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MEASURING CAPABILITIES WITH RANDOM SCALE MODELS. WOMEN'S FREEDOM OF MOVEMENT

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Measuring capabilities with random scale models.

Women's freedom of movement.

by

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Abstract

In Sen's capability approach well-being is evaluated in terms of capabilities (what people are free to do and to be) instead of functionings (what they do and who they are). We utilise random scale models to measure the latent capability of Italian women to move freely when we only observe their realized choices. Our estimations show that the percentage of women predicted to be restricted in their freedom of movement (have restricted capability sets) is 23-25 per cent. If all women were unconstrained, our model predicts that 15-17 per cent of them would choose to do more activities.

Keywords: measurement of capabilities, freedom of movement, random scale models, gender, domestic violence.

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1. Introduction

As an alternative to traditional welfare analysis, Amartya Sen has proposed what he calls the capability approach (Sen, 1985, 1992, 1999). Sen's capability approach distinguishes between what people are free to do and to be (their 'capabilities') and what they do and are (their 'functionings'). In the capability approach, individuals' well-being is evaluated not only in terms of achieved functionings (a vector of observed doings), but also in terms of the freedom to choose between different functionings. The notion of freedom enjoyed by the individual is represented by the individual's capability set (the set of all available vectors of functionings). The capability approach implies that individuals with the same observed functionings may have different well-being because their choice sets (i.e. capabilities) are different.

Attempts to measure capabilities include the direct measurement of capabilities by creating new *ad hoc* surveys (Anand et al 2009) and applying econometric techniques such as structural equation models (Krishnakumar 2007, Krishnakumar and Ballon 2008, Di Tommaso 2007, Di Tommaso et al 2009, Anand et al. 2011). Both these methodology have limitations; on the one hand, direct questions about capabilities may lead to skewed answers because of the problem of adaptive preferences (Sen 1985, 1992, 2009, Elster 1983, Clark 2012), while on the other hand, in structural equation models, the freedom space is taken into account only indirectly through stochastic components.

In this paper we propose a new methodology to measure capabilities. It is based on the random scale modelling approach pioneered by Luce (1959) and McFadden (1973, 1984), extended to a setting with latent capability sets along the lines suggested in Dagsvik (2013). The methodology is used to measure the capability of freedom of movement for Italian women.

The main goal of the paper is to quantify how many women are restricted in their freedom of movement and to analyse what characterizes their restrictions. Unfortunately, the choice sets the

respective women face are not observed, we only observe functionings. Some women may face unobserved restrictions on their choice opportunities due to a violent partner or to the external environment (norms on how women should behave for example), or due to internal fears and feelings of vulnerability because of their past history. What we observe are only the resulting choices, while the capability sets the women face are latent and may vary across women. To deal with this problem, we treat the individual latent choice sets as stochastic.

The data set is derived from a 2006 survey of violence against women and freedom of movement is defined by an index of the number of different activities women attend. We show that between 23.4 and 24.9 per cent of women in our sample are constrained in their movements (have limited capability sets). If we remove the restrictions, between 15.4 and 16.6 per cent of the population of women would choose to exercise more freedom of movement (change their functioning).

Our paper is innovative in that it presents a new methodology for measuring capabilities and applies this methodology to an important aspect of gender inequality: women's freedom of movement. Women's lack of freedom of movement is not often included in gender inequality measures, but it constitutes a strong limitation for many women across different countries in the world.

Section 2 presents our definition of freedom of movement and a discussion of previous literature. Section 3 describes the methodology of random scale models with ranked capability sets, while Section 4 presents descriptive statistics. Estimation results are given in section 5 and simulations in Section 6. Identification issues are discussed in Appendix A.

2. Freedom of movement

Freedom of movement is a particular aspect of individual welfare and is included in the lists of capabilities provided for instance by Nussbaum (1999) or Robeyns (2003, 2004). For instance Martha Nussbaum includes freedom of movement in the list of relevant capabilities constituting what she calls "bodily integrity":

"Bodily integrity. Being able to move freely from place to place; to be secure against violent assault, including sexual assault, marital rape and domestic violence; having opportunities for sexual satisfaction and for choice in matters of reproduction." (Martha Nussbaum, 1999, pg 41).

Freedom from violence is a component of this capability. Our analysis focuses on freedom of movement, because the corresponding capability set is unobserved in our data, while for freedom from violence the capability set is observed (assuming no women would wish for violence). We look at the interdependence between these two capabilities by including psychological, sexual and physical violence among the explanatory variables in our model, though it is unclear what the underlying causal connections may be. Consider a woman who is observed doing few activities; she may have freely chosen so or she may be constrained by fear of violence from her partner. On the other hand, she may choose to do many activities even if this increases the probability of violence from the partner. She may even be participating in many activities to avoid being with a violent partner.

There are few other studies on women's freedom of movement. Robeyns (2004) analyses, gender inequalities in mobility and leisure activities. Mobility is measured by having access to a car or a van, while leisure activities include indicators of social activities and sports' attendance. For both functionings she finds that women have a disadvantage with respect to men which increases with age. She measures functionings and not capabilities because she only observes the realized choices and not the freedom space. Anand et al. (2009), in their survey of capabilities, include the

capability of bodily integrity and freedom of movement. They measure the capability of bodily integrity and of freedom of movement by asking direct questions about the freedom space. So their questions are framed in terms of perception (do you feel safe to……?). Their survey includes questions about feeling safe to go out in the evening or during the day, about being the victim of violent or sexual or domestic assault. The survey also includes a question about enjoyment of recreational activities. Their main research goal is to find the correlation between a list of capabilities and an index of life satisfaction. They find that the parameters for bodily integrity and for recreational activities are not significant for life satisfaction. In another survey of capabilities in Italy, USA and UK, Anand et al. (2013) include questions about having opportuniti*e*s to take part in local social events and the ability to walk safely in the neighbourhood at night. One finding is that Italians have on average more opportunities to take part in social events than British or Americans, but they are less able to walk safely.

Our data set is mainly focused on violence against women, but includes questions on the activities women participate in. Using these questions, we define freedom of movement in a different way from previous papers. Our definition is based on the answers to 8 different questions about the types of activities each woman participates in (going out in the evening, meeting friends, shopping, driving and participation in sports, cultural, political and social activities). Table 1 shows the distribution of the answers to these questions for women between 26 and 65 years of age, who are currently in a relationship (have a partner) and are not disabled. We select women who are currently in a relationship, because we are interested in analysing constraints due to their partners. Women under 26 are excluded because they could still be living with their parents and/or studying. We also exclude women with disabilities, because they have constraints that we do not wish to focus on in this paper.

(Table 1 approximately here)

Our activity index covers freedom of movement in a limited way, because of limitations in our data. One should especially note that we do not know whether a woman engages in the different types of activities listed in Table 1 with her partner or alone. Being able to participate in different activities alone implies more autonomy than doing so with one's partner. The questions about driving and shopping are important because they can to a greater degree be considered autonomous activities.

There are a number of other works that deal with domestic constraints and in particular violence, such as Anand and Santos (2007), Santos (2013), and Di Tommaso et al. (2009). These works are in the spirit of reduced form analysis, in contrast to our structural approach. Anand and Santos (2007) and Santos (2013) have utilized data for the UK to estimate the consequences violent crime and domestic violence have on gender inequalities and basic capabilities. Di Tommaso et al. (2009) have applied a structural equation model with latent variables to analyse the issue of bodily integrity for sexually exploited trafficked women. Aizer (2010) does find that decreases in the wage gap reduce violence against women utilizing data from female hospitalizations for assaults. Bloch and Rao (2002), studying the relationship between violence and dowries in Indian couples, find that some aspects of violent behaviour are strongly related to economic incentives.

