Article:

Chaudhuri, K orcid.org/0000-0002-7492-1369 and Yalonetzky, G orcid.org/0000-0003-2438-0223 (2018) The state of female autonomy in India: A stochastic dominance approach. Journal of Development Studies, 54 (8). pp. 1338-1353. ISSN 0022-0388

https://doi.org/10.1080/00220388.2017.1414186

The state of female autonomy in India: A stochastic dominance approach

Kausik CHAUDHURI * Gaston YALONETZKY†

June 4, 2017

Abstract

The promotion of female autonomy is both intrinsically and instrumentally desirable. We document differences in the distribution of female autonomy in India (using the National Family Health Survey 2005-6) addressing two methodological challenges: the multidimensional nature of the concept and its frequent measurement with ordinal discrete variables (which are not amenable to direct comparisons of social averages). We tackle these challenges with three methods based on stochastic dominance techniques suited for ordinal and dichotomous variables. Whenever these dominance conditions hold for a pairwise comparison, we can conclude that the multidimensional autonomy distribution in one state is more desirable than in another one across a broad range of criteria for the individual and social welfare evaluation of autonomy. Consistently across the three methods, we find that most of the states with better autonomy distributions (in pairwise comparisons) come from the North East and the South, whereas most of the states with worse autonomy distributions come from the North.

Keywords: Female autonomy, counting approach, stochastic dominance, India.
JEL Classification: B54, O15, O53.

*University of Leeds; Maurice Keyworth Building LS2 9JT, UK. E-mail: K.Chaudhuri@lubs.leeds.ac.uk.
†University of Leeds; Maurice Keyworth Building LS2 9JT, UK. E-mail: G.Yalonetzky@leeds.ac.uk.

1 Introduction

Autonomy has traditionally been defined as "the capacity of rational individuals to make an informed, un-coerced decision". Among many conceptual implications, autonomy evokes the ability to influence one's fate and surroundings. This involves a positive aspect ("power to") and a negative aspect ("power over"). Likewise autonomy, and its related notion of agency, can be either passive (when there is little choice) or active (reflecting purposeful behaviour) (Kabeer, 2005). Whichever the form, autonomy is a necessarily multifaceted phenomenon (Narayan, 2005): autonomy over one's health, over one's personal relationships, and so forth. Now, given the existence of different forms of discrimination against women in many societies, the enhancement of female autonomy is intrinsically worth pursuing. Moreover, the literature has put forward many additional instrumental reasons for fostering female autonomy. For instance, female autonomy is causally associated with the ability to benefit from business training for entrepreneurs (Field et al., 2010), it increases the chances of using contraceptives (Moursund and Kravdal, 2003), and it has been found to improve prenatal care, delivery and postnatal care (Mistry et al., 2009). More recently, Duflo (2012) summarized the evidence pointing to a positive correlation between female autonomy and economic development: Higher gender equality can lead to improvements in health and quality of life for women and their family members. Women with greater agency are more likely to have fewer children, more likely to access health services and have control over health and education resources, and less likely to suffer domestic violence.

There is a long and old literature on female autonomy in India and other major south and eastern Asian nations, including the classic study of Dyson and Moore (1983). The main themes are usually the measurement of the extent of female autonomy itself, the identification of autonomy's determinants, its consequences (i.e. its instrumental importance), and recently there has also been an interest in the perception mismatch between husbands and wives when it comes to ascertaining the degree of the wife's autonomy. This literature has found recurrent correlates of female autonomy in south Asian countries, including: kinship systems (posited by Dyson and Moore, 1983), women's earnings and family income (Anderson and Eswaran, 2009), dowry and goods owned (Jejeebhoy and Sathar, 2001), wife and husband education (Anderson and Eswaran, 2009; Jejeebhoy and Sathar, 2001), co-residing mother-in-law (Anderson and Eswaran, 2009; Jejeebhoy and Sathar, 2001), religion and region (Jejeebhoy and Sathar, 2001).

Three factors could plausibly explain the dynamic nature of female autonomy, and gender inequality in general, in India: (a) Sanskritisation (Srinivas, 1956), (b) economic development, and (c) cultural representations of gender (Chatterjee, 1989). 'Sanskritisation' is a process through which lower castes try to imitate the upper castes' customs in order to attain higher social status.[1] In this process, lower castes show higher devotion to the classical 'Sanskrit' way of living. Sanskritisation can be harmful for female autonomy as it promotes a patrilineal structure, patriarchal power relations, virilocality, son preference, low priority to female education and health, social and physical immobility of women, immurement of women from the external world and total economic and social dependence of women on men.[2] Economic development can exert a mixed impact. For instance, the positive impact can come from increased female education. However, there might be a backlash effect, leading to dampening of freedom of movement and participation in decision-making, if husbands react negatively to increased female education, either out of jealousy of improved female education and earning prospects, or out of concern for the prospects of women mingling more freely with other men. According to (Chatterjee, 1989), projecting Indian women as modest, moral, and humble is used to show the superiority of Indian culture against the Western counterpart and this may lead to creation of subjugated Indian women even today. This argument has been reiterated by (Abraham, 2001) and (Derne, 2003).

This paper's purpose is to compare the levels and distribution of female autonomy across Indian states with a proposal to address two methodological challenges: the multi-dimensional nature of female autonomy (Narayan, 2005), and the fact that its indicators are usually ordinal or dichotomous variables. Our proposal looks into the different ways in which the wellbeing provided by a set of dichotomous autonomy indicators can be evaluated relying on individual and social welfare functions. These functions reflect mechanisms to aggregate the set of variables at the individual and social level, respectively. Without being exhaustive, we propose three general methods to measure individual and social welfare derived from female autonomy, each of which encompasses a wide array of possible composite indices based on the set of indicators. For each method we discuss the underlying welfare measurement assumptions and properties, i.e. the meaning of measuring multidimensional autonomy; while also clarifying their limitations.

Our three methods work with stochastic dominance techniques for ordinal and dichotomous variables in order to document whether autonomy comparisons across Indian states are robust to broad classes of individual welfare functions (each, embedding large varieties of composite indices). When the dominance conditions hold, the ensuing robust ordering (i.e. comparison) has an interpretation in terms of preference over lotteries based on these individual welfare ("utility") functions. Moreover, if our purpose is to rank Indian states in terms of the relative desirability of their autonomy distributions, then when the conditions hold, we do not need to choose, and justify the choice, among several potentially suitable composite indices. More specifically, our second and third methods relate to the counting approach (Townsend, 1979) now popular in the measurement of multidimensional poverty (e.g. in the UNDP's "Multidimensional Poverty Index", see (Alkire and Santos, 2014)), but also being used in different areas of social science, including female autonomy itself (e.g. Alkire et al., 2013).

Our empirical analysis is based on India's National Family Health Survey 2005-6, which has questions on female autonomy over decisions involving small and large household purchases, family visits, health, and command over husband's money. We compare the multivariate distributions of female autonomy across Indian states, and we find that Southern (i.e. Kerala, Tamil Nadu, Andhra Pradesh or Karnataka) and North-Eastern states (i.e. those beyond the Siliguri corridor plus Sikkim) tend to dominate Northern States. Accordingly, the main "dominators" (i.e. states that more frequently turn up with better autonomy distributions vis-a-vis other states) tend to come from the North East, whereas the main "dominated" states are from the North. Remarkably, our results are fairly consistent across the three methods.

