Country and to its Regions or Geographical areas, as a weighted arithmetic mean of the individual insecurity perception of the citizens. Finally, the last sections are devoted to discussions and conclusions.

2. The Rasch model

Under the hypothesis of unidimensionality of the latent construct, also verified by a previously performed factor analysis[1], a procedure based on the RM may be effectively considered. This model assumes that the responses are affected by two different components: the first related to

[1] The Factor Analysis showed the presence of one eigenvalue remarkably higher with respect to the others.

the personal characteristics of the subjects and the other to the "displacement" of the generic item gathering the latent aspect of interest. For this reason, this model is properly used only if, as we suppose, these components work independently (separability). We recall that the classical approach of RM assumes that the response probability of each subject to a generic item depends on the level of the latent aspect (ability) and on the difficulty of the item. It allows using a wider variety of observed variables (items) not necessary highly correlated, thus improving the discriminant power of the procedure, since the observation of the person characteristic is replicated all over the items, net of the item characteristics.
The classical Rasch example (1960), given in [13], concerns in fact the evaluation of the learning level of students, by estimating the intrinsic aptitude of the subjects net of the effect of the proposed trails, so adjusting the possible distortion due to the adopted measurement tool (survey items). In order to evaluate the insecurity perception level of each citizen, we assume that it corresponds to the perceived evaluation of the environmental contest danger, net of the proposed item affects, so considering the self-predisposition to be afraid. Once obtained the individual insecurity perception measure, one may compute the corresponding measures either at nation-wide, or aggregated by geographical areas (North-West, North-East, Centre, South and Isles) or by regional contexts, in order to compare and to evaluate the possible existing differences.
RM belongs to the family of IRT measurement models, which scale raw observed scores into linear reproducible measurements.
Under the hypotheses that there are two different aspects (linked to subjects and items), acting in a separable manner, RM allows to construct a single metric scale defining a ranking of Items and Person parameters. The main limitation of the classical methods is that they don't take into account these concomitant, but separable, effects. RM is designed to estimate the subject's level on the latent trait, net of item characteristics, and items' net of subjects. With reference to a particular measurement scale, for a specific latent aspect (ability or opinion), let x_{ij} be the response of the generic unit $i=1,\ldots, I$ to the item $j=1,\ldots, J$ (typically given on a conventional Likert scale), choosing among the integer values $k=0, 1,\ldots, m_j$ (each item may assume a different number of modalities). Let π_{ijk} be the probability that unit i, with person parameter θ_i, chooses the category k for evaluating the item j; it may be represented through a proper "link function" $\varphi(\theta_i,\beta_j)$ in the parameters θ_i and β_j, accounting, respectively, for personal and item characteristics. RM (see, for example, [3]) assumes the last relation to be of the logistic type. In the family of the polytomous models, we consider the PCM (see [10]), for which the items may have different ordered response categories. The PCM gives the probability π_{ijk}, as:

$$\pi_{ijk} = \frac{\exp\left\{k\left(\theta_i - \beta_j\right) - \sum_{h=0}^{k}\tau_{jh}\right\}}{\sum_{s=0}^{m_j}\exp\left\{s\left(\theta_i - \beta_j\right) - \sum_{h=0}^{s}\tau_{jh}\right\}}$$

where $\tau_{j0} = 0$ and τ_{jh}, $(h=1,\ldots, m_j)$, called thresholds are the points of equal probability of categories h-1 and h for the item j. Thresholds sum to zero, $\sum_{h=1}^{m_j}\tau_{jh} = 0$, for all the items.
Since it is reasonable to assume that the thresholds are not the same for all the items, i.e., each item has its own unique rating scale structure, the PCM appears the most appropriate model.

In the contest of victimization analysis the parameters θ_i and β_j have a specific interpretation. The individual characteristic θ_i, usually called "ability", may be conceived as the individual crime fear (the individual Insecurity Perception Index): subjects with higher score in this subscale (Personal Location) will have a higher level of insecurity and fear. The item characteristic β_j, called "item difficulty" in the classical Rasch example, in this context represents the item propensity to obtain, by the respondents, systematically high or low scores when measuring the latent trait of interest. They reflect the worry level for a particular aspect measured by each item of the survey. In this way it is possible to order the survey's items on the basis of their different tendency in arousing insecurity.
Depending on the fact that the model allows the separation of the person and item characteristics, the item parameters are estimated conditionally to the personal parameter estimation. This result is achieved using conditional maximum likelihood estimation, in which the response space is partitioned according to person total score. The raw score, for an item or a person, are obtained by the sufficient statistic for the corresponding parameter estimate.