3. A Random Scale Model with ranked latent capability sets

Let us assume that individuals have the possibility to choose among some or all alternatives in a countable set, S, of universal alternatives. The universal set, S, is the absolute maximal set of alternatives that are relevant, regardless of whether or not they are available to everybody. The agent is assumed to have preferences over the alternatives in S. Let C denote the choice set of a particular agent (for simplicity we drop the indexation of the agent). It consists of all the

functionings available to the agent. For some agents *C* may be equal to *S*, but in many situations the choice set will be a proper subset of *S*. In our context, *C* represents the agents capability set, and the elements of *C* are the functionings that are available to the agent. The universal set *S* contains all the functionings that are generally possible.

Our modelling approach is based on agents choosing functionings from their capability sets in accordance with the Random Scale Model. Let U_j denote a scale function that represents the welfare of an agent observed utilizing functioning *j* (assuming functioning *j* is available to the agent). Following McFadden (1973, 1984), we assume that $U_j = v_j + \varepsilon_j$, where v_j is a deterministic term that depends on observed characteristics and ε_j is a random error term that is supposed to capture unobserved characteristics that affect the agent's welfare. The random error terms, ε_j, are assumed to be independent with c.d.f. exp(-exp(-*x*)).

Let $J(C)$ denote the choice of the agent when the choice set is equal to *C*. It is assumed that the woman chooses the alternative in C that maximizes the scale U_j, that is, $J(C) = j$ if $U_j = \max_{k \in C} U_k$. Furthermore, let $P_j(C)$ be the probability that the woman shall choose *j*, given the choice set *C*. The choice probabilities that follow are given by (McFadden, 1984)

$$P(J(C) = j) = P_j(C) = \frac{\exp(v_j)}{\sum_{k \in C} \exp(v_k)}, \qquad j \in C \subset S, \tag{1}$$

which is the well-known Multinomial Logit Model.

This framework allows one to relax the rather strong consistency assumptions central to the conventional deterministic utility theory. This goes some way towards meeting the objections of Sen (1985, 1992, 1999) which argue that the standard assumptions of utility theory, such as completeness and transitivity, do not hold.

The motivation of psychologists such as Thurstone (1927) for proposing a random scale framework was to deal with the observational fact that individuals often violate transitivity when faced with replications of (seemingly) identical choice experiments. His explanation was that decision makers may be ambiguous about the precise value of the respective alternatives, in the sense that if the same choice setting is repeated they may choose a different alternative. This unpredictable temporal variation in tastes is represented by the stochastic error terms in the scale representation. The Random Scale Model is particularly designed to allow for this type of seemingly bounded rational behaviour. It can also be consistent with patterns of intransitivity, see Luce and Suppes (1965, p. 350). Moreover, in some cases, this theory leads to more practical methods for doing empirical analyses than the conventional deterministic micro economic theory. In particular, this is true for qualitative choice settings with a finite number of alternatives (discrete alternatives), that are characterized by multidimensional attributes (characteristics).

In our context, the assumption that the agents' preferences are uncertain, in the sense used by Thurstone (1927), is of crucial importance. A currently chosen alternative is considered only a momentary choice. Other, different, choices may be made in the future (even under the same circumstances) due to the influence of whims in perception and problems with assessing the precise value of the alternatives once and for all. This implies that reducing the opportunities available to an agent while leaving her with the possibility of making her current choice, will nevertheless reduce her well-being because it reduces the range of possibilities in the future. Our stochastic structure thereby makes an agents' well-being depend, not only on her choices (functionings), but also on her opportunities (capability sets).

In most empirical situations the capability sets of the agents are unobservable. The above traditional random utility framework can readily be extended to settings with latent capability sets, see for example Ben-Akiva and Watanatada (1981), Dagsvik (1994, 2013) and Dagsvik et. al.

(2006). For simplicity of exposition, we assume that there are a total of *H* possible functionings (going from *1* to *H*), that capability set C_j denotes the smallest capability set that includes functioning *j,* and that all possible capability sets can be strictly ranked; so that $C_j : C_1 \subset C_2 \subset C_3 \cdots \subset C_H \subset S$. This implies that the functionings we are considering can also be uniformly ranked, so that, for example, a capability set that includes the functioning "doing many activities" always includes the possibility of doing few activities (it excludes the possibility of being forced to do many activities). Our modelling approach can be generalized to cases with non-ranked latent capability sets**.** In our empirical model we do this by constructing an index of activities counting the number of activities participated in. It is implicitly assumed that an individual participating in many activities always has the option to participate in fewer activities.

We now let $r(C_j)$ denote the conditional probability that the capability set is equal to C_j, $r(C_j) = P(C = C_j)$. We shall call these probabilities restriction probabilities, which must satisfy the restriction $\sum_{s=1}^{H} r(C_s) = 1$.

Let Q_j be the probability of choosing alternative *j* for an individual. If such an individual is observed choosing alternative *j,* this can only happen if her choice set includes this alternative, i.e. is equal to or greater than C_j. Furthermore, we have that the joint probability of having choice set C_s and choosing alternative *j,* is equal to

$$P(J(C) = j, C = C_s) = P(J(C) = j \mid C = C_s) \cdot P(C = C_s) = P_j(C_s) \cdot r(C_s). \qquad (2)$$

Hence, by summing over all possible choice sets it follows that we must have

$$Q_j = \sum_{s=j}^{H} P_j(C_s) \cdot r(C_s), \quad j \in \{1, \cdots, H\}. \qquad (3)$$

In the special case of $j=1$, this can be written

$$Q_1 = r(C_1) + \sum_{s=2}^{H} P_1(C_s) \cdot r(C_s), \quad (4)$$

while in the special case of $j=H$, it can be written

$$Q_H = P_H(C_H) \cdot r(C_H). \quad (5)$$

In the following we estimate a three state model with the following probabilities of being in each state given by equation (3) above:

$$Q_1 = P_1(C_3) \cdot r(C_3) + P_1(C_2) \cdot r(C_2) + r(C_1) \quad (3a)$$

$$Q_2 = P_2(C_3) \cdot r(C_3) + P_2(C_2) \cdot r(C_2) \quad (3b)$$

$$Q_3 = P_3(C_3) \cdot r(C_3), \quad (3c)$$

where Q_1 is the probability of being (either voluntarily or involuntarily) in state 1, Q_2 is the probability of being in state 2 and Q_3 is the probability of being in state 3.

The fundamental insight of the capability approach to welfare is that it is preferable to evaluate individuals' well-being by their opportunities instead of their choices. As mentioned above, the stochastic nature of our approach makes the well-being of the agents depend on the capability set. To see this, define the conditional indirect random scale, $V_C(\varepsilon_{1,\ldots,} \varepsilon_H)$, as the scale of the chosen alternative in C which is the maximum of the scale function taken over the alternatives in the choice set C. Following Thurstone, we interpret the random terms of the scale function, ε_1, as both representing unobserved heterogeneity among the agents and randomness in the agents' choices, in the sense that under repetition of seemingly identical choice experiments an agent may choose different alternatives on each occasion.

The conditional indirect random scale $V_C(\varepsilon_{1,\ldots,} \varepsilon_H)$ will under our distributional assumptions be extreme value distributed. Let $\bar{V}(C_s)$ be the deterministic part (representative part) of the

conditional indirect scale, conditional on choice set C_s being available, defined as $\bar{V}(C_s) = \mathrm{E}\max_{k\in C_s} U_k$. Due to the distributional assumptions about U_k, it is well known that one obtains

$$\bar{V}(C_s) = \log\left(\sum_{k\in C_s} \exp(v_k)\right), \tag{6}$$

where it should be noted that the evaluation $\exp(v_k)$ is the same across choice sets.