Although our results corroborate previous evidence that "less sanscritized" states fare better than "sanscritized" ones in terms of female autonomy; we do find several exceptions in state-to-state comparisons. So it is not always the case that any random southern state or "chicken-neck" state will dominate a northern state. Among comparisons of "less sanscritized" states, there are also interesting results: generally (although with exceptions) most "chicken-neck" states dominate southern states.

The rest of the paper is organized as follows: The next section describes the three methods proposed for robust comparisons of multidimensional autonomy with dichotomized variables. Then the Data section describes the autonomy questions available, as well as alternative dichotomization options. This is followed by a section discussing our results for the three methods and for alternative dichotomization choices. Finally, the paper concludes with some remarks.

2 Methodology: Female autonomy comparisons across populations from a welfare-function perspective

How can we perform basic comparisons of female autonomy when we have several ordinal or dichotomous indicators? One possibility is to report results using only probability distributions. This is, for instance, the path followed by the Indian Government's "Gender equality and women's empowerment in India" report. They report a dashboard of these distributions, i.e. for each autonomy indicator separately, although in theory they could also report multivariate distributions. However, with three or more indicators this task can become cumbersome and the results may be difficult to read and understand. Besides, a dashboard approach to multivariate phenomena bears the limitation of dismissing the information embedded in the joint distribution of indicators across a sample or population (Alkire et al., 2015).

Another well-known method, which is sensitive to the joint distribution of indicators, is the construction of scores based on dichotomized variables. This can be performed in different ways, and there are plenty of examples for this approach (e.g. Oppenheim, 2005). For instance, if the variables measure the dichotomous access to services, then the score could provide a composite index of aggregate access such that the more services for which there is access, the higher the value of the score. If one uses exogenous weights to construct the score (e.g. assigned by the researcher or through participatory methods) then a counting approach is being used (e.g. as in part of the procedure implemented by Alkire et al. (2013)). Alternatively the score can also be constructed using multiple correspondence analysis (as in the proposal of Asselin and Anh (2008)) or other latent variable models, in which case the weights are endogenous and determined by the dataset (Alkire et al., 2015). This approach bears important advantages, e.g. being able to order completely populations e.g. by average value of the score or composite index. However the welfare interpretation, implications and limitations of any particular choice for the construction of scores is rarely discussed in the autonomy literature.

Finally, as will be discussed and proposed in this section, with stochastic dominance conditions we can test whether multidimensional autonomy comparisons would be robust to a broad set of specific welfare measurement criteria. If we find that the multivariate autonomy distribution of society "A" dominates that of "B" according to some specific condition, then we could also interpret that people who value autonomy according to some defined welfare criteria would rather live in "A" and face its "autonomy lottery", if "autonomy" were the only realm they cared about and they could not know a priori which degree of autonomy they would enjoy in whichever society they lived (i.e. a sort of Rawlsian "veil of ignorance").

In order to introduce our proposal, imagine a survey with questions on D dimensions of female autonomy (e.g. health care, household purchases, family visits, etc.). In the case of India's National Family Health Survey (2005-6) an autonomy question, e.g. on final say over decisions regarding the wife's health, has the following three answer categories: wife decides alone, husband and wife decide jointly, husband decides alone on behalf of both. With these responses we construct a dichotomous variable for dimension d, A_d, such that $A_d = 1$ only if the wife has a say in the decision (i.e. either decides alone, or jointly with the husband). Otherwise, if the decision is made by the husband on behalf of the wife then: $A_d = 0$. While it is uncontroversial to state that, from an autonomy perspective, a woman's exclusion from a decision affecting her life is worse than not being excluded, we do not find compelling reasons to assert that, in every circumstance, a woman deciding alone is more autonomous than one deciding jointly with her husband. Hence we merge the two latter categories.

However, in some cases like autonomy on health decisions, one could justify attributing higher value of a woman's alone decision over a joint decision; relying, for instance, on the notion of bodily integrity which involves reproduction choices (Nussbaum, 2000). On the other hand, in relatively well-working marriages, one could also argue that joint marital decisions on the wife's health, based on respectful dialogue, should not be placed beneath the option of a wife's lone decision. Since we find both arguments appealing, we dichotomize the health autonomy variable under both criteria (and pursue the analysis using both options, although only reporting fully one set of results since they do not differ significantly), i.e. once setting $A_d = 1$ only if the wife has a say in the decision, and once setting $A_d = 1$ only if the wife has the *sole* say in the decision.

The next step is to propose an individual welfare evaluation function: $U(A_1, A_2, ..., A_D) : \{0,1\}^D \rightarrow \mathcal{R}_+$. We want the welfare function to satisfy at least the following property:

Axiom 1. *Monotonicity:* $U(A_d = 1) > U(A_d = 0)$ *for any* d*, ceteris paribus.*

Axiom 1 states that a woman draws more satisfaction from having autonomy over any given dimension than from not having it. If the variables were continuous we would say that all the first partial derivatives are positive. In some cases, we could also consider the following property:

Axiom 2. *Weak complementarity: All the first-order cross-partial differences of U are non-negative.*[3]

Weak complementarity states that acquiring autonomy over other dimensions does not diminish the welfare impact of acquiring autonomy over any given dimension. If the variables were continuous, we would say that all the first-order cross-partial derivatives are either positive or zero. The rationale of weak complementarity lies in the difficulty of considering or finding situations in which enjoying autonomy over an extra dimension of life would diminish the increase in welfare satisfaction from acquiring autonomy in another dimension, in every possible combination of dimensions simultaneously. If the welfare function satisfies axiom 2 then we say that any pair of variables exhibits a weak form of ALEP complementarity (Kannai, 1980). In one of our autonomy comparison methods proposed below, we will allow for a relaxation of weak complementarity as well.

Our social comparisons are then based on social welfare evaluation functions which aggregate the individual welfare function. We focus on the simplest and most popular social welfare function which is, basically, additively separable in the individual utility functions, and symmetric across individuals. For comparability purposes we impose a population principle property on the social welfare function, whereby a cloning of each individual by the same factor (e.g. a duplication) renders social welfare unchanged. This property requires considering social welfare as an average across individual welfare functions:

$$W \equiv \frac{1}{N}\sum_{i=1}^{N} U(A_{i1}, A_{i2}, ..., A_{iD}) \tag{1}$$

where N is the population size and the variables have now a subscript i to denote individual i. We are interested then in comparisons of the form $\Delta W \equiv W^S - W^T$, where S and T are two populations, e.g. two countries. The question is: How can we perform these autonomy comparisons relying on multiple dichotomous variables? There are a few options. Without exhausting all of them, in this paper we propose and apply three methods, all derived from variations of the same welfare measurement framework.