3. The application

The study considers the "*Italian survey on citizens' safety*" data, within the ISTAT Multi-scope Survey (2002), submitted to a representative Italian population sample of 60000 citizens, aged 14+. The representativeness of the sample is at nation-wide, as well as at macro-regional and regional. We use some of the survey items to build up the *Insecurity Perception Index*. In particular, we consider the items, from the Section 3 of the survey, related to several aspects of the latent construct of interest; in particular, those referring to environmental safety perceptions, to security measures and to behaviours assumed in order to protect oneself against crime or to face the fear of being victim of a crime (see the Appendix). Data analysis was performed by means of R software.
Several tests verifying the coherency of the model, the hypothesis of unidimensionality of the construct and the global goodness of fit were performed. The *Person Separation Index* (*PSI*) evaluates the reliability and the goodness of fit, and verifies the coherency of the data to the model: a value of 0.848 indicates a good performance (see [1]).

3.1 Item Ranking: fear analysis

The item location parameter estimates and the fit statistics are reported in Table 1. In order to evaluate the agreement between model and data, it is possible to use specific diagnostic measures based on residuals, given by the differences between the observed answer and those reconstructed by the model. The expected values of the Outfit and Infit Mean Square Statistics is 1, corresponding to a perfect fit of the data to the model. Since a perfect fit is never achieved with real data, a reasonable range is represented by values between 0.6 and 1.4 (see [18]). Therefore, only Item 3, Carrying self-defense tools, has Infit and Outfit values outside the range.
The χ^2 test for each single item compares the observed answer distribution with the estimated one. Since every test statistic usually increases with the sample size (in our study the sample size is equal to 60000), the null hypotheses of distribution equality is often rejected, also for alternatives very close to H_0 (see [9] and [19]).

Table 1. Item Location Parameters Estimates (β_j) and fit statistics.

Item	Description	β_j	Chisq	df	p-value	Infit	Outfit
1	Safety walking alone in the dark	0,178	51262	53700	1	0,955	0,933
2	Avoiding places/people for safety reasons	0,202	50533	54612	1	0,925	0,926
3	Carrying self-defense tools	1,505	126480	58055	0,000	2,179	1,075
4	Locking the doors	0,282	68732	47392	0,000	1,450	1,173
5	Fear to go out at night	0,688	71522	58846	0,000	1,215	1,007
6	Safety when home alone after dark	1,061	61381	58846	0,000	1,043	1,008
7	Fear of having one's car stolen	-0,096	52443	53394	0,998	0,982	0,966
8	Fear of having one's home robbed	-0,396	47016	58846	1	0,799	0,783
9	Fear of pick/pockets	-0,046	42694	58846	1	0,725	0,739
10	Fear of robbery/aggression	0,004	37648	58846	1	0,640	0,661
11	Fear of sexual harassment	0,074	51651	58846	1	0,878	0,902
12	Influence of criminality on habits	0,083	56193	58846	1	0,663	0,650

However, comparing the two distributions for the items, showing the highest values of the test statistic (the lowest p-value) we note that the two distributions (not reported in the paper) are very close to each other; moreover, only the Item 3, among those showing the lowest p-values (3, 4, 5, 6) attains problematic Infit levels. Therefore, we may consider that only Item 3 misfits the model.

The following Table 2 shows the results of item location parameters estimates obtained without the problematic Item 3; PCM ranks the most meaningful items by the item locations β_j , ranging from -0,3050 to 1,2336. High positive values of β_j identify less relevant aspects for the measure of fear latent trait; on the contrary, high negative values identify the aspects evaluated more alarming. The results suggest a fear rating: items with a low score are related to more worrying situations, items with a high score are related to less alarming situations.

Table 2. Item Location Parameters Estimates (β_j) and fit statistics (Item 3 excluded).