From equation (6) it follows that in our case, with ranked latent capability sets, we have $\bar{V}(C_1) < \bar{V}(C_2) < \cdots < \bar{V}(C_H)$. In other words, the conditional indirect scale is increasing in the size of the opportunity set. As a measure of the well-being of individuals, it thereby has the desired property of valuing opportunities instead of only choices. In the following analysis of freedom of movement, we will not be using this measure, since we only consider a one-dimensional concept of freedom and thereby can directly say that it is better to have an unconstrained freedom of movement than a constrained one. If we were trying to evaluate different combinations of freedoms, then having a measure of the above type would be valuable. The unconditional representative indirect scale function is defined by

$$\mathrm{E}\bar{V}(C) = \sum_{s=1}^{H} \bar{V}(C_s)\cdot r(C_s) = \sum_{s=1}^{H} r(C_s)\cdot \log\left(\sum_{k\in C_s} \exp(v_k)\right). \tag{7}$$

Thus the conditional indirect scale function is the mean value of the chosen functioning restricted to a given capability set C_s, whereas the unconditional indirect scale function is the mean value of the conditional indirect scale where the mean is taken over the possible capability sets. By means of $\mathrm{E}\,\bar{V}(C)$ one may analyse how welfare (in an ordinal sense) varies across households (identified by covariate values) for given selected capability sets. See Dagsvik (2013) for more details on this and for a discussion of how to develop a welfare function and a capability adjusted income distribution based on the indirect random scale function.

We assume that the explanatory variables in the preference and restriction probabilities have a linear form. For individual *i*, the structural part of the scale function is given by,

$$v_{ij} = X_i \beta_j, \qquad (8)$$

for $j = 1, 2, \ldots, H$, with $v_{iH} = 0$, and where X_i is a vector of characteristics which influences a individual *i*'s preferences (including 1 as one of the components) and $\{\beta_j\}$ are vectors of unknown parameters. The assumption that $v_{iH} = 0$ is simply a normalization and represents no loss of generality. Similarly, we assume that the restriction probability is given by

$$r(C_s) = \frac{\exp(Z_i \gamma_s)}{\sum_{r=1}^{H} \exp(Z_i \gamma_r)}, \qquad (9)$$

for $s = 1, 2, \ldots, H$, with γ_H normalized to zero, and where Z_i is a vector of covariates which influences the possibility that individual *i* will be rationed (including 1 as one of the components) and $\{\gamma_s\}$ are unknown parameter vectors. The vector Z_i may include both environment and individual characteristics. The variables included in the X-vector should only be associated with preferences, while other variables are included in the Z-vector. This distinction is not always easy to make. For example, in our analysis we choose to include work (working / not working) in the Z-vector because working requires a certain freedom of movement and thereby reduces the probability of being restricted. It could be argued that working is also an indication of a preference for a high degree of movement, but we assume that such preferences are taken care of by the education and age of the women we study.

4. Data

The data set consists of a survey of 25,000 Italian women between 16 and 70 years old interviewed over the phone in 2006 (Istat, Indagine Multiscopo sulla Sicurezza delle donne, 2006).

The survey is designed to detect three types of violence against women: physical violence; sexual violence (ranging from harassment to rape); and psychological violence (your partner prevents you from working, from studying, from being in control of your money, from seeing your family, etc.). Moreover the survey contains information on individual characteristics of the women, such as the number of children, age, education, job qualification, full time/part time, work at home or outside the home, along with variables on social activities such as going to the cinema, to the theatre, meeting friends, sports, participation to associations, to political activities, to volunteer activities, etc. The survey also contains detailed information on the current partner and previous partners.

We select a sample of women who are currently in a relationship (marriage, co-habitation or engagement), from 26 to 65 years of age and exclude those who are disabled. The resulting sample consists of 17,350 women.

In our estimations we utilize an index of activities defined over the number of activities women participates in often or sometimes (see Table 1 above for the list of activities). We will consider that a women participates in an activity if she answers "often or sometimes" to the first five questions, answers "once a week or more" to the questions on going out in the evening and going shopping or answers "yes" to the question on driving. This index takes values from 1 to 3 (see Table 2). The three states described by the index correspond to the universal set, *S*. The possible choice sets available to the women are $C_1 = \{1\}$, $C_2 = \{1,2\}$, or $C_3 = \{1,2,3\}$.

(Table 2 approximately here)

The index of activities is equal to 1 if the woman participates in 0, 1 or 2 activities often or sometimes, it is equal to 2 if the woman participates in 3 activities often or sometimes, and it is equal to 3 if the woman participates in 4, 5, 6, 7 or 8 activities often or sometimes. Each index value

constitutes a different state in our model. In devising the index we chose to concentrate on extreme behaviour (participating in few activities) instead of distributing the observations evenly across states. This builds on the implied assumption that it is more likely to find restricted women among those participating in few activities than among those participating in many. It is important to note that state 3 implicitly defines a state of full freedom of movement, so that any woman participating in 4 or more activities is deemed to have full freedom of movement. In other words, our analysis assumes that the 54.1 per cent of women in state 3 are never restricted. If we had defined state 3 as consisting of those participating in 5 or more activities than this would have fallen to 36.0 per cent. Considering the types of activities we have data for, we found it natural to set the cut-off point at 4 activities or more. We have also estimated a model based on a four state activity index, but found that the increased number of states complicated our estimation due to empty cells, without changing the general results derived in our model using the 3 state activity index.

(Table 3 approximately here)

Table 3 provides descriptive statistics of the exogenous variables for the three states of the activity index. The average age of the women in our sample is decreasing from about 50 years old in state 1 to 45 years old in state 3. As expected, younger women are involved in more activities. Educated women are involved in more activities than women with less education. Also as expected, the health of women doing few activities is worse than the health of those doing many, with 31 per cent of women who are involved in 0, 1 or 2 activities (state 1 of the activity index) being healthy, while 42 per cent of women who are involved in 4,5,6,7 or 8 activities (state 3 of the activity index) are healthy. The health variable is a dummy variable taking the value of one if the woman replies

that she had never had any of a set of ten health problems. The list of questions and their descriptive statistics are reported in table B1 in Appendix B.

We utilize two variables for domestic violence: a dummy variable equal to one if a woman has been subjected to either physical or sexual violence and a variable for psychological violence which is equal to the sum of positive responses to questions about psychological violence. Table B2 in Appendix B contains the list of questions which were asked about psychological violence. Table 3 shows that psychological violence decreases when going from state 1 to state 3. On average women in state 1 have been subjected to 1.1 different types of psychological violence while women in state 3 have been subjected to 0.92 types of psychological violence. Table 3 also shows that physical and sexual violence increases slightly with increased activity. As expected, working women are more active, while women with older partner participate in fewer activities.

Among women in state 1 (few activities) there is a higher percentage of southern women (44 per cent), while among women in state 3 (many activities) 47 per cent are from the north. In Italy, southern regions have lower gender equality; for instance women participation in the labour force is lower than in the north, men's involvement in care work and domestic activities is also lower; there are also less women involved in politics. We have include regional dummies to take into account different levels of gender inequalities across the country.

The education of the partner is also included among the explanatory variables; 66 per cent of women in state 1 have a partner with low education against 35 per cent of women in state 3.

5. Estimation results

We have estimated both the choice probabilities and the restriction probabilities in the three state model. Tables 4 and 5 report the parameter estimates and marginal effects for two specifications of the model. The first specification is our preferred specification, including among

the X variables only the personal characteristics of the woman (age and education), and among the Z's the dummies for woman's health and work, a variable for psychological violence by the partner, a dummy for sexual or physical violence by the partner, a dummy for a partner with a low education, a variable denoting the age difference between the partners and regional dummies. We prefer this specification because we consider all these variables to be related to whether a woman is constrained in her freedom of movement or not.

Even so, it is open to discussion whether our specification is the best; whether other variables should be included in the preference probabilities (among the X variables) instead of being included in the restriction probabilities (among the Z variables). To see how much of a difference this makes, we have estimated an alternative specification, specification 2, where the dummies for woman's health and whether she works are included in the preference probability instead of in the restriction probability. Specification 2 shows that our results seem fairly robust to our choice of which variables to include in the preference probability and which to include in the restriction probability. It should also be noted that the likelihood is larger (less negative) for specification 1 than for specification 2.