2.1 First method: a first-order stochastic dominance condition for multiple dichotomous variables

Let P_S be a 2^D-dimensional vector representing the joint discrete probability distribution of autonomy dichotomous variables in society S, i.e.: $P : [p(0,0,...,0), p(1,0,...,0), ..., p(1,1,...,1)]$, where, for instance,: $p(0,0,...,0) \equiv Pr[A_1 = 0, A_2 = 0, A_D = 0]$. Likewise the cumulative distribution is worth defining: $F : [F(0,0,...,0), F(1,0,0,...0), ..., F(1,1,...,1)]$, where, for instance: $F(1,0,0,...,0) \equiv Pr[A_1 \leqslant 1, A_2 = 0, A_D = 0]$, and of course $F(1,1,...,1) = 1$. Finally, we define the survival function: $\overline{F} : [\overline{F}(0,0,...,0), \overline{F}(1,0,0,...0), ..., \overline{F}(1,1,...,1)]$, where, for instance: $\overline{F}(1,0,0,...,0) \equiv Pr[A_1 = 1, A_2 \geqslant 0, A_D \geqslant 0]$, and of course $F(0,0,...,0) = 1$.

If we want autonomy comparisons to be consistent with the properties of monotonicity, weak complementarity, additive separability and population principle, but do not want to choose any particular functional form for U, we can test the following first-order dominance condition:

Condition 1. *First-order stochastic dominance:* $\Delta W > 0 \;\; \forall W$ *satisfying population principle, symmetry, and additive separability, and* $\forall U$ *satisfying monotonicity and weak complementarity if and only if* $\Delta\overline{F}(i1, i2, ..., iD) \geqslant 0 \;\forall i1, i2, ..., iD = 0, 1$ *with at least one strict inequality.*

Proof. See Appendix. ■

Condition 1 states that expected welfare from autonomy in S is higher than in T, for any individual welfare function satisfying monotonicity and weak complementarity, if and only if the total joint survival distribution of the autonomy variables in S is never below that in B, and is strictly above for some combination of values of the autonomy variables. Therefore, when the condition holds for a pair of Indian states, an autonomy comparison is robust to any (potentially arbitrary) choice of individual welfare functions satisfying monotonicity and weak complementarity. If condition 1 holds, then we say that S dominates T in first order, denoted by $S \succ^1 T$.[4]

The fulfillment of the condition can also be given the following interpretation: If W is considered an expected level of satisfaction from autonomy (or of "overall" autonomy itself), then it could be considered a type of lottery, in which each level of autonomy welfare comes along with a probability of occurrence attached to it. Hypothetically if a woman could choose in which state to be born among two compared options (e.g. S and T), a situation of $S \succ^1 T$, should lead the woman to choose S, even though she does not know exactly which realized level of autonomy she may actually enjoy in state S. However, given this "veil of ignorance", state S offers a more appealing "lottery". Note that in many situations dominance cannot be established, i.e. when the survival distribution functions "cross" ($\Delta\overline{F}(i1, i2, ..., iD) \geqslant 0$ for some $i1, i2, ..., iD$ but otherwise $\Delta\overline{F}(i1, i2, ..., iD) \leqslant 0$). This is why dominance conditions are set to provide, normally, partial or incomplete rankings, also known as pre-(or quasi) orderings.

In order to test for the presence of first-order stochastic dominance in pairwise comparisons, we need to ascertain whether $\Delta\overline{F}(i1, i2, ..., iD) \geqslant 0 \;\forall i1, i2, ..., iD = 0, 1$ (with at least one strict inequality) holds. For that purpose we can use the test proposed by Yalonetzky (2013). In practice, a test of condition 1 may be too demanding computationally, and in terms of sample size requirements, if D is too large. In our Indian dataset we have 5 autonomy variables in dichotomous form. Therefore the joint discrete survival distribution vector contains 32 probabilities, yielding 31 comparison points. [5] Therefore, even though the test is not difficult to implement in our case (especially given the relatively large sample sizes we have), it could become unwieldy should D be greater.

An interesting aspect of stochastic dominance conditions is a trade-off between the stringency of the distributional condition (e.g. on joint survival functions) and the breadth of the class of welfare functions for which the condition applies. The more stringent the distributional condition the broader the class of welfare functions for which a comparison will be robust. For instance, condition 1 is quite stringent, especially when D is large: in order for it to hold, two joint survival functions mapping from a multivariate domain must not cross. But the pay-off is also large: if the condition holds, then "A" dominates "B" for a broad class of welfare functions.

The next method re-balances the trade-off in favour of a less stringent distributional condition, but at the cost of being relevant for a narrower, albeit still informative, class of welfare functions. It requires imposing more structure on the individual welfare function.

2.2 Second method: a first-order stochastic dominance condition for a class of linear composite indices based on multiple dichotomous variables

If we render all first-order cross-partial differences equal to zero, then we are effectively restricting the class of admissible U to that of additively separable functions. That is:

$$U = \sum_{i=1}^{D} u_i(A_i), \quad u_i(1) > u_i(0) \tag{2}$$

Essentially U in 2 becomes a simple linear composite index. In fact, given the dichotomous nature of the variables, all members of U in 2 can be summarized in a class of weighted sums, with $u_i(A_i) = w_i A_i$, with $w_i > 0$ and $\sum_{i=1}^{D} w_i = 1$. We can then perform state-wise comparisons using U in 2 in combination with the additively separable, and population-invariant, social welfare functions from 1. Both an advantage and a challenge of doing these comparisons is that the weights, w_i, can be chosen in many different ways. However, there is a simple, first-order dominance condition whose fulfillment guarantees that any weighting choice produces robust comparisons (i.e. S exhibits a better autonomy distribution than T regardless of the choice of weights). Let $p_i(1) \equiv \Pr[A_i = 1]$, then the condition is:

Condition 2. *First-order stochastic dominance additive:* $\Delta W > 0 \;\; \forall W$ *satisfying population principle, symmetry, and additive separability, and* $\forall U$ *satisfying monotonicity and null first-order cross-partial differences if and only if* $\Delta p_i(1) \geqslant 0 \;\forall i = 1, 2, ..., D$ *with at least one strict inequality.*

Proof. See Appendix. ■

Condition 2 states that expected welfare from autonomy in S is higher than in T, for any weighting scheme in $U = \sum_{i=1}^{D} w_i A_i$, if and only if the proportion of people with the best level of autonomy in every autonomy indicator in S is never below that in B, and is strictly above for at least one autonomy variable. Therefore, when the condition holds for a pair of Indian states, an autonomy comparison is robust to any (potentially arbitrary) choice of individual welfare functions. If condition 2 holds, then we say that S dominates T in first order for additively separable individual welfare functions, denoted by $S >^{11} T$. Note also that fulfillment of condition 1 implies fulfillment of 2, but the reverse is not true. We will test condition 2 when we perform the autonomy comparisons across Indian states. For that purpose we apply a traditional two-population, intersection-union, one-tailed z-test for proportions.

While this method is suitable for the type of individual welfare functions in 2, which comprises all simple linear composite indices of the form $\sum_{i=1}^{D} w_i A_i$, it has some limitations. Firstly, by construction, we are ruling out any strictly positive complementarity interactions between the autonomy dimensions at the individual level. For that reason, we effectively neglect the social joint distribution of autonomy variables; in fact the computation of W based on the individual welfare functions in 2 does not even require datasets with information over all autonomy dimensions for the same people. The computation can be done from separate surveys, if necessary. Secondly, this framework assumes implicitly that a woman would be willing to give up autonomy over dimension i in favour of obtaining autonomy over dimension j as long as $w_j > w_i$.

The third method, proposed below, restores the importance of the joint distribution of autonomy variables among women, without the computational challenges posed by the first method.