Item	Description	β_j	Chisq	df	p-value	Infit	Outfit
1	Safety walking alone in the dark	0,312	51699	53634	1	0,964	0,941
2	Avoiding places/people for safety reasons	0,290	50730	54545	1	0,930	0,930
4	Locking the doors	0,377	69477	47346	0,000	1,467	1,190
5	Fear to go out at night	0,791	71910	58767	0,000	1,224	1,023
6	Safety when home alone after dark	1,234	62857	58767	0,000	1,070	1,038
7	Fear of having one's car stolen	0,012	52598	53330	0,988	0,986	0,965
8	Fear of having one's home robbed	-0,305	46318	58767	1	0,788	0,771
9	Fear of pickpockets	0,056	41614	58767	1	0,708	0,720
10	Fear of robbery/aggression	0,101	36600	58767	1	0,623	0,644
11	Fear of sexual harassment	0,182	52852	58767	1	0,899	0,904
12	Influence of criminality on habits	0,173	54868	58767	1	0,934	0,914

We obtained a homogenous item rating both at national and at Macro-Area levels.
With reference to the psychological literature (see [2], [4], [11] and [16]), the considered items may be classified into three particular groups, concerning the following categories: an affective aspect, a cognitive aspect and a behavioral aspect relating to the coping strategies. The affective aspect is the emotional reaction to the possibility of suffering a crime or being in a dangerous situation (items 1, 5, 6). This set of items is referred to personal and irrational sensations. The cognitive aspect represents the judgment/perception of the risk to suffer an offence and/or to be victim of a crime; it is a more rational and cerebral reaction (items 7, 8, 9, 10, 11, 12). The behavioral aspect refers to the strategies adopted to cope with the victimization risk (coping strategies, items 2, 4).
Figure 1 shows the distributions of both person (in the superior panel) and item location scores (in the inferior panel), using the same conventional metric scale.

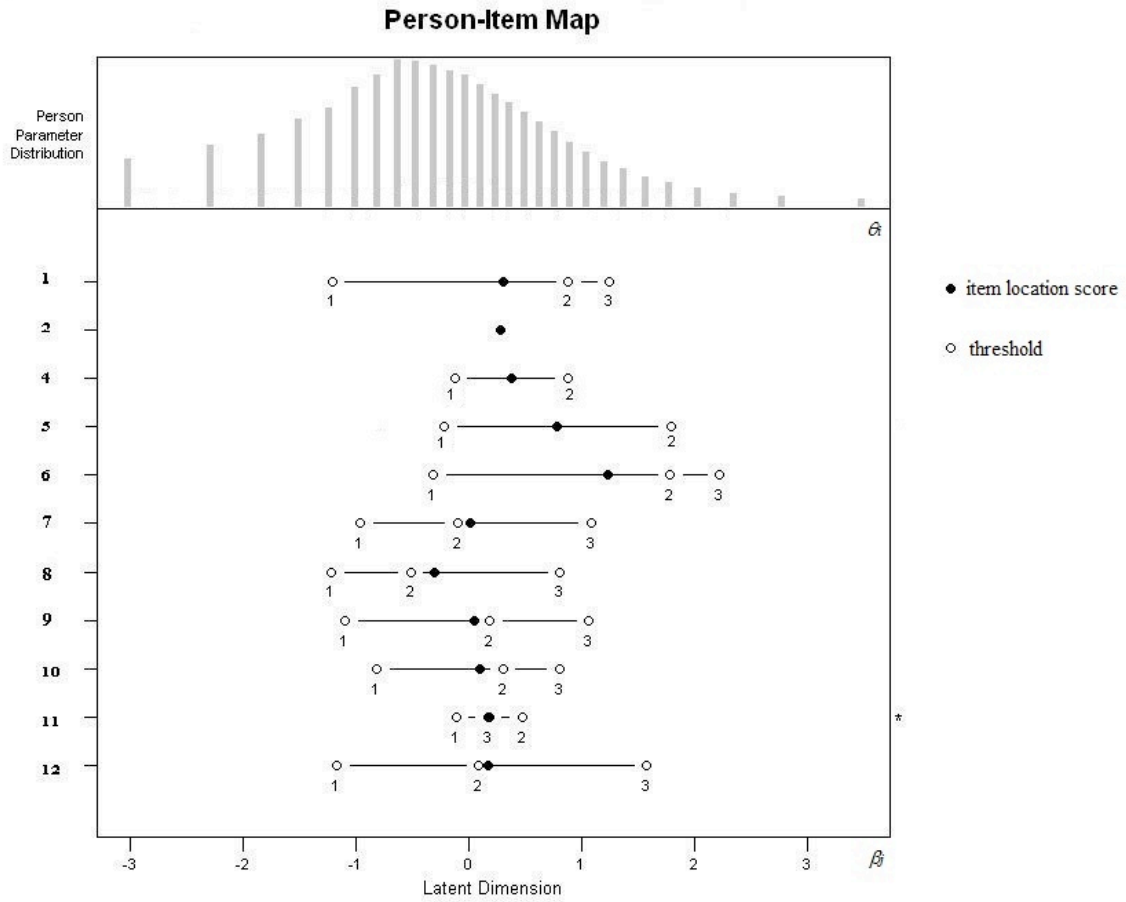

Figure 1. Personal and Items Location Scores Distributions.