In discussing the estimation results, we focus on the marginal effect of each variable on the probability of being observed to be in state 3, doing many activities. Marginal effects for continuous variables are the derivatives of the Q probabilities (the probability of being observed in one of the states) with respect to a change in the variable. Marginal effects for dummy variables are the changes in the Q probabilities when the dummy goes from 0 to 1. The marginal effect for psychological violence is also for a change from 0 to 1, even though it is continuous. Since most women answer no to all the questions on psychological violence, the median size of this variable is 0 and it is natural to look at the change from 0 to answering yes to one question. Note that the

marginal effects for each variable sums to zero across states. The base category is state 3: doing 4 or more activities.

In assessing the marginal effects on the observed probability, Q_j, it is important to remember that some variables work through the preference probability, P_j, and some through the restriction probability r_j. A positive marginal effect, increasing the probability of observing an individual in state 3, can be due to an increase in the desire to be in state 3 (to do many activities) if the variable affects the preference relationship (is included among the *X*-variables). Or, it can be because of a decrease in the probability of being restricted in one's freedom of movement (less chance of being restricted to doing few activities) if the variable affects the restriction probability (is included among the *Z*-variables).

(Table 4 and 5 approximately here)

The probability of Italian women wishing to do many activities decreases with age and increases with education in both the specifications we look at. Including health and work in the preference probability, as is done in specification 2, increases the marginal effects of the other preference variables compared to specification 1. The marginal effect (on being in state 3) of age is negative, decreasing the probability of doing more 4 or more activities by 0.7 percentage points both in specification 1 and 2. Having a university degree increases the probability of being in state 3 by 29 percentage points in specification 1 and by 36 points in specification 2. A high school degree increases the probability by 19 percentage points in specification 1 and by 22 percentage points in specification 2. Education might be a proxy for income, with educated women being more involved in many activities not only for socio-cultural reasons, but also because activities are costly.

In both specifications, increased age difference, living in southern Italy or having a partner with a low education increase the probability of being restricted in one's ability to be active, decreasing the probability of being in state 3. Living in the south of Italy decreases the probability of being in state 3 by 6 percentage points in specification 1 and by 4 percentage points in specification 2. This could be due to differences in cultural norms for the behaviour of women, since the south has more gender inequality than the north. The largest marginal effect (among the restricted variables) is found for women with a low educated partner. Having a partner with a low education decreases the probability of being in state 3 by 10 and 6 percentage points in specification 1 and 2 respectively. As with the education of the women, this variable may to a certain extent be a proxy for income.

The difference between our two specifications is in whether health and work are included in the preference relationship or in the restriction relationship. In the first case, they affect the desire to have different levels of activity, while in the second case they affect the probability of being restricted in their freedom of movement. For this reason, the size of the marginal effects in the two cases cannot be directly compared, but one would expect their signs to be the same (which is the case in our estimations). In specification 1, being healthy decreases the probability of being restricted in doing activities, thereby increasing the probability of being in state 3 by 3 percentage points. In specification 2, being healthy increases the desire for being active, thereby increasing the probability of being in state 3 by 8 percentage points. Work has a similar positive (significant) effect on being in state 3 as health, but the effect is weaker. As with education, work can be considered a proxy for income.

5.1 Violence by the partner

Of the variables considered in our two specifications, the violence variables seem to have the least stable (and least significant) relationship to freedom of movement (aside from living in central Italy). Even when significant, the effects of violence are small. The marginal effects for psychological and physical violence are insignificant in specification 2, while they are larger and significant in specification 1. In specification 1, being exposed to psychological violence (answering positively to one of the questions about psychological violence) increases the probability of being constrained and thereby decreases the probability of being in state 3 by 0.4 percentage points, while being exposed to physical or sexual violence decreases the probability of being in state 3 by 1.5 percentage points. In specification 2 only the parameter estimate for state 1 is significant, while the marginal effects are all insignificant (some could of course be significant if we choose a different base category when calculating the marginal effects). The sign of this parameter is the same between specifications.

This has surprised us even though these results conform with the descriptive statistics of Table 3, where those in state 3 experience a greater prevalence of such violence than those in state 1 or 2. It is not obvious why psychological and sexual/physical violence should have opposite effects on the probability of being restricted in one's freedom of movement. Psychological violence might be considered a controlling behaviour of the same kind as behaviour which limits freedom of movement (also Anand and Santos 2007 find that fears and vulnerability have a negative impact on freedom of movement), while physical violence can be considered reactive behaviour, which increases as the control of the women decreases (when she for example engages in more activities outside the home). In any case, our results indicate that the reasons for and effects of violence by a women's partner are complicated, requiring further inquiry.

5.2 Alternative specifications – sensitivity analysis

We have also estimated the model with health in both the preference and the restriction probabilities (specification 3 in Table C1). Results of this and the following alternative estimations are shown in Appendix C. The parameters for the health dummy are not significant at the 95% level in the preference probability (but are at the 90% level), while in the restriction probability the health parameter for state 1 is significant, but not the one for state 2. The in-sample predictions are close to those of specification 1. This might indicate that specification 1 is to be preferred, but we believe the ultimate choice of specification must rest on information or assumptions outside the data (it is in general the case that latent variables can only be identified using outside restricting assumptions of either a stochastic or functional nature, otherwise they would not be considered latent). To us it seems more intuitive to model health and work (and the other variables in the restriction probability) as influencing the restrictions women face than modelling them as determining preferences.

It is a possibility that the effect of the violence variables is reduced due to multicollinearity with the partner variables (age difference, partner's education, and where they live). Also, the discussion above indicates that there might be simultaneity between the number of activities a woman pursues and her experience of violence by her partner. To check whether multicollinearity is a problem, we have re-estimated specification 2 with only the violence variables in the restriction probabilities (specification 4 in Table C2). In this case, we get that the parameters for both the violence variables are significant in state 1 and not significant in state 2, as in specification 1, and the signs of the parameters are the same as in specification 1 and 2. It would therefore seem that multicollinearity is not a significant problem for the significance of the violence variables.

Furthermore, we have checked for any simultaneity bias by re-estimating both specifications 1 and 2 without the violence variables (specifications 1b and 2b in tables C3 and C4). Compared to specifications 1 and 2, we find only minor changes in the parameter estimates and in the marginal

effects. The number of women restricted in their freedom of movement declines by 0.9 per cent in specification 1, while it declines by 5.5 per cent in specification 2. The better robustness of specification 1 in this context is another reason to prefer it to specification 2. So it seems that violence is not a main determinant (if a determinant at all) of whether a woman is constrained in her freedom of movement and thereby cannot lead to strong multicollinearity or simultaneity problems.

6. Simulations

Above we discussed the effect of the different variables separately. In this section we will look more closely at the aggregate behaviour of our model, looking at in-sample predictions of the number of women who are constrained and how the restriction probabilities vary for different groups of women (for different combinations of explanatory variables). These simulations demonstrate that random scale models such as ours can offer a suitable framework for measuring well-being freedom and capabilities. Table 6 shows the general fit of our estimations, with observed frequencies and the predicted average probabilities for the three states. As expected, predicted average probabilities are very close to the observed ones (but not equal, as they would be in, for example, a multinomial logit model).

(Table 6 approximately here)

A measure of the capability of having freedom of movement can be found by simulating the number of women who are constrained to be in state 1 and in state 2 (the expected number restricted to each state is found by summing the individual restriction probabilities $r_i(C_j)$ across all i individuals in our sample). In the following tables we report results for both specifications 1 and 2, but mainly limit our comments in the text to our preferred specification, specification 1.

(Table 7 approximately here)

Table 7 shows the number of women predicted to be constrained. The table shows that the expected number of women constrained to state 1 (with a choice set, $C_1 = \{1\}$, consisting only of state 1) is 2,201, consisting of 12.7 per cent of the women in the sample. These women do not have the opportunity to be able to choose to be in state 2 or 3. There are 2,117 women constrained to choosing between state 1 or 2 (with choice set, $C_2 = \{1,2\}$), which is 12.2 per cent of the women in the sample. Women with choice set $C_2 = \{1,2\}$ are prevented from choosing to be in state 3 (doing 4 or more activities). The total number of women who are constrained, those with either choice set $C_1 = \{1\}$ or $C_2 = \{1,2\}$, is thereby equal to 4,317, which is 24.9 per cent of the sample. It is notable that while specification 2 gives roughly the same total number of constrained women as specification 1, it gives a very different distribution between those constrained to choice set C_1 and those constrained to C_2.