2.3 Third method: a first-order stochastic dominance condition combined with a counting approach to autonomy measurement

We can also perform comparisons positing that women value the (weighted) number itself of life dimensions over which they exert autonomy. In that case we can define the following simple composite index (as in the previous section):

$$X = \sum_{d=1}^{D} w_d A_d \tag{3}$$

But now we consider an individual welfare function of the form:

$$U = u(X), \quad u(i) > u(j) \ \forall i > j. \tag{4}$$

Note the following: Firstly, U in 4 may not necessarily satisfy the property of weak complementarity, but allows for non-zero first-order cross-partial differences. Secondly, once we choose a set of weights, we get one specific vector of possible values for X. The maximum number of elements of that vector is 2^D, and the number of elements is $D + 1$ whenever $w_i = \frac{1}{D} \ \forall i = 1, 2, ..., D$, i.e. when the weights are equal. Therefore X always has a discrete probability distribution even though it may take values from the domain of real numbers. If we do not want to make any particular choice for u, we can perform an autonomy comparison based on individual welfare functions of the form in 4 by testing a first-order stochastic dominance condition based on the cumulative discrete probability distribution of X. We will have a different dominance condition for any given choice of weights in 3 (unlike the second method where the condition applies directly to all possible weights).

For our comparisons of autonomy across Indian states, we will consider the specific case in which $w_i = \frac{1}{D} \ \forall i = 1, 2, ..., D$. This case of equal weights implies a "pure" counting approach to the measurement of multidimensional autonomy, whereby women are deemed to value the total number of dimensions over which they exert autonomy per se. It also assumes that a woman may accept a gain of autonomy over any dimension of life as compensation for a loss of autonomy over any other dimension. This reflect the symmetry of the individual welfare function when weights are equal. Let $p(i) \equiv \Pr[X = \frac{i}{D}]$ and $F(i) \equiv \Pr[X \leqslant \frac{i}{D}]$. Then the dominance condition is:

Condition 3. *First-order stochastic dominance counting:* $\Delta W > 0 \ \ \forall W$ *satisfying population principle, symmetry, and additive separability, and* $\forall U$ *of the counting form in 4 with* $w_i = \frac{1}{D} \ \forall i = 1, 2, ..., D$ *if and only if* $\Delta F(i) \leqslant 0 \ \forall i = 0, 1, 2, ..., D-1$ *with at least one strict inequality.*

Proof. See Appendix. ∎

For condition 3 we use the test proposed by Yalonetzky (2013). If condition 3 is fulfilled then society S has a more appealing autonomy distribution than T, as long as the individual welfare functions belong in the class of counting measures with equal weights like 4, i.e. $S \succ^{cew} T$. Note that the individual welfare function is now more flexible regarding the signs that its first-order cross-partial differences can take. Similar conditions can also be derived for asymmetric cases where $\exists i | w_i \neq \frac{1}{D}$.

3 Data

We rely on India's National Family Survey 2005-6. Our sample contains 87588 women aged 15 to 49 years old. Every Indian states has at least 1,000 observations. More than 90% of the households are headed by men. And we have 29 Indian states, which yields 406 pairwise comparisons. Following a long literature, we have divided the states into macro-regions. In addition to the traditional North-South divisions we consider a separate North Eastern region comprising the states to the East of the Siliguri corridor and Bangladesh, including Sikkim. Our definition of the South comprises: Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, and Goa.[6] All the other states are deemed Northern.

3.1 Autonomy questions

Our survey has questions on five dimensions of female autonomy: final say over day-to-day household purchase decisions; final say over own health care decisions; final say over large household purchase decisions; final say over visits to family or relatives decisions; and final say over spending husband's money decisions. For each of these questions, the possible answer categories are: decision is made by the husband; decision is made jointly; and decision is made (by the woman) alone. As mentioned before, it is clear that the option "decision is made by the husband" entails limited autonomy, at least vis-a-vis the alternatives. By contrast, it is harder to justify that "decision is made alone" signifies a superior state of autonomy compared to "decision is made jointly", especially in common realms of living in which it is reasonably expected that partners make decisions jointly (e.g. large household purchases). Therefore, before implementing the methods, we dichotomized the variables by merging the "joint decision" category with the "alone decision" category.

For the reasons mentioned above, we also performed comparisons using an alternative dichotomization of the health autonomy variable, whereby "decision is made by the husband" was combined with "decision is made jointly" into the lower autonomy category, while "decision made alone" was left as a separate category of better autonomy. Our results remain more or less invariant to this alternative dichotomization of the health autonomy variable. Hence we briefly report on the results of this alternative dichotomization. [7]

4 Results

We divide this section in five subsections. Subsections 1 to 3 discuss the results from the three methods (Method 1, Method 2 and Method 3) respectively. In subsection 4, we highlight the regional pattern of the dominance relationships using those three methods. In subsection 5 we discuss possible driving factors behind our results.

4.1 Dominance Relationships: Method 1

We report the dominance relationships using Method 1 in this subsection. There are 261 first-order dominance relationships emerging out of the 406 comparisons; that is, about 64% of the state-wise comparisons are robust to the potentially arbitrary choice of individual welfare functions satisfying monotonicity and weak complementarity. 230 relationships are significant at 10% confidence level, of which 224 are also significant at 5%, and 208 also at 1%. In other words, less than 12% of the relationships are not significant at 10%.

Table 1 reports the proportion of all dominance relationships in which each Indian state appears in the role of "dominating" state, followed by the proportion in which they appear in the role of "dominated" state. It also shows the probability of being a "dominating" states conditional on being in a dominance relationship (fifth column headed by: "$(1)/[(1)+(2)]$ (%)"). Note that if the prospects of appearing in a "dominating" or a "dominated" role were completely random, then we would expect any state fulfilling either role in about 3.4% of all dominance relationships, and the probability of being a "dominator" conditional on being in a dominance relationship would be about 50%.

Several interesting patterns emerge. Firstly, most North Eastern states are the "dominators", each in more than 8% of all comparisons, e.g., Manipur (9.2%), Mizoram (9.6%), Nagaland (9.2%) and Sikkim (8.0%). The same cannot be inferred about the Southern States with the exception of Tamil Nadu (6.1%), Maharashtra (4.9%) and Goa (4.2%). By contrast, the southern state of Kerala, with a high Human Development Index (HDI), acts as a "dominator" only in 1.9% cases. The situation with most of the Northern states is even worse; they rarely appear as "dominators" at all, with the exception of Delhi (6.1%) and Jharkhand (3.4%), a newly formed state in the year 2000 mainly due to the tribal demands. Meanwhile, Northern states, like Jammu and Kashmir (9.2%), Rajasthan (8.4%), West Bengal (7.7%), Bihar and Uttaranchal (both at 6.1%) are the "dominated" in relatively high proportions of all dominance relationships.

Secondly, the probability of being a "dominator" conditional on being in a dominance relationship is 100% for four North Eastern states: Manipur, Meghalaya, Mizoram, and Nagaland; and more than 85% in two other states: Arunachal Pradesh and Sikkim. Amongst the Southern states, only Maharashtra and Tamil Nadu, show a conditional probability of being "dominator" higher than 70%. Almost all the Northern states, except Delhi and Jharkhand, show the reverse: the conditional probability of being "dominated" is higher than 50%. Thirdly, there are some interesting exceptions. Tripura is always dominated in its dominance relationships despite being a North Eastern State; similarly Karnataka is dominated in 95% of its dominance relationships despite being in the South. Three Northern states, Jammu and Kashmir, Rajasthan and West Bengal are always dominated.