The inferior panel shows, for each item) the threshold scores (white points) and the item location scores (black points). Looking at the item location distribution, we may assess that the most important items, with an high location score, for defining the fear concept are those related to the cognitive aspect; the citizen insecurity perception is referred to the most rational dimension, that is the evaluation of the risk of suffering a crime, and it is less dependent on the emotional aspects (personal and subjective concern to suffer an offence). The fear of crime depends mainly on

objective and rational evaluations. We observe that in the item 11 the threshold are disordered: it may be related to an effective difficulty of interpreting the intermediate modalities of the item.

3.2 Insecurity Perception Index

With reference to the PCM we may so develop an index to evaluate the citizen insecurity perception for the Italian citizens, also disaggregated by Macro-Areas, defined by the Geographical Areas ISTAT classification, and by Regions.

Index (1) is made up as a weighted arithmetic mean of the Individual Person Location Scores θ_i, i=1,…, I, assuming values ranging from –3,03 to 3,48:

$$IPI = \frac{\sum_{i=1}^{I} \theta_i w_i}{\sum_{i=1}^{I} w_i} \qquad (1)$$

The w_i are weights assigned to every sample units. They are calculated by ISTAT in order to take into account the distribution of the sample by Macro-Area and by Region with respect to that of the corresponding whole population and in order to overcome the problems related to the non-sampling errors. The weights are obtained multiplying the invers of the inclusion sample probability by a correction factor; the correction factor is calculated in order to satisfy the equality between the sample estimates of the totals of some basic features of the population and the real ones (for more information see [7]).

The Person Location Scores, net of the items influence, represent exactly the personal level of fear of each subject. High values of the *Insecurity Perception Index* (*IPI*) indicate high levels of insecurity and fear perceived by a generic Italian or Macro-Areas citizen. The National and Macro-Area Index are presented in Table 3. South Area is characterized by the highest value of the Index (highest insecurity level).

Table 3. Insecurity Perception Index (Italy and Macro-Areas).

Area	Italy	North-West	North-East	Centre	South	Isles
IPI	-0,1152	-0,1025	-0,2316	-0,1627	0,0291	-0,1728

We reproduce the same analysis in a regional context. Figure 2 and Table 4 show the Regional Insecurity Perception Level[2].

The critical regions (with higher insecurity perception level) are Campania, Puglia and, generally speaking, the regions with large urban areas. Sparsely populated regions present a lower fear level (i.e. Trentino Alto Adige, Valle d'Aosta, immediately followed by Friuli V.G., Molise and Sardegna). These conclusions confirm the results presented in the report "*Indagine Multiscopo sulle famiglie - Sicurezza dei cittadini*" and in particular the region ranking described from ISTAT by a comparison of distribution frequencies of the items in the different regions (see [6], Chapter 11). Moreover, our method allows quantifying this ranking on a metric scale.

[2] The chromatic scale in Figure 2 is obtained by dividing the range of *IPI* into five equal intervals, from a low to an high insecurity perception level.

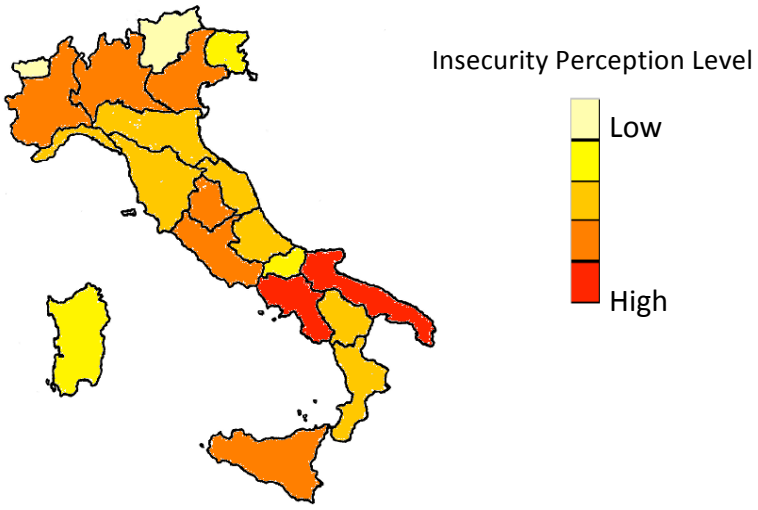

Figure 2. Map of Regional Insecurity Perception Index.