(Table 8 approximately here)

Table 8 shows how many women change states if no one is restricted. This implies that all women have the choice set $C_3 = \{1,2.3\}$, so their choices are solely determined by their preference probabilities $P_j(C)$. Some of the women constrained to choice set $C_1 = \{1\}$ will now choose to become more active, ending up in state 2 or 3. Some of the women constrained to choice set $C_2 = \{1,2\}$ will now choose to go to state 3. Note that our model specification implies that some women who are constrained to choice set C_2, having chosen state 1, now move to state 3.

Table 8 shows that 2,336 women leave state 1 if unconstrained (in specification 1). This consists of 1,874 women who were constrained to choice set C_1 and 462 who were constrained to choice set C_2. Those leaving state 1 is 50.6 per cent of the women originally in this state (which is 13.5 per cent of all women in our sample). The table also shows that the net change in state 2 is a loss of 547 women, consisting partly of women entering state 2 from state 1 and partly of women leaving state 2 for state 3. Finally, 16.6 per cent of the population of women go from being restricted to either state 1 or 2 to choosing state 3 (doing 4 or more activities).

In specification 2 we find slightly lower over-all numbers than in specification 1, with 23.4 per cent of women being constrained in their movements and 15.4 per cent of them choosing to change to state 3 if all constraints were removed (there are larger differences for the distribution and changes in states 1 and 2).

(Table 9 approximately here)

Table 9 shows the variability in the probabilities resulting from our estimated model. It illustrates how the probabilities vary according to changes in the explanatory variables, showing maximum and minimum probabilities along with their 95% confidence intervals. The table reports the predicted probability of being constrained to either state 1 or 2 (restricted to either choice set C_1 or C_2) for three types of individuals. The base category is a woman with a non-violent partner who is 3.44 years older (the average age difference) and where the partner has at least a high school education. The woman has a high school degree or higher, she is not healthy, does not work and lives in northern Italy. For specification 1, the base category has a 16.5 per cent probability of being constrained, which is lower than the 24.9 per cent we find over the whole sample population (see Table 7).

The minimum probability category is a woman with a physically or sexually violent partner who is 0.60 years younger (the average age difference minus one standard deviation) and where the partner has at least a high school education. She has a high school degree or higher. The woman is healthy, works and lives in northern Italy. For this category the predicted probability of be constrained is equal to 6.6 per cent.

The maximum probability category is a woman with a psychologically violent partner, who is 7.49 years older (the average age difference plus one standard deviation). Both partners do not have a high school degree or higher. The woman is not healthy, does not works and lives in southern Italy. The predicted probability for this category is 53.7 per cent.

To illustrate the accuracy of our estimation method we have also reported in table 9 the confidence intervals for the predicted probabilities. We see that the parameter estimates give a variation in predicted probability from 8 to 52 per cent, while the 95 per cent confidence intervals give a range from 4 to 56 per cent. For the three categories shown in table 9, the 95 confidence interval is plus minus 4 to 5 percentage points.

7. Conclusion

Our paper is innovative and important for two reasons. First, it shows a new methodology to measure well-being freedom, i.e. capabilities. Second, it applies the methodology to an aspect of gender inequality, women's freedom of movement, which is potentially very interesting to measure in many other cultural, social and religious contexts.

We have used a random scale model to measure the capability of freedom of movement for Italian women. Our estimates imply that between 23.4 and 24.9 per cent of women in our sample are constrained in their movements (have limited capability sets). If we remove their constraints, between 15.4 and 16.6 per cent of the population of women would choose to exercise more freedom

of movement, changing their functionings (doing 4 or more activities). Not all constrained women would change because some will prefer doing few activities even when unconstrained.

We find that the probability of women being constrained in their freedom of movement increases with increased age difference between the partners, with living in southern Italy or having a partner with a low education. Being healthy and being exposed to physical violence are both positively related to freedom of movement, while being exposed to psychological violence is negatively related to freedom of movement. Further investigations are needed on this issue; in particular it would be useful to have a panel data set in order to explore the dynamic relation between violence and movement over the life cycle.

Within the capability approach it is important to develop methods to input the restrictions in freedom faced by individuals when their restrictions are unobserved. Having such methods increases the applicability of the capability approach and opens up many interesting research questions which would otherwise be difficult to analyse. Even so, it is important to acknowledge that the inference measures presented in our paper are less precise than what we would get if we could measure the restrictions directly.

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Table 1: Observed functionings of 8 women's activities; 17.350 Italian women.

Percent of women.

	How often do you meet friends?	How often do you go to the cinema, theatre, concerts?	How often do you practice sports?	Do you work as a volunteer or attend a club, an association or a political party?	Do you practice other activities?
Often	25.9	8.3	18.3	8.2	6.63
Sometimes	33.5	26.0	11.7	5.8	22.7
Rarely	22.9	22.0	7.0	3.0	17.41
Never	17.7	43.7	62.9	83,0	53.25
No reply	0,01	0,01	0	0.01	0.01
	100,0	100,0	100,0	100,0	100,0

Table 1 continued: Observed functionings of 8 women's activities; 17.350 Italian women.

Percent of women.

	How often do you go out in the evening?	How often do you go shopping?		Do you drive a car or motorcycle?
Once a week or more	51,0	96,3	Yes	70.06
Once a month or sometimes a month	27,0	2,8	No	29.94
Sometimes a year	13,4	0,3		
Never	8,5	0,5		
No reply	0,2	0,1		
	100,0	100,0		100,0

Table 2: Activity index: the number of activities a woman participates in*.

Index=	1	2	3	
Number of activities=	0-2	3	4-8	Total
Number of women	4,548	3,423	9,379	17,350
Percentage	26.2	19.7	54.1	100

* Answers "often" or "sometimes" to questions on activity, except for going out in the evening, shopping or driving. In these cases active women answer "once a week or more" to the questions on going out in the evening and going shopping or answer "yes" to the question on driving.

Table 3: Descriptive statistics: 17,350 Italian women

	Mean		
	State 1	State 2	State 3
Woman's age in years	50.062	46.459	44.742
Woman degree= 1 if the woman has a university degree;=0 otherwise	0.053	0.088	0.205
Woman high school=1 if the woman has a high school diploma; =0 otherwise	0.269	0.394	0.491
Woman low education=1 if the woman has no high school diploma; =0 otherwise	0.679	0.519	0.304
Woman healthy= 1 if does not have any health problems based on a list of 10 questions*	0.305	0.362	0.416
Psychological violence by partner=number of positive responses to questions about psychological violence**	1.103	0.994	0.925
Physical or sexual violence by partner=1 if such violence is flagged in survey	0.062	0.064	0.068
Woman Works = 1 if the woman works;=0 otherwise	0.375	0.470	0.603
Age difference = age of partner minus age of woman	3.771	3.499	3.261
Northern Italy = 1 if the woman and partner live in northern Italy; =0 otherwise	0.381	0.426	0.468
Central Italy = 1 if the woman and partner live in central Italy; =0 otherwise	0.176	0.183	0.206
Southern Italy = 1 if the woman and partner live in southern Italy; =0 otherwise	0.443	0.391	0.326
Partner low education=1 if the partner has no high school diploma ;=0 otherwise	0.660	0.526	0.349

*See table A1in the appendix for questions on health.

**See table A.2 in the appendix for questions on psychological violence.

Table 4. Parameter estimates and marginal effects, 17,350 observations. Specification 1.