Table 1: State roles in dominance relationships: Method 1

State	Region	% Dominating (1)	% Dominated (2)	(1)/[(1) + (2)] (%)
Andhra P	South	0.766	4.215	15.385
Arunachal P	North East	6.130	0.383	94.118
Assam	North East	5.747	1.533	78.947
Bihar	North	0.766	6.130	11.111
Chattisgarh	North	0.383	3.831	9.091
Delhi	North	6.130	1.533	80.000
Goa	South	4.215	1.916	68.750
Gujarat	North	2.299	4.215	35.294
Haryana	North	2.682	3.065	46.667
Himachal P	North	2.682	2.682	50.000
Jammu and K	North	0.000	9.195	0.000
Jharkand	North	3.448	3.065	52.941
Karnataka	South	0.383	7.280	5.000
Kerala	South	1.916	2.299	45.455
Madhya P	North	0.766	4.981	13.333
Maharashtra	South	4.981	1.916	72.222
Manipur	North East	9.195	0.000	100.000
Meghalaya	North East	7.663	0.000	100.000
Mizoram	North East	9.579	0.000	100.000
Nagaland	North East	9.195	0.000	100.000
Orissa	North	2.682	4.215	38.889
Punjab	North	1.149	2.299	33.333
Rajasthan	North	0.000	8.429	0.000
Sikkim	North East	8.046	1.149	87.500
Tamil Nadu	South	6.130	1.533	80.000
Tripura	North East	0.000	6.513	0.000
Uttaranchal	North	1.149	6.130	15.789
Uttar P	North	1.916	3.831	33.333
West Bengal	North	0.000	7.663	0.000

4.2 Dominance Relationships: Method 2

Table 2 reports the results using Method 2. In this case, there are 330 first-order dominance relationships emerging out of the 406 comparisons. This means that about 81%

of the state-wise comparisons of the linear composite autonomy indices are robust to the potentially arbitrary choice of weights. This higher proportion of dominance relationships, vis-a-vis method 1, is to be expected since condition 2 is less stringent to meet than condition 1. 278 relationships are significant at 10% confidence level, of which 264 are also significant at 5%, and 243 also at 1%. In other words, less than 16% of the relationships are not significant at 10%.

Roughly the same pattern emerges as in Table 1 with the following exceptions. For Kerala, a state located in the South, the probability of being a "dominator" conditional on being in a dominance relationship increases from 45.5% to 71.1%. More Northern states are the "dominator" in relatively high proportions of all dominance relationships, e.g. Delhi (75%), Harayana (52.6%), Himachal Pradesh (50%) and Uttar Pradesh (50%). By contrast, the conditional probability of being a "dominator" decresaes for Jharkhand from 52.9% to 45% when we use Method 2 compared to Method 1.

Table 2: State roles in dominance relationships: Method 2

State	Region	% Dominating (1)	% Dominated (2)	(1)/[(1) + (2)] (%)
Andhra P	South	3.030	4.242	41.667
Arunachal P	North East	4.848	1.515	76.190
Assam	North East	6.667	1.515	81.481
Bihar	North	1.212	6.061	16.667
Chattisgarh	North	0.303	6.364	4.545
Delhi	North	5.455	1.818	75.000
Goa	South	3.939	2.121	65.000
Gujarat	North	2.424	5.152	32.000
Haryana	North	3.030	2.727	52.632
Himachal P	North	3.333	3.333	50.000
Jammu and K	North	0.000	7.576	0.000
Jharkand	North	2.727	3.333	45.000
Karnataka	South	0.303	6.667	4.348
Kerala	South	4.545	1.818	71.429
Madhya P	North	1.515	5.455	21.739
Maharashtra	South	4.545	2.424	65.217
Manipur	North East	7.576	0.303	96.154
Meghalaya	North East	7.576	0.000	100.000
Mizoram	North East	7.576	0.000	100.000
Nagaland	North East	7.879	0.000	100.000
Orissa	North	3.030	3.636	45.455
Punjab	North	0.909	1.818	33.333
Rajasthan	North	0.000	7.576	0.000
Sikkim	North East	7.273	1.212	85.714
Tamil Nadu	South	5.152	2.121	70.833
Tripura	North East	0.303	6.061	4.762
Uttaranchal	North	1.212	5.758	17.391
Uttar P	North	3.333	3.333	50.000
West Bengal	North	0.303	6.061	4.762

4.3 Dominance Relationships: Method 3

Table 3 reports our findings. 377 first-order dominance relationships emerge out of the 406. This means that almost 93% of the state-wise comparisons of multidimensional autonomy are robust to different individual welfare functions evaluating the autonomy score constructed following 3. 319 relationships are significant at 10% confidence level, of which 297 are also significant at 5%, and 274 also at 1%. In other words, less than 16% of the relationships are not significant at 10%.

The results more or less corroborate the same pattern in Table 1 and in Table 1 with the following exceptions. For the North Eastern state of Assam, the probability of being a "dominator" conditional on being in a dominance relationship has decreased from 78.9% (Method 1) and 81.5% (Method 2) to 58.3%. The same pattern is observed for Meghalaya, another North Eastern State (a decrease from 100% in the previous two methods to 76.2%). For Punjab, a state located in the North, this conditional probability of being a "dominator" increased from 33.3% (in both Methods 1 and 2) to 60%.

Table 3: State roles in dominance relationships: Method 3

State	Region	% Dominating (1)	% Dominated (2)	(1)/[(1) + (2)] (%)
Andhra P	South	1.326	5.570	19.231
Arunachal P	North East	6.631	0.531	92.593
Assam	North East	3.714	2.653	58.333
Bihar	North	0.796	6.101	11.538
Chattisgarh	North	2.918	3.979	42.308
Delhi	North	5.305	1.857	74.074
Goa	South	5.836	1.326	81.481
Gujarat	North	2.918	3.714	44.000
Haryana	North	3.183	3.448	48.000
Himachal P	North	3.979	2.122	65.217
Jammu and K	North	0.000	7.162	0.000
Jharkand	North	2.918	3.714	44.000
Karnataka	South	0.531	6.897	7.143
Kerala	South	4.244	2.122	66.667
Madhya P	North	2.122	5.305	28.571
Maharashtra	South	4.509	2.122	68.000
Manipur	North East	6.631	0.531	92.593
Meghalaya	North East	4.244	1.326	76.190
Mizoram	North East	7.162	0.000	100.000
Nagaland	North East	7.162	0.000	100.000
Orissa	North	2.387	4.775	33.333
Punjab	North	3.979	2.653	60.000
Rajasthan	North	0.000	7.162	0.000
Sikkim	North East	6.366	1.061	85.714
Tamil Nadu	South	5.570	1.592	77.778
Tripura	North East	1.326	5.570	19.231
Uttaranchal	North	1.061	5.570	16.000
Uttar P	North	2.387	4.775	33.333
West Bengal	North	0.796	6.366	11.111

4.4 Regional Pattern in the dominance relationships

Table 4 classifies the dominance relationships by the region of the involved states. If the region appears on the rows it means that the dominating states belong in it, whereas if a region appears on the column it means that dominated states belong in it. For instance, for Method 1, the bottom middle cell indicates that 38.7% of all dominance relationships involve a North Eastern state dominating a Northern state. Similarly, for Method 2 and Method 3, the figures stand at 33.03% and 28.38% for the same category.