Table 4. Value of Insecurity Perception Index (IPI) by Region.

Region	IPI	Region	IPI
Piemonte	-0,1204	Marche	-0,2947
Valle d'Aosta	-0,5912	Lazio	-0,0506
Lombardia	-0,0675	Abruzzo	-0,2159
Trentino Alto Adige	-0,6133	Molise	-0,3806
Veneto	-0,1341	Campania	0,2012
Friuli Venezia Giulia	-0,4071	Puglia	0,0802
Liguria	-0,2149	Basilicata	-0,2965
Emilia Romagna	-0,2055	Calabria	-0,2339
Toscana	-0,2721	Sicilia	-0,1236
Umbria	-0,1666	Sardegna	-0,3190

3.3 Discussion

The aim of this paper was to define an Insecurity Perception Index, in order to measure the level of personal fear to suffer an offence and/or the fear to be victim of a crime. It is a subjective measure of the fear since our analysis does not consider the number of crimes eventually suffered, neither the real risk to be victim of a crime (objective measurement of the security).

By the PCM we obtain an indicator which could be represented a dependent variable in a predictive victimization model. By considering a multiple-item approach, our method can be improved to define a latent variable, which summarizes various different aspects of the same latent trait of interest (fear of crime).

We may also note that all the measures produced at National and Macro Area levels are almost always negative (Table 4). Coming back to the Figure 1 we may observe that the Personal Location Score distribution is translated towards negative values. Comparing the two metric scales, we may note that subjects have a lower insecurity perception mean level with respect to the items, whose mean level is conventionally zero. It suggests that the ISTAT questionnaire

should be a little improved: a possible solution may consist in a slighting correction of the proposed items, reformulating the questions by requiring more explicitly the level to which the respondent opinion corresponds.

4. Conclusion and future development

To sum up, by applying the Rasch Model we developed a new Citizen Perception Insecurity Index for the Italian country, also disaggregated by geographical areas. In the psychometrical and statistical literature a synthetic indicator measuring the latent construct concerning the fear of crime and the insecurity perception was introduced. Our proposal makes it possible to quantify the psychological aspects related to the personal insecurity perception.
Personal Location Scores, referred to Italian citizens, are net of the proposed items effects: using the Rasch Model we have so produced a more accurate and precise measure of this latent concept. The Index can be used for either a descriptive or an inferential purpose in order to develop criminological forecast models, in which IPI represents the dependent variable.

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APPENDIX
ISTAT MULTI-SCOPE SURVEY (2002): ITALIAN SURVEY ON CITIZENS' SAFETY

The 12 items of the Section III "La percezione della propria sicurezza" considered in the analysis.

Item 1	Safety walking alone in the dark	
Safe		= 1
Quite safe		= 2
Not very safe		= 3
Unsafe		= 4
Item 2	Avoiding places/people for safety reasons	
No		= 1
Yes		= 2
Item 3	Carrying self-defense tools	
No		= 1
Sometimes		= 2
Always		= 3
Item 4	Locking the doors	
No		= 1
Sometimes		= 2
Always		= 3
Item 5	Fear to go out at night	
No		= 1
Sometimes		= 2
Always		= 3
Item 6	Safety when home alone after dark	
Safe		= 1
Quite safe		= 2
Not very safe		= 3
Unsafe		= 4
Item 7	Fear of having one's car stolen	
Very afraid		= 4
Quite afraid		= 3
Not very afraid		= 2
Unafraid		= 1
Item 8	Fear of having one's home robbed	
Very afraid		= 4
Quite afraid		= 3
Not very afraid		= 2
Unafraid		= 1
Item 9	Fear of pick/pockets	
Very afraid		= 4
Quite afraid		= 3
Not very afraid		= 2
Unafraid		= 1
Item 10	Fear of robbery/aggression	
Very afraid		= 4
Quite afraid		= 3
Not very afraid		= 2
Unafraid		= 1
Item 11	Fear of sexual harassment	
Very afraid		= 4
Quite afraid		= 3
Not very afraid		= 2
Unafraid		= 1
Item 12	Influence of criminality on habits	
Very concerned		= 4
Quite concerned		= 3
Not very concerned		= 2
Unconcerned		= 1