	State 1: 0-2 activities		State 2: 3 activities		State 3: 4-8 activities	
Variables names	Parameter	Marginal effect $\partial Q/\partial x$	Parameter	Marginal effect $\partial Q/\partial x$	Parameter	Marginal effect $\partial Q/\partial x$
Preference variables, *X*						
Woman's Age	0.0630*	0.0087*	0.0112*	-0.0017*	-	-0.0071*
	(0.0056)	*(0.0005)*	*(0.0034)*	*(0.0005)*		*(0.0006)*
Woman Degree[1]	-4.2028*	-0.1865*	-1.6899*	-0.1054*	-	0.2919*
	(1.2684)	*(0.0108)*	*(0.3336)*	*(0.0114)*		*(0.0134)*
Woman High School[1]	-1.7174*	-0.1359*	-0.7930*	-0.0551*	-	0.1910*
	(0.1697)	*(0.0084)*	*(0.1002)*	*(0.0082)*		*(0.0102)*
Constant	-4.0309*		-1.4398*		-	
	(0.3546)		*(0.2145)*			
Restriction variables, *Z*						
Woman is Healthy[1]	-0.5048*	-0.0305*	-0.3303*	0.0016	-	0.0289*
	(0.0826)	*(0.0047)*	*(0.1312)*	*(0.0031)*		*(0.0050)*
Woman Works[1]	-0.2057*	-0.0173*	-0.4561*	-0.0051	-	0.0225*
	(0.0729)	*(0.0048)*	*(0.1324)*	*(0.0035)*		*(0.0057)*
Psychological violence by partner.[1]	0.0744*	0.0050*	0.0102	-0.0013	-	-0.0036*
	(0.0202)	*(0.0014)*	*(0.0310)*	*(0.0009)*		*(0.0014)*
Physical or sexual violence by partner.[1]	-0.3474*	-0.0199*	-0.0554	0.0049		0.0149
	(0.1506)	*(0.0079)*	*(0.2104)*	*(0.0055)*		*(0.0093)*
Age Difference	0.0208*	0.0779*	0.0137	0.0031	-	-0.0810*
	(0.0086)	*(0.0088)*	*(0.0129)*	*(0.0090)*		*(0.0141)*
Central Italy[1]	0.1111	0.0082	0.0658	-0.0008	-	-0.0074
	(0.0978)	*(0.0067)*	*(0.1668)*	*(0.0047)*		*(0.0072)*
Southern Italy[1]	0.5733*	0.0545*	0.7134*	0.0077	-	-0.0622*
	(0.0803)	*(0.0061)*	*(0.1794)*	*(0.0047)*		*(0.0067)*
Partner Low Education[1]	0.8334*	0.0849*	1.0573*	0.0143*	-	-0.0992*
	(0.0814)	*(0.0074)*	*(0.2311)*	*(0.0065)*		*(0.0085)*
Constant	-2.3185*		-2.4345*		-	
	(0.1689)		*(0.4090)*			

The base state for the estimation is State 3: women engaged in 4-8 activities; the base category (in terms of dummies) is a woman who is not healthy, does not work and lives in northern Italy with a low education level and a non-violent partner with a high school degree or higher. The marginal effects are evaluated for the base category at the average age of the woman (46.48 years of age) and at the average age difference of the couple (3.44 years).

1) The marginal effect $\partial Q^R/\partial x$ is for discrete change of dummy variable (and psychological violence variable) from 0 to 1.

*$p<0.05$, log likelihood = -15980.5, standard errors in parenthesis

Table 5. Parameter estimates and marginal effects with health and work among the preference variables, 17,350 observations. Specification 2.

	State 1: 0-2 activities		State 2: 3 activities		State 3: 4-8 activities	
Variables names	Parameter	Marginal effect $\partial Q/\partial x$	Parameter	Marginal effect $\partial Q/\partial x$	Parameter	Marginal effect $\partial Q/\partial x$
Preference variables, *X*						
Woman's Age	0.0447*	0.0084*	0.0119*	-0.0017*	-	-0.0068*
	(0.0042)	*(0.0005)*	*(0.0042)*	*(0.0005)*		*(0.0007)*
Woman Degree[1]	-2.4978*	-0.2319*	-2.0155*	-0.1267*	-	0.3586*
	(0.4829)	*(0.0117)*	*(0.5058)*	*(0.0121)*		*(0.0179)*
Woman High School[1]	-1.2956*	-0.1631*	-0.8720*	-0.0563*	-	0.2195*
	(0.1169)	*(0.0090)*	*(0.1251)*	*(0.0085)*		*(0.0115)*
Woman is healthy[1]	-0.4615*	-0.0709*	-0.2565*	-0.0094	-	0.0803*
	(0.0661)	*(0.0096)*	*(0.0662)*	*(0.0084)*		*(0.0118)*
Woman Works[1]	-0.2740*	-0.0359*	-0.2539*	-0.0219*	-	0.0579*
	(0.0657)	*(0.0105)*	*(0.0655)*	*(0.0085)*		*(0.0123)*
Constant	-2.6076*		-1.3976*		-	
	(0.2728)		*(0.2771)*			
Restriction variables, *Z*						
Psychological violence by partner.[1]	0.1485*	0.0012	0.0306	0.0006		-0.0018
	(0.0508)	*(0.0008)*	*(0.0245)*	*(0.0007)*		*(0.0014)*
Physical or sexual violence by partner.[1]	-0.5604	-0.0062	-0.1968	-0.0039	-	0.0101
	(0.4130)	*(0.0044)*	*(0.1623)*	*(0.0035)*		*(0.0078)*
Age Difference	0.0799*	0.0321*	0.0050	0.0219*	-	-0.0540*
	(0.0254)	*(0.0084)*	*(0.0091)*	*(0.0068)*		*(0.0150)*
Central Italy[1]	0.5864	0.0014	0.0061	-0.0003	-	-0.0011
	(0.4961)	*(0.0033)*	*(0.1093)*	*(0.0027)*		*(0.0055)*
Southern Italy[1]	1.6967*	0.0248*	0.5142*	0.0116*	-	-0.0364*
	(0.5188)	*(0.0061)*	*(0.1176)*	*(0.0044)*		*(0.0057)*
Partner Low Education[1]	2.5723*	0.0457*	0.7702*	0.0167*	-	-0.0624*
	(1.1991)	*(0.0072)*	*(0.1552)*	*(0.0050)*		*(0.0070)*
Constant	-6.2498*		-1.9932*		-	
	(1.7125)		*(0.3371)*			

The base state for the estimation is State 3: women engaged in 4-8 activities; the base category (in terms of dummies) is a woman who is not healthy, does not work and lives in northern Italy with a low education level and a non-violent partner with a high school degree or higher. The marginal effects are evaluated for the base category at the average age of the woman (46.48 years of age) and at the average age difference of the couple (3.44 years).

1) The marginal effect $\partial Q^R/\partial x$ is for discrete change of dummy variable (and psychological violence variable) from 0 to 1.

*$p<0.05$, log likelihood = -15987.04, standard errors in parenthesis

Table 6. Observed frequencies, predicted average probabilities. 17,350 women.

	States 1: 0-2 activities	State 2: 3 activities	State 3: 4-8 activities
Observed frequencies	26.21%	19.73%	54.06%
Predicted average probabilities (spec. 1)	26,24%	19,79%	53,97%
Predicted average probabilities (spec. 2)	26,25%	19,79%	53,96%

Table 7. Number of women predicted to be constrained. Number and per cent of all women, 17,350 observations.

	Constrained to choice set $C_1 = \{1\}$	Constrained to choice set $C_2 = \{1,2\}$	Total constrained
Specification 1			
Expected number of constrained women	2,201	2,117	4,317
- Percent constrained	12.7	12.2	24.9
Specification 2			
Expected number of constrained women	662	3,390	4,051
- Percent constrained	3.8	19.5	23.4

Table 8. Change in the number of women in each state if there are no restrictions. Number and per cent of all women, 17,350 observations.

	State 1	State 2	State 3
Specification 1			
Net change if all women are simulated to be unconstrained	-2,336	-547	+2,883
- Percent change	-13.5	-3.2	+16.6
Specification 2			
Net change if all women are simulated to be unconstrained	-1,600	-1,071	+2,671
- Percent change	-9.2	-6.2	+15.4

Table 9. Predicted probability of being constrained to either states 1 or 2 (having restricted choice set $C_1 = \{1\}$ or $C_2 = \{1,2\}$) for some categories of individuals. Per cent and 95% confidence interval.