The rightmost column ("Total rows") aggregates the columns across and yields the distribution of dominance relationships by regional origin of the dominating state. Clearly, the majority of dominating states are either North Eastern or Northern. However, in most relationships where Northern states dominate, the dominated states are also from the North ($24.53/31.03 = 79.05\%$ for Method 1, $25.76/33.33 = 77.29\%$ for Method 2 and $28.91/39.26 = 73.64\%$ for Method 3). The proportion of domination over states from the same region is much smaller for North Eastern states ($5.75/55.76 = 10.35\%$, $6.67/49.70 = 13.42\%$ and $6.90/43.24 = 15.96\%$ for Methods 1, 2, and 3 respectively). The proportion of domination over states from the same region is also smaller for the Southern states ($1.92/13.41 = 14.32\%$, $2.12/16.97 = 12.49\%$ and $2.65/17.51 = 15.13\%$ for methods 1, 2, and 3, respectively), in fact almost similar to that of North Eastern states.

The bottom row ("total columns") aggregates the rows across and yields the distribution of dominance relationships by regional origin of the dominated state. Most dominated states come from the North (always higher than 70.0%), and only 33.5%, 35.5% and 40.8% (by using methods 1, 2, and 3, respectively) of them are dominated by other Northern states.

Table 4 also tells us that among the relationships involving a Southern versus a Northern state, Southern states dominate in about 70% of them taking the average of the dominance relationships using the three methods (70.3%, 73.8%, and 66.2%, for methods 1, 2, and 3 respectively). Similarly, in comparisons involving a North Eastern versus a Northern state, North Eastern states dominate in 92.0% of cases on average; with the highest proportion of domination occurring for Method 1 at 94.3% of cases ($38.7/(38.7 + 2.3)$); followed by method 2 at 92.4%, and method 3 at 89.2%. Finally, in comparisons involving a North Eastern versus a Southern State, North Eastern states dominate in 87.6% of cases on average with lowest dominance occurring with Method 3 ($7.96/(7.96 + 1.33) = 85.7\%$), followed by method 1 (87.9%) and method 2 (89.2%).

In summary, Table 4 shows the high prevalence of dominance relationships in which either a North Eastern or a Southern state dominate a Northern state; but also the supremacy of North Eastern states when compared against states *from any other region*.

Now, how do the apparent outlier states affect results reported in Table 4? According to Tables 1, 2 and 3, we observe that Tripura is dominated on average in 6.05% of all relationships using the three methods (6.513 in Method 1, 6.061 in Method 2 and 5.57 in Method 3), whereas North Eastern states are dominated in 10.62% of all relationships (Table 4, taking the average of all the bottom rows). This means that Tripura alone explains more than half (56.94%) of all situations in which North Eastern states turn up dominated.

Table 4: Dominance relationships by Macro-region (%)

Method 1	$\succ^1$ Southern state	$\succ^1$ Northern state	$\succ^1$ North Eastern state	Total Rows
Southern state $\succ^1$	1.92	9.96	1.53	13.41
Northern state $\succ^1$	4.21	24.52	2.30	31.03
North Eastern state $\succ^1$	11.11	38.70	5.75	55.56
Total Columns	17.24	73.18	9.58	100
Method 2	$\succ^{11}$ Southern state	$\succ^{11}$ Northern state	$\succ^{11}$ North Eastern state	Total Rows
Southern state $\succ^{11}$	2.12	13.64	1.21	16.97
Northern state $\succ^{11}$	4.85	25.76	2.73	33.33
North Eastern state $\succ^{11}$	10.00	33.03	6.67	49.70
Total Columns	16.97	72.42	10.61	100
Method 3	$\succ^{cew}$ Southern state	$\succ^{cew}$ Northern state	$\succ^{cew}$ North Eastern state	Total Rows
Southern state $\succ^{cew}$	2.65	13.52	1.33	17.51
Northern state $\succ^{cew}$	6.90	28.91	3.45	39.26
North Eastern state $\succ^{cew}$	7.96	28.38	6.90	43.24
Total Columns	17.51	70.82	11.67	100

Similarly, Karnataka is dominated in 6.95% of all relationships on an average, whereas Southern states are dominated in 17.24% on average of all cases. Therefore Karnataka alone generates about 40% of situations in which Southern states end up dominated. In the Northern region, Jammu and Kashmir, Rajasthan and West Bengal stand out for their high propensity to be dominated states conditional on being in a dominance relationship.

How do results reported in Table 4 change if we apply the alternative dichotomization for the health autonomy variable? Firstly, the number of dominance relationships does not change at all for methods 1 and 2. Meanwhile, with method 3 we find 10 additional dominance relationships, i.e. 387 in total, vis-a-vis the previous dichotomization. Again, large proportions of the dominance relationships are statistically significant at 10% and lower levels.

Secondly, the pattern of dominance by North Eastern states over Northern states decreases, but it still significantly large (89.7%, 85.5%, and 89.4%, for methods 1, 2, and 3, respectively). The pattern of dominance of Southern states over Northern states also decreases mildly (63.6%, 65.2%, and 66.7%, for methods 1, 2, and 3, respectively). We reach a similar conclusion for comparisons of North Eastern against Southern states. The rate of domination decreases only slightly (84.1%, 83.3%, and 83.8%, for methods 1, 2, and 3 respectively).

Thirdly, each likelihood of appearing in dominance relationships as "dominator", and as "dominated", remains fairly stable for all states when we change the health dichotomization. These relative frequencies increase or decrease for some states, but never departing significantly from the original values. Sometimes the effect of the alternative dichotomization on these ratios depends on the method used. For example, with the new dichotomization, Jammu and Kashmir appear as "dominated" about 8%, 13%, and 7.2% of the times (for methods 1, 2, and 3, respectively), which means that the alternative dichotomization improves the stand of Jammu and Kashmir according to method 1, but not according to the other two methods.[8]

In conclusion, it seems that the alternative dichotomization, placing higher importance on "lone decision" in health autonomy, mainly decreases the intensity of the patterns of regional domination, without substantially blurring or overturning them.

4.5 Discussion

Here we briefly discuss some potential correlates of the regional patterns of dominance relationships. On a first glance, the impact of sanskritization and some measures of economic development associate well with the distribution of "dominator" and "dominated" roles across states and regions. For instance, most of the Northern states, with the exceptions of Delhi and (to some extent) Himachal Pradesh, are dominated by states located either in the North East or the South. According to the Reserve Bank of India, Annual Report in 2013, in 2011–12, the percentage of people living below the poverty line, based on mixed reference period consumption, was 9.91% in Delhi, compared to 21.92% in India as a whole. The poverty rates in all the surrounding Northern states is higher, except for Punjab and Himachal Pradesh. Similarly, the literacy rate in Delhi is higher than the national average (81.7% in 2001 compared to the national average of 64.8%). The other Northern state with a comparable literacy rate is Himachal Pradesh (76.5%) according to the Indian Census 2001.[9]

The dominance of North Eastern states could plausibly be associated to the presence of tribal populations and the importance of Christianity, especially in states like Manipur, Meghalaya, Nagaland, and Mizoram. Hence the impact of sanskritisation would be minimal. Possibly, the better performance of Jharkhand out of the three newly formed states in India by the time of the survey (Chattisgarh and Uttaranchal being the other two) could also be related to the strong presence of a tribal population (26.3% of the total population as per 2001 census). [10] In fact, the state was formed primarily due to the demand of tribal movements, mainly the Jharkhand Mukti Morcha (JMM), which allied tribal grievances to more general objections to north Bihari domination (Chandra et al., 2008, pp. 148-151). However, the presence of a politically active and/or demographically significant tribal population may not necessarily correlate with a good performance in state-wise autonomy comparisons. For example, Chattisgarh did not perform well, notwithstanding its sizeable tribal population (31.8% according to the Indian Census 2001). Moreover, Chattisgarh is not known for a relatively high prevalence of some obvious markers of female seclusion (e.g. purdah/ghoonghat wearing) or low social status (e.g. dowry payments) (UNDP, 2005, p. 76). This case exemplifies that the task of associating socioeconomic and cultural indicators to the observed state-wide patterns of female autonomy is anything but straightforward.

The dismal performance of West Bengal could be attributed to the lower economic empowerment of women, especially in rural areas, as otherwise they enjoy higher political empowerment than several other states in India. The indices of 'power over economic resources' and of 'economic participation and decision-making power' for West Bengal in 2006 stand at 0.202 and 0.426, respectively, compared to the national averages of 0.319 and 0.546 (Ministry of Women and Child Development, 2009). This has ensued from the lower worker-population ratio, higher involvement of female workers in marginal activities compared to their male counterparts, higher growth of real wages for male agricultural workers, and widening female-male wage gap. Thus, West Bengal provides a good example of the imperfect correlation of female autonomy (or empowerment) indicators across different realms of life (Malhotra and Schuler, 2005).

5 Conclusion

A fairly robust pattern of regional domination emerges from the three methods (and two alternative dichotomizations for health autonomy) implemented. North Eastern states are more likely to dominate states from other Indian regions whenever a dominance relationship exists. This means that the multivariate distributions of female autonomy in North Eastern states are generally more desirable than their counterpart distributions in other parts of India, for several classes of individual welfare evaluation criteria. Likewise in dominance relationships involving Southern versus Northern states, the former are more likely to appear dominating the latter.

As mentioned, regional domination patterns do not change much by method used (even by alternative dichotomization of the health autonomy indicator); but, interestingly, intra-regional variations matter. For instance, Tripura appear as dominated in the majority of dominance relationships in which it participates; despite hailing from the North-East where most other states almost always turn up as "dominators". Something similar occurs to Andhra Pradesh and Karnataka, both Southern states who never appear as "dominators" in more than 50% of their dominance relationships; by contrast to other Southern states like Kerala, Goa and Tamil Nadu, which generally dominate in their respective dominance relationships. [11] In a different way, both Delhi and Himachal Pradesh represent exceptions to the northern-state pattern. These states actually appear as "dominators" in at least 50% of their dominance relationships. Delhi in particular dominates more than 70% of the time. *Hence differences between states within the same region do matter.*

At this stage it is worth mentioning some methodological and conceptual limitations, which would be common to like-minded studies. Methodologically, while the fulfillment of dominance conditions guarantees the robustness of a comparison to several alternative choices among broad classes of welfare evaluation functions, they remain silent as to any cardinality of the comparison. For that purpose one needs to choose specific evaluation functions. Likewise, when a dominance condition cannot be established, any pairwise comparison must invariably rely on a choice of autonomy index. Since the dominance condition is not met in this case, the rank established by the comparison will inevitably depend on the choice of index.

Conceptually, some caveats need to be taken into account, in general, when working on female autonomy with survey-based indicators (e.g. see chapters in Narayan, 2005, for a discussion). For instance, it would be harder to ascertain that a woman who decides alone on a realm of life bears real autonomy over it, if that dimension is actually worthless to her husband. [12] Hence the importance of social norms in defining the realms of female autonomy. Some researchers claim that, when widely accepted norms uphold the right and power of women to make decisions over a specific dimension, there is no real *individual* autonomy to speak of (Malhotra and Schuler, 2005). We may not go as far as to dismiss dimensions where widespread female autonomy is enforced by social norms. If anything we would deem the lack of individual autonomy in such settings perhaps even more serious. Meanwhile, contrasting this view on social norms and drawing from the (Sen-Nussbaum) capability approach, we do advocate studying the extent of female autonomy over realms of life which *both women and men have reason to value*.

Finally, we would like to point out a few more avenues of future research. Firstly, other welfare evaluation methods can be considered in addition to the three proposed. Secondly, in between traditional dominance tools and measurement based on composite indices, there is available an intermediate path of using dominance-intensity conditions whose fulfillment guarantees that the social welfare difference between countries A and B is stronger than between E and F for a broad class of welfare functions. These techniques might provide further interesting insights. Thirdly, future research should attempt a conditioning strategy, perhaps coupled with dominance comparisons, in order to inquiry further and deeper into the causes of state and regional variations in the multivariate distributions of female autonomy in India, without losing sight of those states that may constitute an "exception to the rule" vis-a-vis their surrounding regions. Fourthly, just as we found important state exceptions to regional patterns, it would be worth studying provincial comparisons within states. The latter is warranted both by the large populations of most Indian states by global standards, and by reports pointing to actual provincial differences in perceptions of women's status within some Indian states (e.g. the case of Chattisgarh, UNDP, 2005).

6 Appendix (FOR ONLINE ACCESS ONLY)

All the proofs in this section are either extensions or direct applications of Hadar and Russell (1969, Theorem 1).

6.1 Proof of condition 1

First, we construct ΔW using the general form in 1, but considering only U satisfying weak complementarity. Then we sum ΔW by parts (using "Abel's formula") in order to render the right-hand side of ΔW as the sum of products of first-order cross-partial differences multiplied by joint survival distributions. We get the result derived by Yalonetzky (2013, equation 20, p. 143), in which clearly $\Delta W > 0$ for all U characterized by weak complementarity if and only if all the joint survival probabilities of S are never below those of T, and at least once strictly above. Now note that, by definition of survival functions, if $\Delta\overline{F}(i1, i2, ..., iD) \geqslant 0 \ \forall i1, i2, ..., iD = 0, 1$ (with at least one strict inequality), then all the other joint survival functions of lower order (i.e. involving fewer than the total of D variables, including the marginal survival distributions) will also have to be non-negative. Therefore $\Delta\overline{F}(i1, i2, ..., iD) \geqslant 0 \ \forall i1, i2, ..., iD = 0, 1$ (with at least one strict inequality) is a sufficient condition for $\Delta W > 0$. It is also a necessary condition, because otherwise we could find some U function fulfilling monotonicity and weak complementarity such that $\Delta W < 0$.