	Predicted probability of being constrained	95 % confidence interval	
Base category[1]			
Specification 1	16.5	10.7	22.3
Specification 2	12.4	5.6	19.1
Minimum probability category[2]			
Specification 1	6.6	2.6	10.7
Specification 2	10.1	3.7	16.6
Maximum probability category[3]			
Specification 1	53.7	49.9	57.5
Specification 2	48.1	42.6	53.7

[1] The base category is a woman with a non-violent partner who is 3.44 years older (the average age difference) and where the partner has at least a high school education. She has a high school degree or higher. The woman is not healthy, does not work and lives in northern Italy.

[2] The minimum probability category is a woman with a physically or sexually violent partner who is 0.60 years younger (the average age difference minus one standard deviation) and where the partner has at least a high school education. She has a high school degree or higher. The woman is healthy, works and lives in northern Italy.

[3] The maximum probability category is a woman with a psychologically violent partner, who is 7.49 years older (the average age difference plus one standard deviation). Both partners do not have a high school degree or higher. The woman is not healthy, does not works and lives in southern Italy.

Appendix A: Identification issues

It is possible to get identification by introducing observed discrete covariates into the preference terms $\{v_j\}$ and the restriction probabilities. To see that the model can be identified in this case, we show that the unrestricted choice probabilities and the restriction probabilities can be expressed as functions of the observable probabilities, Q_j. By this we mean that, within subsamples of observationally identical households, all the probabilities $r(C_s)$ and $P_j(C_s)$, $j \in C_s$, $s = 1, 2, \ldots, H$, can in principle be estimated by replacing the respective observable probabilities by their empirical counterparts, provided the subsamples are sufficiently large.

To see that introducing discrete covariates can identify our model, consider a two state model. From equations (1) and (8) we have

$$P_1(C_2) = \frac{\exp(X_i\beta)}{1+\exp(X_i\beta)}, \tag{10a}$$

$$P_2(C_2) = \frac{1}{1+\exp(X_i\beta)}. \tag{10b}$$

From this, together with equations (3) and (9) we get

$$Q_1 = r(C_1) + P_1(C_2)\cdot r(C_2) = \frac{\exp(X_i\beta)+\exp(Z_i\gamma)+\exp(X_i\beta+Z_i\gamma)}{1+\exp(X_i\beta)+\exp(Z_i\gamma)+\exp(X_i\beta+Z_i\gamma)} \tag{11a}$$

$$Q_2 = P_2(C_2)\cdot r(C_2) = \frac{1}{1+\exp(X_i\beta)+\exp(Z_i\gamma)+\exp(X_i\beta+Z_i\gamma)}. \tag{11b}$$

Rewriting equations (11) as odds-ratios we get

$$\frac{Q_1}{Q_2} = \exp(X_i\beta)+\exp(Z_i\gamma)+\exp(X_i\beta+Z_i\gamma). \tag{12}$$

Assume there is one dichotomous explanatory variable in each of the vectors so that $X_i=\{1,x_i\}$ and $Z_i=\{1,z_i\}$, with $x_i \in \{0,1\}$ and $z_i \in \{0,1\}$. This means that we can view women as belonging to one of four groups composed of the four different possible combinations of x_i and z_i

(note that as the number of variables increases linearly, the number of possible combinations increases geometrically). We therefore get the following four equations for the four different subgroups among those who might be restricted in their choices:

$$\frac{Q_1}{Q_2} = \exp(\beta_0) + \exp(\gamma_0) + \exp(\beta_0 + \gamma_0), \qquad \text{if } x_i = 0,\ z_i = 0 \quad (12a)$$

$$\frac{Q_1}{Q_2} = \exp(\beta_0 + \beta_1) + \exp(\gamma_0) + \exp(\beta_0 + \beta_1 + \gamma_0), \qquad \text{if } x_i = 1,\ z_i = 0 \quad (12b)$$

$$\frac{Q_1}{Q_2} = \exp(\beta_0) + \exp(\gamma_0 + \gamma_1) + \exp(\beta_0 + \gamma_0 + \gamma_1), \qquad \text{if } x_i = 0,\ z_i = 1 \quad (12c)$$

$$\frac{Q_1}{Q_2} = \exp(\beta_0 + \beta_1) + \exp(\gamma_0 + \gamma_1) + \exp(\beta_0 + \beta_1 + \gamma_0 + \gamma_1), \qquad \text{if } x_i = 1,\ z_i = 1 \quad (12d)$$

where the parameter vectors are given as $\beta = \{\beta_0, \beta_1\}'$ and $\gamma = \{\gamma_0, \gamma_1\}'$. This is four equations in four parameters, so there is now a possibility of the model being identified. Since these equations are non-linear, one cannot generally use a simple counting rule to generally establish identifiability, but the above indicates that a fairly small set of discrete explanatory variable should in practice lead to identification without requiring assumptions about who might be at risk of being restricted.

In general, the above model is only identified if we exogenously decide that a subgroup is never restricted, but in our case we have enough discrete explanatory variables to identify the model in the manner described above without needing to specify an unrestricted subgroup.

For continuous variables identification is readily established. Consider the two-state model

$$Q_1 = r + (1 - P) \cdot r \quad (13a)$$

$$Q_2 = P \cdot r \quad (13b)$$

$$P = 1/(1 + \exp(-\beta_0 - \beta_1 x)) \quad (13c)$$

$$r = 1/(1 + \exp(-\gamma_0 - \gamma_1 z)) \quad (13d)$$

where x and z are now considered as continuous variables. From the equations in (13) we get

$$\partial \log Q_2/\partial x - \left[\partial^2 \log Q_2/(\partial x)^2\right] / \left[\partial \log Q_2/\partial x\right] = \beta_1 \qquad (14)$$

so that β_1 is identified from the (theoretically) observable moments of Q_2. Furthermore, from

$$\log[P/(1-P)] = \left[\beta_1 - \partial \log Q_2/\partial x\right] / \left[\partial \log Q_2/\partial x\right] = \beta_0 + \beta_1 x \qquad (15)$$

we see that β_0 is identified when β_1 is identified separately as done above. Identification of γ_0 and γ_1 is done in a similar manner. Note that establishing that identification is possible in theory does not necessarily mean that it is always achieved in practice.

Appendix B: Health and Psychological violence variables

Table B1: Women who are healthy; not having health problems*, 17,350 women

	Mean		
	State 1	State 2	State 3
Does not have headache=1; 0 otherwise.	0.660	0.687	0.726
Does not have toothache	0.888	0.913	0.938
Does not have a disturbed stomach, nausea or vomit	0.850	0.876	0.886
Does not have an irregular heartbeat	0.832	0.879	0.900
Does not experience weakness and fatigue	0.701	0.772	0.799
Does not suffer from insomnia	0.785	0.829	0.860
Does not suffer from depression	0.893	0.934	0.958
Does not suffer from a weakening of memory or of the capacity to concentrate	0.879	0.916	0.935
Does not have recurrent pain in other parts of the body	0.711	0.765	0.801
Does not have other health problems	0.911	0.928	0.940

* Possible answers to the health questions are “often”, “sometimes”, “rarely”, “never”, “no response” and “do not know”. We only consider those who answer “never” to not have the health problem in question.