6.2 Proof of condition 2

Again, we construct ΔW, but now using the U in 2. Note that for W we get:

$$W = \frac{1}{N} \sum_{n=1}^{N} \sum_{i=1}^{D} u_i(A_i) = \sum_{j=0}^{1} \sum_{i=1}^{D} u_i(j) p_i(j) \tag{5}$$

Then we sum ΔW by parts (using "Abel's formula") and we get:

$$\Delta W = \sum_{i=1}^{D} [u_i(1) - u_i(0)] \Delta p_i(1) \tag{6}$$

Given that $[u_i(1) - u_i(0)] > 0 \ \forall i = 1, 2, ..., D$ due to satisfaction of monotonicity, then $\Delta W > 0$ if and only if $\Delta p_i(1) \geqslant 0 \ \forall i = 1, 2, ..., D$ with at least one strict inequality.

6.3 Proof of condition 3

Now we construct ΔW using U in 4 with $w_i = \frac{1}{D} \ \forall i$. Note that for W we get:

$$W = \frac{1}{N} \sum_{n=1}^{N} U(X) = \sum_{i=0}^{D} U(i) p(i) \tag{7}$$

Then we sum ΔW by parts (using "Abel's formula") and we get:

$$\Delta W = -\sum_{i=0}^{D} [U(\frac{i+1}{D}) - U(\frac{i}{D})] \Delta F(i) \tag{8}$$

From 8 we can deduce that $\Delta W > 0$ if and only if $\Delta F(i) \leqslant 0 \ \forall i = 0, 1, 2, ..., D-1$ with at least one strict inequality.

7 Acknowledgments

The authors would like to thank two anonymous referees, Paola Ballon, Sabina Alkire, Suman Seth, participants at the conference of the Society for Economic Measurement, Paris, July 2015, and seminar participants at OPHI Seminar Series, November 28th 2013, and at the Leeds Economics Seminar series, February , 2014; for very helpful and constructive comments. We would also like to thank Melissa Friedman for very valuable and efficient research assistance.

Notes

[1]We would like to thank an anonymous referee for emphasizing the importance of 'sanskritisation' in this literature.

[2]There is an old literature investigating the possible original causes behind the low autonomy of women among Hindu societies in India, vis-a-vis other southern and eastern Asian peoples. For instance, Boserup (2011) relates it to the degree of female participation (or lack thereof) in the different modes of agricultural production across the regions.

[3]By first-order cross-partial difference we mean the non-continuous equivalent of first-order cross-partial derivatives. For example with $D = 2$, the first-order cross-partial difference would be: $[U(1,1) - U(1,0)] - [U(0,1) - U(0,0)]$.

[4]Alternative dominance conditions can also be applied if we allow for welfare functions not fulfilling the property of weak complementarity. However, there are not enough conditions for all possible combinations of first-order cross-partial differences, and the interpretations of their different possible signs becomes quite challenging, unlike condition 1. For a discussion see Yalonetzky (2013).

[5]Since the first survival probability is equal to 1.

[6]Telangana, formed in 2014, was still part of Andhra Pradesh when the survey was carried out.

[7]We would like to thank an anonymous referee for suggesting the alternative dichotomization.

[8]Detailed results are available from the authors upon request.

[9]See censusindia.gov.in/Tables_Published/A-Series/A-Series_links/t_00_006.aspx.

[10]See censusindia.gov.in/Tables_Published/A-Series/pca_main.html

[11]Although Kerala dominates in less than 50% of its relationships according to method 1.

[12]We would like to thank Melissa Friedman for pointing out this issue.

References

Abraham, L. (2001). Redrawing the lakshman rekha: Gender differences and cultural constructions in youth sexuality in urban India. *South Asia: Journal of South Asian Studies 24*(4), 133–56.

Alkire, S., J. Foster, S. Seth, M. E. Santos, J. M. Roche, and P. Ballon (2015). *Multidimensional poverty measurement and analysis*. Oxford University Press.

Alkire, S., R. Meinzen-Dick, A. Peterman, A. Quisumbing, G. Seymour, and A. Vaz (2013). The women's empowerment in agriculture index. *World Development 52*, 71–91.

Alkire, S. and M. E. Santos (2014). Measuring acute poverty in the developing world: Robustness and scope of the multidimensional poverty index. *World Development 59*, 251–74.

Anderson, S. and M. Eswaran (2009). What determines female autonomy? evidence from Bangladesh. *Journal of Development Economics 90*, 179–91.

Asselin, L.-M. and V. t. Anh (2008). Multidimensional poverty and multiple correspondence analysis. In N. Kakwani and J. Silber (Eds.), *Quantitative approaches to multidimensional poverty measurement*, Chapter 5, pp. 80–103. Palgrave MacMillan.

Boserup, E. (2011). *Woman's role in economic development*. Earthscan. Reprinted.

Chandra, B., M. Mukherjee, and A. Mukherjee (2008). *India since independence*. Penguin Books.

Chatterjee, P. (1989). Colonialism, nationalism, and colonialized women: The contest in India. *American Ethnologist 16*, 622–33.

Derne, S. (2003). Arnold Schwarzenegger, ally McBeal and arranged marriages: Globalization on the ground in India. *Contexts 2*, 12–20.

Duflo, E. (2012). Women empowerment and economic development. *Journal of Economic Literature 50*(4), 1051–79.

Dyson, T. and M. Moore (1983). On kinship structure, female autonomy, and demographic behavior in India. *Population and Development Review 9*(1), 35–60.

Field, E., S. Jayachandran, and R. Pande (2010). Do traditional institutions constrain female entrepreneurship? a field experiment on business training in India. *The American Economic Review 100*(2), 125–9.

Hadar, J. and W. Russell (1969). Rules for ordering uncertain prospects. *American Economic Review 59*, 25–34.

Jejeebhoy, S. and Z. Sathar (2001). Women's autonomy in India and Pakistan: The influence of religion and region. *Population and Development Review 27*(4), 687–712.

Kabeer, N. (2005). Gender equality and women's empowerment: A critical analysis of the third millennium development goal 1. *Gender & Development 13*(1), 13–24.

Kannai, Y. (1980). The alep definition of complementarity and least concave utility functions. *Journal of Economic Theory 22*(1), 115–7.

Malhotra, A. and S. Schuler (2005). *Measuring Empowerment*, Chapter Women's empowerment as a variable in international development, pp. 71–88. The World Bank.

Ministry of Women and Child Development (2009). *Gendering Human Development Indices: Recasting the Gender Development Index and Gender Empowerment Measure for India*. Government of India.

Mistry, R., O. Galal, and M. Lu (2009). Women's autonomy and pregnancy care in rural India: A contextual analysis. *Social Science and Medicine 69*, 926–33.

Moursund, A. and O. Kravdal (2003). Individual and community effects of women's education and autonomy on contraceptive use in India. *Population Studies 57*(3), 285–301.

Narayan, D. (Ed.) (2005). *Measuring empowerment*. The World Bank.

Nussbaum, M. (2000). *Sex and social justice*. Oxford University Press.

Oppenheim, K. (2005). *Measuring empowerment*, Chapter Measuring women's empowerment: learning from cross-national research, pp. 89–102. The World Bank.

Srinivas, M. (1956). A note on sanskritization and westernization. *Far Eastern Quarterly 4*, 481–96.

Townsend, P. (1979). *Poverty in the United Kingdom*. Penguin Books.

UNDP (2005). *Chhattisgarh Human Development Report of 2005*. UNDP.

Yalonetzky, G. (2013). Stochastic dominance with ordinal variables: Conditions and a test. *Econometric Reviews 32*(1), 126–63.