Table B2: Women who have been subjected to psychological violence by partner, 17,350 women

	Mean		
	State 1	State 2	State 3
Partner is angry if you talk to another man*	0.146	0.140	0.127
Partner humiliates you in front of others*	0.092	0.082	0.074
Partner criticizes appearance*	0.099	0.111	0.096
Partner criticizes housework*	0.107	0.111	0.109
Partner ignores you*	0.182	0.164	0.173
Partner insults or verbally abuses you*	0.111	0.105	0.090
Partner hinders contact with friends or family**	0.059	0.057	0.046
Partner hinders work**	0.056	0.036	0.028
Partner hinders studying**	0.051	0.036	0.038
Partner controls appearance**	0.019	0.014	0.012
Partner doubts faithfulness**	0.044	0.038	0.038
Partner controls the woman's movements**	0.011	0.011	0.008
Partner controls the woman's spending**	0.068	0.053	0.052
Partner hinders the women in having knowledge of family income**	0.022	0.015	0.015
Partner hinders use of his or the family's money**	0.015	0.010	0.007
Partner ruins or destroys your personal things**	0.008	0.005	0.005
Partner harms or threatens to harm his children**	0.005	0.003	0.002
Partner harms or threatens to harm those close to you**	0.003	0.001	0.001
Partner harms or threatens to harm his animals**	0.004	0.002	0.003

* Possible answers to the this question is "often", "sometimes", "rarely", "never", "no response" and "do not know". We consider all those who do not answer "never" to have been subjected to the psychological violence in question.

** Possible answers to the this question is "yes", "no", "no response" and "do not know". We only consider those who answer "yes" to have been subjected to the psychological violence problem in question.

Appendix C: alternative specifications

Table C1. Parameter estimates, 17,350 observations. Specification 3.

	State 1: 0-2 activities	State 2: 3 activities	State 3: 4-8 activities
Variables names	Parameter	Parameter	Parameter
Preference variables, *X*			
Woman's Age	0.0637*	0.0120*	-
	(0.0063)	*(0.0041)*	
Woman Degree[1]	-4.4966*	-1.8765*	-
	(1.6432)	*(0.6222)*	
Woman High School[1]	-1.7437*	-0.8250*	-
	(0.2068)	*(0.1409)*	
Woman is Healthy[1]	-0.2199	-0.2089	
	(0.1215)	*(0.1177)*	
Constant	-4.0065*	-1.4261*	-
	(0.4202)	*(0.2682)*	
Restriction variables, *Z*			
Woman is Healthy[1]	-0.4304*	-0.0065	-
	(0.1111)	*(0.1794)*	
Woman Works[1]	-0.1998*	-0.4269*	-
	(0.0732)	*(0.1436)*	
Psychological violence by partner.[1]	0.0746*	0.0079	-
	(0.0203)	*(0.0305)*	
Physical or sexual violence by partner.[1]	-0.3483*	-0.1089	
	(0.1501)	*(0.2079)*	
Age Difference	0.0207*	0.0088	-
	(0.0087)	*(0.0121)*	
Central Italy[1]	0.1124	0.0404	-
	(0.0981)	*(0.1506)*	
Southern Italy[1]	0.0531*	0.6595*	-
	(0.0809)	*(0.2025)*	
Partner Low Education[1]	0.8266*	0.9722*	-
	(0.0821)	*(0.2684)*	
Constant	-2.3370*	-2.3663*	-
	(0.1883)	*(0.5022)*	

The base state for the estimation is State 3: women engaged in 4-8 activities; the base category (in terms of dummies) is a woman who is not healthy, does not work and lives in northern Italy with a low education level and a non-violent partner with a high school degree or higher.

*$p<0.05$, log likelihood = -15978.4, standard errors in parenthesis

Table C2. Parameter estimates, 17,350 observations. Specification 4.

	State 1: 0-2 activities	State 2: 3 activities	State 3: 4-8 activities
Variables names	Parameter	Parameter	Parameter
Preference variables, *X*			
Woman's Age	0.0442*	0.0058*	-
	(0.0041)	*(0.0029)*	
Woman Degree[1]	-3.1882*	-1.7065*	-
	(0.5802)	*(0.3708)*	
Woman High School[1]	-1.5224*	-0.7927*	-
	(0.1274)	*(0.0970)*	
Woman is Healthy[1]	-0.4487*	-0.2141*	
	(0.0598)	*(0.0543)*	
Woman Works[1]	-0.3604*	-0.2666*	
	(0.0625)	*(0.0551)*	
Constant	-2.2101*	-0.7239*	-
	(0.2635)	*(0.1951)*	
Restriction variables, *Z*			
Psychological violence by partner.[1]	0.1447*	0.0657	-
	(0.0359)	*(0.0538)*	
Physical or sexual violence by partner.[1]	-0.4865*	-0.4906	
	(0.2452)	*(0.4544)*	
Constant	-2.6814*	-2.5381*	-
	(0.2770)	*(0.6074)*	

The base state for the estimation is State 3: women engaged in 4-8 activities; the base category (in terms of dummies) is a woman who is not healthy, does not work and lives in northern Italy with a low education level and a non-violent partner with a high school degree or higher.

*p<0.05, log likelihood = -15142.8, standard errors in parenthesis

Table C3. Parameter estimates, 17,350 observations. Specification 1b.

	State 1: 0-2 activities	State 2: 3 activities	State 3: 4-8 activities
Variables names	Parameter	Parameter	Parameter
Preference variables, *X*			
Woman's Age	0.0627*	0.0111*	-
	(0.0056)	*(0.0033)*	
Woman Degree[1]	-4.0270*	-1.6574*	-
	(1.1207)	*(0.3021)*	
Woman High School[1]	-1.7006*	-0.7854*	-
	(0.1672)	*(0.0953)*	
Constant	-4.0070*	-1.4276*	-
	(0.3521)	*(0.2068)*	
Restriction variables, *Z*			
Woman is Healthy[1]	-0.5273*	-0.3396*	-
	(0.0835)	*(0.1316)*	
Woman Works[1]	-0.2155*	-0.4623*	-
	(0.0731)	*(0.1324)*	
Age Difference	0.0217*	0.0140	-
	(0.0087)	*(0.0131)*	
Central Italy[1]	0.1140	0.0696	-
	(0.0983)	*(0.1708)*	
Southern Italy[1]	0.5835*	0.7309*	-
	(0.0810)	*(0.1791)*	
Partner Low Education[1]	0.8534*	1.0757*	-
	(0.0831)	*(0.2270)*	
Constant	-2.2758*	-2.4624*	-
	(0.1667)	*(0.4013)*	

The base state for the estimation is State 3: women engaged in 4-8 activities; the base category (in terms of dummies) is a woman who is not healthy, does not work and lives in northern Italy with a low education level and a non-violent partner with a high school degree or higher.

*$p<0.05$, log likelihood = -15987.6, standard errors in parenthesis

Table C4 Parameter estimates, 17,350 observations. Specification 2b.

	State 1: 0-2 activities	State 2: 3 activities	State 3: 4-8 activities
Variables names	Parameter	Parameter	Parameter
Preference variables, *X*			
Woman's Age	0.0434*	0.0108*	-
	(0.0043)	*(0.0043)*	
Woman Degree[1]	-2.3101*	-1.8388*	-
	(0.4485)	*(0.4720)*	
Woman High School[1]	-1.2516*	-0.8314*	-
	(0.1217)	*(0.1308)*	
Woman is Healthy[1]	-0.4634*	-0.2496*	
	(0.0669)	*(0.0675)*	
Woman Works[1]	-0.2677*	-0.2460*	
	(0.0650)	*(0.0651)*	
Constant	-2.5076*	-1.3123*	-
	(0.2887)	*(0.2920)*	
Restriction variables, *Z*			
Age Difference	0.0866*	0.0052	-
	(0.0253)	*(0.0098)*	
Central Italy[1]	0.4892	0.0155	-
	(0.4830)	*(0.1183)*	
Southern Italy[1]	1.6647*	0.5657*	-
	(0.4545)	*(0.1506)*	
Partner Low Education[1]	2.7897*	0.8308*	-
	(1.3152)	*(0.2033)*	
Constant	-6.3284*	-2.1165*	-
	(0.7130)	*(0.4436)*	

The base state for the estimation is State 3: women engaged in 4-8 activities; the base category (in terms of dummies) is a woman who is not healthy, does not work and lives in northern Italy with a low education level and a non-violent partner with a high school degree or higher.

*p<0.05, log likelihood = -15993.0, standard errors in parenthesis